Volume 2, Issue 7 – March 2011

ISSN No. 0976-254X

# Rail Business

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# RAILWAY BUDGET — HOPE & HYPE


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V K Agarwal


Vinoo Mathur


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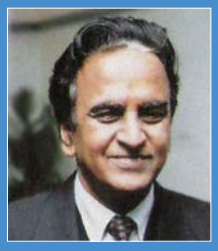
e-mail: headlinersadvertising@gmail.com



S. Dhasarathy

Every man's work, whether it be literature or anything… ….

**Railway Budget 2011-12: An insider's view from outside**

After working with IR for about 4 decades and watching it close from outside for up to a decade now, my reaction is a mixed bag of emotions. Presented by a politician to her contemporary elites in the Parliament, an over dose of "politics" was expected, but never to witness such annihilation of "economics" at the altar of "politics".

The positive signs:

- Contrary to widespread perception of an operating ratio of around 105%, it is a relief that it would be 92% this year and 91% next year.
- Procuring 18500 wagons.
- Enhancing the network coverage by adding 1000 km annually (200 km in earlier years).
- Halving train accidents during last five years.

Chronic problems like disproportionate staff costs, losses in passenger services etc., have plagued IR for quite some time. Successive ministers have shunned unpopular decisions like increasing fares or decreasing staff strength. Year after year, we continue to put up with the marginal deterioration, hoping that some solution will eventually emerge, a grim reminder of the proverbial frog that was boiled to death.

Discounting technology gains in productivity and ordering induction of staff, based on vacancies in direct proportion to work output, can win accolades in the political arena. Employee Productivity in IR is already as low as 0.8, in sharp contrast to other railways of comparable size (China 1.4, Australia 3.6, Russia 2.0 and USA 15.2 : data for 2006). There should be sustained efforts to control staff costs to less than a third of the earnings.

Network expansion driven by lobbies : Instead of an equitable development of rail lines based on needs by factoring the population and rail density, impending elections and the lobbying power of the parties appear to have driven the selection of rail lines and other goodies. New projects chosen by brazen political decisions by persons who seem to represent a region rather than the country continue to perpetuate this skew.

Freight traffic is the bread and butter of IR. Freight business is muted, over taxed and under cared. Yet, this sector is not given the importance that it deserves. "Tariff Ratio" in IR is rapidly deteriorating year after year, from 0.47 in 1950, to 0.27 in 2009-10 and an all time low of 0.25 is reached this year, taking us farther away from the magical figure of 1.0.

Accounting Reforms Project : Having criticized the budget distortions of earlier years in the "WHITE PAPER 2009", it was expected that the Minister would have taken this opportunity to freeze the accounting format, duly implementing the key recommendations of the "Indian Railways Accounting Reforms Project". This would have lent to a better appreciation of Railways' performance making financial reporting more transparent in future years.

…is always a portrait of himself… Samuel Butler.

We are privileged to bring a Guest Editorial from S Dhasarathy, an Ex. Member of IR board

# A difficult year, but high hopes for 2011

V K Sahai,
Chairman
Indian Railways
Board

For VK Sahai, Chairman of IR Board, it is a matter of satisfaction that the Annual Investment Plan for coming fiscal at ₹ 57,630 Cr is the highest ever in a single year. For the IR Board, a critical area is the need to augment capacities, as the ability to take incremental traffic on existing routes will not be adequate in coming years. Sahai has reason to be satisfied that future investment needs can be met with market borrowing routed through the Indian Railway Finance Corporation which has been permitted to raise ₹ 20,000 Cr including ₹ 10,000 Cr for network projects. In a well coordinated decision the Central government has allowed the National Highway Authority (NHAI) also to raise a similar amount through tax free bonds. NHAI will use this money to provision for viability gap funding. Proposed allocation for roads, ports and airports has been increased by 23%. The FII limit in corporate infrastructure bonds has been raised by $ 20 b which is expected to lead to better patronage of the bond issues. Normally IRFC raises around ₹ 10,000 Cr annually for rolling stock but will now raise an additional ₹10,000 Cr through tax free bonds for select capacity enhancement works.

In an interview to RAIL BUSINESS Sahai emphasized that various cost push factors coalesced in 2010 to render IR finances under severe pressure. It is normal for businesses of the size of IR to go through financial swings and these should be viewed in their perspective. Sahai stressed that the fundamentals of capacity growth and a dedicated management and staff remain strong and IR will overcome the current cash crunch. Pressures on staff costs are periodic and linked to the government pay commissions and IR has successfully been able to meet with all these cash outflows.

Sahai is clear that various project organisations that work on IR projects need to be tuned up for meeting timelines and the current pace of execution is grossly inadequate. Accordingly, he expects to structure and man the Organization for Project Implementation (COPI) with offices in Delhi, Kolkata, Mumbai and Bangalore within the next six months. The IR Board would define the role of this organisation and sort out any issues for manning these high level appointments.

Sahai, who is also responsible for operations, is concerned that higher margin traffic like iron ore for export may not see any revival in the coming year. Instead he plans to fill in the existing capacities with the surging movement in imported coal. In recent years even as ports on the Eastern sea board have become capacity constrained, ports on the Western coast have been able to grow on this traffic. Reportedly travel leads on this movement are also healthy. It may be of some concern that routes for iron ore export and for imported coal are not the same and sectional capacities could become a concern for raising the extra 70 mt in the next fiscal. Some experts do not easily foresee traffic leads increasing significantly. RB

# Right time for a rail stimulus package

V K Agarwal,
Ex Chairman,
IR Board

Within the constraints of resources, IR has done exceedingly well in improving its operational and safety performance also using some improved technologies. However, the main problem area remains the growth of infrastructure. While moving infrastructure could be arranged with comparative ease, it is the fixed infrastructure which takes a lot of time and inputs and also needs detailed advanced planning.

Growth of rail network has been very slow after Independence with 18% increase in route km (pace of construction being about 1/3rd of the pre-Independence era). Both rail and road already face severe capacity constraints especially on busy routes and will become much worse with the traffic doubling in next 7-10 years.

The IR freight rates are high and passenger fares low but still the market share is being lost in both the categories of traffic. It is more of a problem of capacity/congestion rather than being a fare related issue. On IR, average speeds of goods trains are less than 25 kph (maximum permissible speed being 75 kph) indicating more than severe congestion.

Rail infrastructure urgently needs development at a much accelerated pace. Since most projects are financially not viable, rail projects will need additional inputs by way of Viability Gap cum Accelerated Development Funds.

A ten year Development Plan of the IR would need inputs of about ₹ 1.4 lakh Cr per year, with about ₹ 90,000 Cr per year being arranged through IR's financial savings/borrowings/private investments and the balance ₹ 50,000 Cr per year from the central Government. IR's usual plan size for the last 7-8 year period has been about ₹ 25,000 Cr per year including a Gross Budgetary Support of around 35%. The investment levels have thus to be increased by 4 to 5 times to achieve the desired levels of inputs.

The current Budget has enlarged Plan Size to ₹ 57,630 Cr (highest ever) by organising additional finances and higher budgetary support and is trying to work towards IR's Vision Document 2020. Further, Pradhan Mantri Rail Vikas Yojana has also been started for socially desirable rail projects. These are laudable and significant movements in the right direction. However, the pace at which the financial resources need to be provided do not match requirements, if the Vision 2020 is to be achieved. Dedicated Freight Corridors will need Viability Gap cum Accelerated Development Funds to the tune of around 50% of their cost. RB

# The railway budget: an investment perspective

...Vinoo Mathur

The best way of evaluating the Railway budget is to assess performance of the Railways in financial and physical terms during the current Fiscal 2010-11 and the projected figures for growth in the year ahead. An additional aspect, perhaps more important, which needs to be considered is how the policy announcements and investment plans are expected to impact the long term growth of the organisation and its ability to meet the long term goals set out a year ago in the Vision 2020 statement.


### Performance 2010-11

With respect to the financial performance in 2010 -11 the total receipts at ₹ 97,151 Cr are marginally lower than the projection of ₹ 97,721 Cr in last year's budget. The total expenditure in the revised budget is expected to be ₹ 88129 Cr against a budgeted ₹ 87,940 Cr. Although, the figures appear to match the budget projections, this has only been possible by reducing the Appropriation to the Depreciation Reserve Fund which was budgeted at ₹ 7,600 Cr and has been reduced by ₹ 1,900 Cr to ₹ 5,700 Cr. This is cause for concern. The net ordinary working expenses at ₹ 67,000 Cr have also gone up by ₹ 2000 Cr as compared to what had been projected.

In terms of physical growth in 2010-11, freight traffic is expected at 924 mt against a forecast of 944 mt and 888 mt in the previous year, a growth of only 4% against 9% achieved a few years ago. On the passenger front growth in number of passengers booked is expected to be 7831 million which is a little higher than what was budgeted and indicates a 6% growth over the previous year. The poor growth in freight traffic is attributed to a ban on Iron ore exports and disruption in traffic due to agitations; however, this is a very worrying aspect and perhaps also indicates that capacity constraints are also beginning to affect output.

Where the Railway has shown a positive trend is the improvement in performance in executing works. The organisation expects to deliver 700 km of new lines against a target of 1000 km and 250 km achieved in the previous year. Similarly 800 km of gauge conversion, 700 km of doubling works and 1000 km of electrification are likely to be completed in accordance with the target it set itself. Unfortunately, the 27 new line projects and 15 gauge conversion projects that will be completed will provide very little additional capacity for facilitating growth in freight traffic. IR expects to acquire 515 locomotives against a plan of 480. Against a target for acquiring 1039 EMU/MEMU coaches and 3582 other coaches, actual acquisitions are expected to be 905 and 2961, respectively. Wagon acquisition is likely to be 14,500 wagons against a plan for acquiring 18,000 wagons. The wagon industry, it appears, has still not geared up to meet the increase in demand.

For 2010-2011 the annual plan provided for ₹ 41426 Cr against which ₹ 40315 Cr is likely to be spent. This is at about the same level as 2009-10 when the plan size was ₹ 39672 Cr. Another trend is the re-appropriation done within the plan heads during the year. For example, the allocation to some heads was raised significantly e.g. New Line 14.4% and Gauge Conversion 56% whereas there was a significant cut in other plan heads like Traffic Facilities -37%, Computerisation -37%, Track renewals -8%, Bridge Works -19.4%, and Machinery & Plant -21.3%. Here again, the majority of New Line and Gauge Conversion Projects targeted for completion will not provide any additional capacity where it is required although in the smaller plan heads like traffic facilities, computerisation, M&P and track renewals the fallout may have serious long term consequences.

### Plan for 2011-12

The total revenue receipts in 2011-12 are expected to be ₹ 109,450 Cr, a growth rate of 12.6% over 2010-11 whereas expenditure is expected to increase at 10.5% to ₹ 97,400 Cr. The Gross Traffic Receipts are expected to grow without any freight or fare rate increases being announced. With respect to physical output, freight tonnage will go up to 993 mt. The year on year increase of freight tonnage is projected at 7.5%, net t-km at 7.6% and freight revenue at 9.8%. Passenger volume is projected at 8,272 million passengers. Whereas passenger volume will grow by 6%, passenger kilometres and passenger revenue are each expected to grow at 11%.

Vinoo Mathur,
(Ex Member Traffic IR Board)
Managing Director
The Bharuch Dahej Railway Co. Ltd.

BUDGET HIGHLIGHT

"Annual investment plan grows to ₹ 57,630 Cr"

Growth in freight traffic, therefore, will continue to trail the GDP growth of the economy which is expected to be 8 to 9%.

With regard to the Annual Plan there has been a very significant increase in the plan outlay which has gone up to ₹ 57,630 Cr for 2011-12, a whopping increase of 43% over the previous year. Where will this money come from? The plan is proposed to be financed from Gross Budgetary Support of ₹ 20,000 Cr, Diesel cess of ₹ 1041 Cr, Internal Resources of ₹ 14,219 Cr and Market Borrowings through IRFC of ₹ 20, 594 Cr. It is expected that about ₹ 10,000 Cr of this will be raised through Tax Free Bonds. The Borrowings through IRFC have more than doubled. For the first time IRFC borrowings will be used, in a significant way, for other than funding Rolling Stock which has a possible risk that investment in unviable 'Socially Desirable' lines will go up significantly. Generating internal resources of over ₹ 14,000 Cr for the Annual Plan is also a challenge. Although, increasing borrowings is a way for raising investment funds it places an added responsibility that the money be invested wisely.

The Plan provides for ₹ 8433 Cr for New Lines, an increase of 69% over the current year's spending, ₹ 6502 Cr for Metropolitan Projects – a more than tenfold increase, ₹ 5418 Cr for doubling an increase of 145%. Significant increases in allocation over 2010-11 have been provided for the Signal & Telecom (20%) and Electrification (49%). Higher allocations have also been made for traffic facilities, computerization and research where there were big cuts in the current year. Whereas, in case of New Lines and metropolitan projects there appear to have been compulsions to achieve socioeconomic objectives of Government, in other areas funding is well directed. The greater allocation for doubling, electrification, signalling & telecommunication and Dedicated Freight Corridor works should contribute to capacity building. The big jump in the plan size will also require greater emphasis on speeding up execution. In this regard the Minister had announced the setting up of a Central Organization for Project Implementation.

An interesting announcement was the creation of a Pradhan Mantri Rail Vikas Yojana under which a non-lapsable fund would be created for executing socially desirable projects. Similarly a non-lapsable Fund for completing Projects in the North-East was also announced. It is not clear as to what would be the source for funding these schemes. The concept is good; however, there is need for separating socially desirable projects from capacity building projects and identifying separate sources for financing them in a way that capacity creation gets priority. This is an important issue and Government for the future growth of the organisation needs to distinguish between what is socially desirable and what is a priority for creating capacity to facilitate growth. Of the 122 ongoing New Line Projects only about ten are considered commercially viable. Similarly of the 40 sections of new line projects targeted for completion in 2011-12 very few will be of any short or long term operational or commercial benefit to IR. On the other hand tremendous returns can be expected from the 35 sections expected to be doubled during the year.

Overall, the budget reflects the difficult financial position IR is going through. It has some new features. For the first time the budget proposes raising investment funds through tax free bonds. This highlights the need for IR to explore options for raising investment funds from sources other than internal generation and Government Budgetary Support. Public Private Partnership, which is one possibility, has made a very slow beginning. It is important that models for PPP in different spheres of rail activity must be developed in consultation with industry in order to make it succeed. The non-lapsable fund for socially-desirable projects is also a positive but needs to be followed up so that it becomes workable proposition. The failure to raise passenger fares, in particular, is difficult to understand from a professional organisational perspective. Moreover, there is an urgent need to analyse costs as, despite growth in volumes, unit costs are high and it must take concrete steps to bring them down in order to ensure long term viability. The key lesson is that IR needs to focus on its core business objectives and plan for rapid capacity creation to achieve growth objectives set in its Vision 2020. RB

# Passenger services: robust initiatives

- Additional AC double-decker services will be introduced on Jaipur-Delhi and Ahmedabad-Mumbai routes even as the first service is awaiting final trials before introduction on the Howrah-Dhanbad route.
- 20 coach MEMU services have been introduced on the Northern Railway.
- There has been no indication of any plan for incremental increases on the existing speed of 110 kph on the bulk of IR route. However, a pre-feasibility study will be taken up with Japanese support for increasing passenger train speeds to 160-200 kph on Delhi- Mumbai route. Similar studies will be initiated later for Mumbai-Kolkata, Chennai- Bangalore, Delhi-Jaipur and Ahmedabad-Mumbai. What IR has not indicated is whether this increase would take place on existing tracks or a new route. Nothing is known regarding whatever happened to the survey already undertaken for the 250+ kph high speed route linking Ahmedabad to Mumbai and Pune. The promised High Speed Development Authority is also stuck up in procedural insomnia somewhere in New Delhi. RB

# Capacity building: a single minded pursuit

### The present scene

The steep rise in IR expenditure mainly due to salary revisions arising out of the 6th Pay Commission has serious implications not withstanding part provisioning for it in the FY 2008 interim budget. Shortfall in freight traffic during FY 2010 is a matter of concern. Considering an ₹ 60 Cr yield per mt of freight traffic, this alone would account for reduction of ₹1000 Cr in the earning stream.

The core prescription for IR's growth in the recent past has been a concentrated build up in infrastructure. This was reflected in massive 11th Plan (2007 – 2012) projection of ₹ 2.33 Lakh Cr which had envisaged net work expansion and additions and improvement in rolling stock. Major initiative for network expansion was of course the Dedicated Freight Corridors. Building of additional capacity for electric and diesel locomotives, passenger and freight stock and improving their quality and design was another cornerstone of planning. By and large the 11th Plan, now in its last year, has failed to realize significantly on these major initiatives. Freight growth beyond 2006 – 07 (from 728 mt to 924 mt) has largely consumed additional capacity created earlier. Major infrastructure growth in network and rolling stock are key stones that have to be addressed single mindedly.

### Short term strategy

- Network expansion has been emphasized in the current budget. Estimates sight 700 km during 2010 against the originally envisaged 1000 km. For 2011 projections include 1075 km of new lines (₹ 7181 Cr). Most of it has to be in new links and alternative routes like bye passes and other connections linking gauge converted lines. It is important that all time and money should largely support core routes.
- Gauge conversion (GC) should prioritize on alternative routes like Bhildi-Samdi. 2011 Estimates target 1017 Km for GC with an outlay of ₹ 2723 Cr including ₹ 2107 Cr from external borrowing like IRFC Bonds. The 2010-11 revised outlay is ₹ 1319 Cr, down from the original ₹ 2264 Cr, but the physical target has remained unchanged at 800 km. Some magic is working behind the scenes!
- Track Doubling and Electrification are core to capacity building and targets of 700 Km and 1000 Km respectively should be achieved in FY 2010. For FY 2011-12, the target for track doubling is 861 Km (₹ 5408 Cr), with the bulk of ₹ 5293 Cr from IRFC Bonds. Electrification gets ₹ 978 Cr with ₹ 854 Cr from external borrowing.

### Long term

- The new capacity initiatives in freight stock and locomotives have to be speeded up. There is need to improve freight design, particularly to improve tare - weight ratio and increase axle load. It has been demonstrated that overpowering of trains is a better option.
- Maximum moving dimensions should be again looked at critically. We can provide extra width in freight wagons, to increase their capacity.

There is need to move forward with speed. IR can think of a think tank suggest some short and long term measures. Its financing model, which heavily leans on external borrowing, will also need careful handling and management. RB

R R Jaruhar,
Consultant World Bank,
Former Member Engineering,
IR Board

# Generating private capital

IR has developed several business-oriented policies: Railways' Infrastructure for Industry Initiative R3i, Private Freight Terminal, Special Freight Train Operators (SFTO), Automobile Freight Train Operators, Automobile and Ancillary Hubs, Kisan Vision (Cold Chains) and Rail Connectivity to Coal and Iron ore mines (R2CI). IR believes that the response to the policies has been encouraging with 85 proposals received so far though closure of no proposal has been reported so far. Some business houses are keen on a majority stake before they invest in any big ticket project. IR has set up a Single Window System but unfortunately this single window, as indicated on the IR web site, names a room in the corporate office without naming any person or even a contact detail. Often times actions are a better clue to intentions than the words used.

N Madusudhan Rao, Exec. Director (Planning) indicated receipt of 5 proposals under the R3i schemes. He expects exciting interest from steel and coal industries in the ore connectivity projects underR2C.

| Link | Corporate house | RB estimate of cost ₹ Cr |
|---|---|---|
| Dighi port, Maharashtra | Balaji Infrastructure | 550 |
| Dewas port, Maharashtra | Reliance Infra | 500 |
| Jaigarh port, Maharashtra | Jindal Steel | 2000 |
| Astrang port, Orissa | Navyug | 750 |
| Hazira port Gujarat | Essar | 800 |

# Improving system 'genes': Sanjiv Handa


*Sanjiv Handa, Member Mechanical, Indian Railway Board*

The palette is well filled with possibilities, hopes and technologies. A few images emerge now and then, sometimes hazy, but raising expectations of more to come. Sanjiv Handa, Member of IR Board, looks at the palette with a lot of interest and has quite a few pictures in mind. In a freewheeling interview to RAIL BUSINESS after the presentation of the 2011 annual budget, Handa expressed general satisfaction with the planned investments in rolling stock manufacture and maintenance facilities and delineated quite a few initiatives that should materialize in the next financial year. IR's rolling stock manufacture and procurement programme is slated to get ₹ 13800 Cr in FY 2011.

Handa noted that rolling stock production will get required funding with the increased borrowings of ₹ 20000 Cr by IRFC. Asked if such increased borrowings could also mean IRFC funding for various stalled network expansion projects, Handa hoped that such an effort would succeed. For him, running a business effectively is about borrowing money in projects that give a higher return. IR has a wide range of projects that are guaranteed to give good returns on the economic and financial fronts and any increased borrowing should be for the better.

### Network expansion

Handa pointed out that the proposed Pradhan Mantri Rail Yojana will get non- lapsable funding in the 12th five year plan for new network projects, particularly in the socially desirable sector. For him, IR needs to determine better delivery mechanism for in-hand projects so that the expected increase in project funding can be absorbed faster. He pointed out IR plans for setting up an organisation for project implementation (COPI) that will have senior managers in four metros monitor project process. Asked if such a structure would not mix responsibilities with the zonal managers, Handa indicated that the Board is aware of the need to determine responsibilities and the structure would be evolved with care. For him these project "czars" would have to also work as "speed agents" resolving local issues with various stake holders including the state govts and pushing intra-railways coordination on a continuous basis. Delivery mechanisms do need some out-of-the-box thinking and for new structures to be defined for the coming years.

About RAIL BUSINESS concerns regarding available funding getting lesser priority for capacity building projects like the high density routes, Handa was emphatic that such projects are getting priority support and attention on a recurring basis and the IR management is fully aware for the need to speed up capacity building projects.

### Locomotive manufacture

Handa laid out his plans for rolling stock acquisitions in 2011. The Diesel Loco Works at Varanasi is now well on the path to manufacturing above 250 locos including an impressive 160 to the 4500 hp EMD designs. Sources and technologies having been tied up for the EMD class locos, DLW should be able to switch to 100 % production of such locos. In particular, DLW and RDSO have now three possible designs and sources in EMD, Siemens and the indigenous Medha Servo for the traction converter supplies. Problems faced earlier with different software versions (SIBAS from Siemens and EMD's EM 2000) have been sorted out leading to better supply anticipation in coming years. DLW is now producing only the 4500 hp versions that meet with traffic needs. DLW is also working to a specially worked out revised policy for niche high technology products that need a dedicated and different development/procurement approach. Design and procedural requirements for prototype manufacture of the 5500 hp version are also in hand though a definite time line for the prototype production was difficult to come by.

### Passenger coach manufacture

Manufacture of coaches will get a boost when the new coach factory in Rai Bareilly puts out its first coach within three months. Build up to full production level will take some more time. Handa's plans include progressive shift to manufacture of the more modern LHB designs only (the other version known as ICF design dates back almost 60 years). Increases in LHB production have been constrained by limitations in manufacture of the coach bogies that require precision machining on a 5-axis CNC machine. Capacity tie ups have included setting up an IR funded bogie manufacturing facility in Budge Budge (likely to take couple of years) and some outsourcing.

Use of such coaches has been restricted so far to the niche Shatabdi and Rajdhani trains but higher production would permit extension to premier mail and express trains that had been held on hold due to the doubts about using non-air-conditioned coaches on speeds above 130 kph. Necessary mandatory clearances for this purpose have been obtained and Handa expects that 6 trains would be put into service next year. The

60 year old coach factory at Chennai (ICF) is currently in the process of an ₹ 250 Cr investment to permit capacity increase to 1700 coaches per year. This investment will also permit ICF to switch over predominantly to LHB designs when the project takes shape, around 2013. This year ICF expects to manufacture upward of 40 such coaches, depending on supply of bogies from RCF and allied sources. Expectedly with the progressive increase in manufacture of such coaches in Perambur and Rai Bareilly, these will become the new standard for the passengers in India. Riding comfort and ambience will get a new high on IR, in addition to the fact that these coaches can provide incremental higher speeds even on existing tracks.

### On-board waste disposal: a long term concern

Waste disposal and on-board toilets have been a bane of the IR system. Even though trials on bio-toilets have gone on for some years, it is only now that some definite direction and progress has been recorded with a rake fitted with DRDO-developed bio-toilets on the run since end January. DRDO is very confident of making this design work satisfactorily in the Indian conditions of relative misuse. Handa indicated that for a system to be viable, standardisation on the design is a critical requirement as coaches are often diverted to unpredictable routes and absence of facilities, training and spares in any location can mar the acceptability and performance of any design. The satisfaction level with the existing Controlled Discharge Toilets is not good. Increase in the numbers of bio-toilet fitted coaches will be given a boost in coming years: while funding will not be an issue, the ability to develop adequate numbers will be. IR is accordingly planning to take on this activity in the Motibagh (Nagpur) narrow gauge workshop that has relatively current low work load and can handle such work on priority.

### "Super" AC Coach

Plans for the introduction of a "super AC" have been announced in the parliament and a prototype coach will be manufactured in a few months for a first look and preliminary feedback. It is understood that these coaches will have added privacy for the passengers, superior ambience and furnishings and collapsible footsteps to ease usage for passengers using the upper berths. Reluctance to reveal full details is perhaps understandable.

### Improving the 'genes'

The general vision of improving rolling stock designs naturally extends to wagons also. Handa calls this general effort as 'improving the genes'. The effort has obviously not been hassle free: he is everything that a persistent manager should be. Determined in his effort on "gene engineering" the rolling stock family, he laid out an extensive array of system improvements needed and in process.

Wagon utilisation and throughputs have seen an ambitious increase particularly in the covered BCN class of wagons where the throughput per train is up by an impressive 34 %. East Central Railway's Mughalsarai wagon depot, that handles bulk of the wagon requirements for the north bound coal traffic, now maintains almost 100 rakes of stainless steel open wagons of BOXNHL class. These rakes are able to run up to 370 km per day on the average, up from about 330 km on the earlier versions in the same circuits. Performance will be improved further as the earlier service problems on these designs have been addressed and bogie mounted brake systems installed.

In its effort to continuously tune up wagon designs, IR has had a second look at the use of stainless steel covered wagons of the BCNA class. Possibly the next tranche of these wagons will be bought to designs that will use micro alloyed steels in place of stainless steel but the enlarged payload and trainload capacities will be retained. Newer version is expected to reduce procurement costs by up to ₹ 6 Lac per wagon, a hefty saving on the annual bill. Considering procurement procedures, this would imply that the first wagons of this class may be on road by end 2011.

### Improving the wagon coupler

Handa has also addressed the issue of wagon reliability and maintenance needs. He indicated ongoing efforts to improve centre buffer performance. Considering the large number of coupler breaks on indigenously produced couplers (patterned on the AAR type F) on wagons, IR had decided in 2007 to use only imported coupler assemblies from the approved US sources. These have been fitted on the stainless steel BOXNHL and BCNHL wagons where comparative performance has been impressive: almost perfect in terms of in-service reliability. Parallel efforts to improve indigenous production have centered on the processes for quality assurance.

IR has been discussing implementation of a new specification for CBC couplers that draws on the experience with recent imports, experience in quality assurance and changes in AAR specifications. Trial manufacture by some vendors of couplers to this amended specification is now in hand and this effort will see finality in a few months. IR is likely to stop imports of couplers for wagon contracts likely to be awarded later in the year. This improvement, when effected, will go a long way addressing a chronic problem with IR wagon performance. Extension of the bogie mounted brake systems to other wagon classes could also be affected as the vendor base and experience with larger numbers comes in.

### Procurement bottlenecks

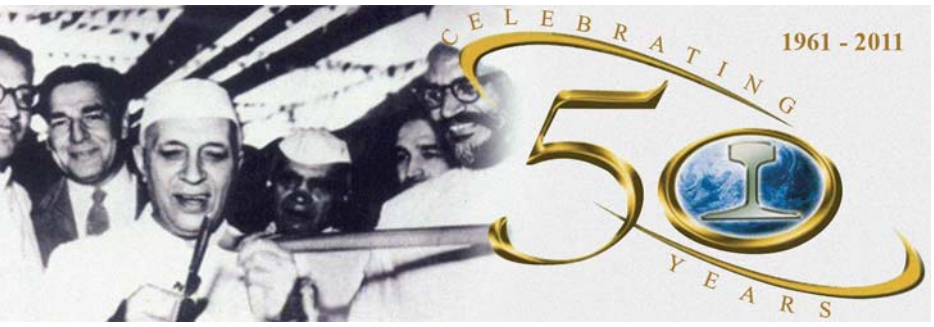
Wagon procurement procedures are also getting a fresh look with a view to increase transparency and provide better incentives for improved quality assurance by current manufacturers. Procedural issues often delay procurement decisions and an effort is being made to address likely issues in the pre-tender discussions so as to limit subsequent delays in the decision making process. With a likely induction of around 16 000 wagons this year and the fact that most of these wagons have improved pay load capacities, wagon availability should ease permitting a growth to the targeted 990 mt in next FY.

### New manufacturing units

While a number of new manufacturing facilities are on the anvil for rolling stock components and wagons, these have been either through IR's own investments or likely joint ventures with state owned cash rich corporations like SAIL. Successes in getting private participation in locomotives, or electric/diesel car set production have not been impressive. While Handa is aware of delays in these actions, he is also conscious of the need to evolve a long term model that can be applied to all streams of such investments. In his view, the time taken now to address various issues and sort out investment priorities, vis a vis IR's own manufacturing units, will be worth the effort in the long run.

The visions are taking shape, albeit slowly. The brush strokes are showing a pattern that can bode well for the railways in India. One could sense a direction and determination in what is being done, very practicable schemes with achievable time lines and defined goals. Like many others, the rail community hopes for successes in all these efforts. RB

# Bhilai rails on a 50 year roll




*Jawahar Lal Nehru, then Prime Minister inaugurating one of the 'temples' of modern India in Bhilai*

V K Arora, CEO , SAIL's Bhilai Steel Plant is a contented man as he lays out the future plans for rail production in his plant. Arora looks back with satisfaction at the last 50 years of rail making in Bhilai: from the humble beginnings in 1961 when the mill produced a rather slender looking 45 kg/m rails to current plans for installation of a new universal rolling mill in 2013. For him, this is a long journey that any steel mill in the world can be proud of. Now in its golden jubilee year of its rail rolling efforts, Bhilai has supplied more than 16 mt of rails to systems in India and customers across the world. Bhilai engineers point out that, if the rails they have supplied so far could be virtually assembled, these would circle the globe almost 10 times. Railways in India are today dependent solely on Bhilai production and the role that a new 1.2 mtpa universal mill will play in the forthcoming SAIL capacity expansions cannot be over emphasized. A modest export of 0.7 mt has been made so far, including 50000 t under way to Sri Lanka right now (through IRCON).

V K Arora, CEO, SAIL's Bhilai Steel Plant

## Up and downstream integration

Arora indicated that SAIL is now in the process of tying up for supply of ores / coal for future expansion plans. Recently a memorandum of understanding has been signed with the Governor, Central Kalimanthan province, Indonesia for development of mineral deposits, setting up of mineral processing facility and required infrastructure. This will be a joint venture between major Indian public sector units SAIL, Coal India, Rashtriya Ispat Nigam, National Mineral Development Corporation, and National Thermal Power Corporation.

SAIL has also recently signed a memorandum of understanding with the IR-PSU IRCON for development of an end-to-end solution provider in track laying and renewal. Arora explained that this will add a new business segment to SAIL rail portfolio and generate an assured off take from its universal mill. This joint-venture will have full solution capability for new tracks and will include a complement of machines for tamping, ballast cleaning, sleeper and rail renewal, track stabilising, switch tamping and in-service ultrasonic testing.

## The early years

Bhilai Steel Plant was set up in collaboration with Russia in the days when each such plant was hailed as a temple of modern India. It is no wonder that the then Prime Minister Jawaharlal Nehru inaugurated the rail mill in 1961. Bhilai has had the distinction of being reckoned as the best integrated steel plant on 9 of the 16 occasions. With a current capacity of 11 mt of saleable steel, the plant will accelerate to 20 mt after current ambitious expansion plans take shape. For the Railways this is a healthy stream of traffic requiring about 100 mt of material movement: 80 mt of raw material and 20 mt of finished product.

Appropriately in its 50th year of operation, we were fortunate to get a detailed perspective from SK Rastogi, retired Dy. General Manager, who was involved in the formative years of the mill way back in 1960s. Rastogi's indirect, though silent, contribution to railways is difficult to disregard. Rastogi and his team were trained in Russia including in the mills at Tagil and Yekaterinburg, the latter in the foothills of the Ural Mountains being infamous for the secret burial of the last Czar Nicholas II and his family in July 1918. Rastogi traced the evolution of the mill indicating that the original mill was similar to the ones in Russia. Some engineers were trained in plants close to Siberia and have been hardened by the extremes, rendered fit for the tough working in a steel mill.

Bhilai product range is systematically displayed on entry to the mill in a collage of cut sections and includes rail profiles of 52 and 60 kg/m, currently used by the Indian railway system (rails are rated by their weight in kg/m). Other profiles produced in the past include UIC 54 and Z U 45 E1. The plant also produces the hefty looking asymmetrical Z U-1 60 rail profile that is used in the points and crossings on rail tracks. Rolled sleepers for rail crossings were produced earlier but the current preference for concrete sleepers in all locations has made this redundant.

With a 1200 work force in the rail mill, the highest production achieved was in 2008 when around 0.8 mt of rail were supplied mainly to Indian customers. The order book in 2009 and 2010 has not been too healthy with production limited to 0.7 mt. This contradicts IR forecasts of higher investments and accelerated construction of new tracks. Lesser rail means lesser new construction and this pointer is not too reassuring for IR's promised capacity increases.

## The process

Starting with production of 13 m length rails in 1960s the plant is now gearing up for delivery of up to 260 m flash butt welded rail lengths. These long rails are produced by in-house welding of suitably length controlled rails. Rolling longer lengths and flash butt welding reduce the number of onsite alumino-thermic joints required as well as overall costs. The impact on reliability and construction costs is immediate particularly as on-site well joints using Thermit welds have a long history of in-service failures with sometimes disastrous accidents.

The process of converting cast billets into rails was detailed by B Sengupta and A K Saxena, Plant Managers. If you have a few hundred horse power at your disposal and a reasonably rigid machine that can make drumsticks

out of steel, rail making is the easiest job going. That is what it sounded like till one got to see the real scale of o perations.

Steel is first produced in LD converter, with the ingredients controlled to give required chemical composition. Starting with manufacture of ingots from Basic Earth furnace, Bhilai shifted to production from LD converter – Concast route in 1987. Sengupta emphasised that a critical requirement for high quality steel is that nonmetallic impurity as well as hydrogen gas content should be reduced so as to eliminate in service fractures. With a nonmetallic inclusion count of less than 1.5 (as defined in standard specifications), the product also requires a hydrogen content of less than 1.5 ppm. This is a demanding requirement for which action was initiated in 1998 when the plant achieved less than three ppm. It took the plant sometime before stabilising to less than 1.6 ppm in all heats in 2003. On line spectroscopy ensures accurate dosing and control. Each melt produces around 120 t of high quality steel. Vacuum degassing removes nonferrous impurities that emanate from furnace linings and the steel making process, besides reducing gas content. Saxena explained that without degassing, hydrogen content may range above 3 ppm but degassing ensures consistent gas levels below 1.6 ppm considered acceptable for top service performance. The continuous casting process generates 4 t blooms.

These blooms are heated to around 1300$^0$C in the 3 coke oven gas fired furnaces, of which each can store up to 90 blooms. A heating time of around 5 hours ensures a good malleable product ready for the "spaghetti making" rolls. The "spaghetti" making occurs in multiple stages, first in 7 passes in the roughing mill and then in the three-high mill. Not surprisingly, this is tough on the rolls that have to be skim -machined continually after just around 3000 t steel has been rolled.

By the time the last roll gets to work, the steel has cooled down to around 900 C. Each bloom can produce about 70 m rail that is cut into appropriate lengths by a mechanical saw. Quality assurance requires that each melt, bloom and rail is tagged and tracked. This is done by roll stamping melt particulars and date during the processing. This is almost like the markings on your milk carton except that steel is tougher to get lasting imprints on.

*The Bhilai Rail team : from left S C Paul, GM, B Sengupta, Dy. GM, Rastogi, Ex. Dy. GM, S C Mehra, GM, A K Saxena, Dy. GM and A Mairel, Dy. GM*

### Bending to straighten

Dough making does not produce straight rails as the section, not being uniform, cools differently and the rails tend to take on longitudinal distortion. This is corrected into a predesigned camber so that on cooling the rail is straight: as little as 0.4 mm over 2 m length. This is checked on- line by a laser measuring machine: modern technology makes things difficult for process quality people. And if some straightening is still required, the SMS Meer cold straightening mill, with its 7 horizontal and 6 vertical rollers, takes care of that. Earlier about 75 % of the rails used to be drilled for fixing fish plates but long welding of rails has now eliminated this need.

### Getting better and stronger

The current rail finishing complex was commissioned in 2001 with the long rail finishing facilities for 26 m in 2005. The new universal rail mill planned for commissioning in 2013 will be capable of rolling 135 m long rail lengths which can be partitioned to required sizes. The roll configuration will include breaking down stands followed by a tandem reversible mill.

This mill is being sourced from SMS Meer, the well known German heavy machinery manufacturer. The entire set up will include a walking beam furnace, cooling bed and a new plant consisting of biaxial horizontal and vertical cold straightening. Besides helping reduce the current high rate of process rejections, the new equipment will have the added advantages of provision of quick changing devices, practice proven and reliably built plant components, in-house computer-aided role pass design and, above all, the ability to produce at a higher pace. With a roll changeover time of just 20 min, the advantages for flexible manufacture are obvious.

The new process has added advantage in as much as the billet will be roll formed from all four sides helping in reduction of inner stresses, smoother rail surface and closer tolerances of the rolled form. It is expected that there will be drastic reduction of roll wear due to reduced friction between the product and the rolls. In current production faster roll wear results in significant out of tolerance product and consequently a very high rate of rejection. This will be supplemented by OVIS (Optical Visual Inspection System) that will soft check any surface defects like nicks and dents, leaving a rail with a "blonde like" surface. For Rastogi and other engineers of his group the new universal mill will be a sea change from what they started with. For them many of the technologies now in place are dreams come true. They bring their expertise to the benefit of railways.

### Harder rail table

Increasing tonnages on railway freight stock as well as the need to reduce rail wear requires that the rail table surface in contact with the wheel is of higher hardness, an impressive 380 BHN on the surface and a little softer inside. The new line will have a selective cooling facility for rails in upright position.

Rail head hardening technology is available to limited manufacturers around the world. The SMS technology employs selective cooling that organises the rail temperature profile, minimises residual stresses and improves rail straightness that is critical for finally achieving track tolerances required for modern high-speed tracks. The head hardening process includes an induc-

tion heater to equalise the temperature profile over the length of the rail and also increases the temperature from around 750 to 850$^0$C . Bhilai produces its rails mainly in accordance with Indian Railways specification IRS T 12. The steel required for such hardened rails will have higher carbon content, up to 0.75% from 0.65%. Top surface hardness peaks at 390 going down to 340 BHN 10 mm below the surface.

The new equipment will have automatic visual and metric measuring lines that include a waywardness testing device, rail profile gauge, eddy current and ultrasonic testing with defect marking stations. Existing lines of course also use ultrasonic and eddy current testing features that are required for finding any defects on the mass of rails produced. VK Arora indicated that the entire upgrade will cost around ₹ 2 200 Cr including about ₹ 1200 Cr for the main package from SMS Meer.

Handling a 130 m long rail section is an interesting exercise that captivates a lay person. The rail welding complex will have capacity of 1.1 mtpa The welding line process will start with input from the rail mill, a brushing unit area with two brushing machines, 2 welding machines, 4 grinding machines for the welding flash, 4 Jack press straightening machines and finally a dispatch area for 260 meter finished rails.

### Developments over 50 years

The 50 year Bhilai journey that began with 45 kg/m rails in 1961 has included the development of 52 kg/m rails early on. Physical strengths of the rails were improved in the upgrade of tensile strength (UTS) from 72 to 90 kg/mm2 in 1983. Also around this time the plant developed 60 kg/m rail that was considered necessary for higher tonnage freight traffic. The plant has already designed a 68 kg/m rail profile for use in the 30 t axle load on dedicated freight lines planned in coming years. Recent development efforts have included production of low alloy rails for higher corrosion resistance of which about 8000t are already in service, mainly on the South Central Railway. The plant hopes to complete the order by rolling 2000t more in coming months. Other efforts have included Copper-Chromium alloyed high strength rails, high yield strength/ UTS vanadium micro-alloyed rails and high conductivity rails for third rail power supply in metro systems.

### Quality issues

Railway systems in India are plagued with high incidence of rail and weld fractures that can have occasional disastrous consequences. Various measures taken to control such fractures have mainly included higher insistence on flash butt welded rails in place of at-site alumino-thermic welds as the latter have much higher incidence of in-service failures. (Better in service testing of rails for incipient flaws through ultrasonic and eddy testing has received much research effort and current technology trends were reported in our November issue). The role of steel mill in ensuring better metallurgical quality of the rails is a foundation on which such service improvements can rest. It is of concern that the internal rejections of rails in Bhilai are at an uncomfortably high level, necessitating a complement of about 100 online inspectors provided by third party inspector RITES. It is understood the rejections are mainly on account of uncontrolled dimensional tolerances. It is likely that with the commissioning of the new mill this battery of third-party inspectors will no longer be needed and IR can significantly reduce incidence of in-service failures.

RB

*Wooden rails and mining cart from a Romanian silver mine, around 16th century (Photo courtesy : Clemens Kirchner, Deutsches Technikmuseum, Berlin)*

# Rail ways: as old as Mohenjo-daro !

Over a million route km of railways exist in the world today. But we could begin in Babylonia of 2245 BC.

The earliest evidence of pathways using rails ("rail ways") can be traced as far back as the Belus ruled empire. Stonemasons then had built imperial roads consisting of two parallel lines of stones, three cubits (5 ft) apart to run vehicles while being pulled by mules and horses, walking down the centre of the track. Such rudimentary tracks, without vehicle guidance, were navigated by the driver's instincts. Later, when Aristophanes was alive, around 400 B C, Greek ships were pulled across the Cornith isthmus on wheeled cradles, which travelled on 5ft 4in rail gauge with independent guidance to remain on rails without human interference and with loops – *ektropoi* – so that vehicles may pass each other! The ruined streets of Pompeii too have evidence of guide rails but it is not certain whether these were constructed intentionally.

A prolonged "rail-less" interval until around twelfth century followed, when German miners started to scrounge central Europe for exploitable seams of metal ores. They often used wooden rails to push their small trucks into the mines (illustrated in the book De Re Metallica, 1556). The first documented railway was the 1603 Wollaton line, near Nottingham, that transported coal from a pithead till 1790. (contributed by Saibal Bose).

# Eastern Railway: the Kolkata soul mate

Think Calcutta: the overfilled streets. The hidden magnificence and style of buildings on Dalhousie (BBD Bagh) and the Esplanade. Trams with museum-style technology running empty even at peak times. Suburban trains teeming with passengers jostling for space and carrying the much delayed government employees. The many languages you can hear at Howrah railway station. The red and green festoons of the political parties. Discourses in *adda* groups. A million images of a city of 10 million or more, images that define the range and complexity of the Eastern Railway. Housed in the iconic Fairlie Place, this railway provides almost a billion passenger trips every year, typically a trip for each Indian, with 85 % suburban passengers mostly on the Howrah and Sealdah terminals. ER delivers services that are busy at the seams, running an impressive 174 long distance passenger expresses every day. Kolkata and ER share their dreams, their problems and their future.

Railways came to Eastern India when the first train ran from Howrah to Hooghly on 15th August, 1854: perhaps the 15 August date symbolizes the oft repeated saying "what Bengal thinks today, India thinks tomorrow". Since then, after many reorganizations and milestones, ER is now a premium Zone with 2452 route kms, 4211 track kms, 1710 trains per day, 547 stations, 3 major workshops and 1.3 lakh employees. Kolkata has bagged IR related headlines in recent years and the ER management is today in the forefront for delivering new railway projects for network expansion, enhanced passenger facilities and a host of manufacturing units: ER could set up new bench marks for other zones. It is a result worth watching for.

Revenue streams include ₹ 3315 Cr form freight services and ₹ 1460 Cr from passenger services. Prior to creation of the new zones, ER included the coal rich Dhanbad division but now coal sources are mainly centered in Asansol Division. A respectable 42 mt is handled every year with coal at about 35 mt. ER needs to add capacities and ease traffic flows particularly around Howrah but is , not surprisingly , restrained by the funding.

### Passenger services at the core

The coming summer months will see India on the travel, to holidays, to examinations, to join marriages and other celebrations, to spend the resources of a preceding harvest and trains will be full, so full that it would be normal to see long distance trains overflowing with passengers. As the Indian summer special trains come in, ER ingenuity and resources will be taxed for addition of 168 special long distance trains, offering 118416 extra sleeper seats and still facing the heat. Popular routes lie towards Delhi, Nainital, Darjeeling, Nepal and Bihar. Considering that passenger services are subsidized from freight earnings, it is not a management paradox that a zone with overbooked services runs at an operating ratio close to 150 %. Also the more services they provide, the more their metrics deteriorate. Incredible India!

A recent effort to improve stations has been to provide upgraded facilities through the Adarsh (ideal) initiative,

*Belur symbolises the improved station facilities at 178 stations*

and ER is in the process of improving 178 stations. Starting with better paint and broom jobs, the second phase will concentrate on brick and mortar additions. ER will complete 20 stations this month that include the remarkable architecture at Dakshineshwar and Belur Math, pilgrimage sites on the banks of the Ganges associated with Saints Ramakrishna and Vivekananda. A more long term approach is the setting up of multifunctional complexes involving better facilities and some commercial businesses at 25 railway stations with 2 stations targeted this month.

Ticketing delays at stations are a common sight and IR has responded by computerizing ticket issues at all stations by linking these with optical fibre network under the Unreserved Ticketing Platform (UTS), with ER providing more than 370 such locations. Kolkata Passenger reservation system now has 756 offices, spread over six Zonal Railways, 9 other locations serving 16 states and serving Andaman & Nicobar Islands and one at Thegu in Sikkim, world's highest ticketing outlet above 4000 m.

In a revival of an old idea of door step ticketing, a mobile ticketing van called Mushkil Aasan ("eased hardship") plies Kolkata, handling about 2500 reservations requests per month ( ₹ 17 lac). This of course is a small fraction of the total summer traffic but caters to clientele with limited mobility and literacy. An initiative that needs to be monitored and nurtured.

### Suburban services

The pressure on suburban services is acute and has been sought to be addressed by increased frequency in peak hours and longer train lengths. Sealdah and Howrah Divisions handle 1184 trains every day, ranging between 9, 10 and 12 car train sets. Progressive migration to 12

Varun Barthuar, General Manager, Eastern Railway


*Reflecting the best in Bengal architecture: the enhanced Dakshineswar station*

car services requires lengthening of platforms and access facilities at some stations and additional cars. Limited at present to 153 train sets, ER hopes that the increased production capacities in coming years will permit better frequency and car length increases.

### New railway factories

- Loco component factories at Dankuni: some of the projects like the IR funded ₹ 250 Cr one for manufacturing diesel locomotive under frames and machining engine blocks for DLW Varanasi have made progress on the ground. The other Dankuni facility as an ancillary to the Chittaranjan Loco Works is planned for the PP route and hasn't seen any ground level activity yet.



- Kancharapara: a new EMU factory is planned with a capacity to manufacture 500 EMU/MEMU coaches per annum. It is intended that this factory in the PPP/JV route would enable manufacturing of lightweight stainless steel EMU/MEMU coaches with 3 phase IGBT propulsion and regenerative braking. Investment is likely be around ₹ 2000 Cr and IR has so far pre-qualified eight companies / groups for bids that have not been called for yet. International bidding has attracted majors like Siemens, Bombardier, Alstom, Stadler, Hitachi, Kawasaki, Rotem, Hyundai, ABB and CAF (Spain). Indian manufacturer TEXMACO is a part of the bid with Kawasaki while Titagarh Wagon has teamed up with Stadler and ABB. This is a long lead and big ticket project but the bid papers are waiting for what has been termed as "due diligence", perhaps a euphemism for "waiting for somebody to take a big decision". The purchase model in this bid would be a benchmark for other such initiatives for locomotive and other factories announced by IR which are also stuck for "due diligence".

- Bogie Manufacturing Factory : A ₹ 60 Cr bogie manufacturing unit , as an added part of the Punjab based Rail Coach Factory, is now taking shape at Budge Budge, around 30 km south of Kolkata. RITES has been entrusted this project for turnkey execution and ER will provide local coordination

- Wagon Industry at Kulti: RITES and SAIL have signed an MOU brokered by IR for a wagon manufacturing facility at the premises of SAIL Growth Works, Kulti near Asansol. This would manufacture 1200 Wagons per annum (plus rehabilitation of 300 wagons). A JV is reported to have been formed with ground work likely in coming months.

### Project profiles

ER has a large number of extensions and links spread around the system. Progress of new lines has been better than before with some projects still steeped in local indecision including for land.

**New Lines:** ER has already commissioned the 5 km line between Tarakeswar and Talpur and 17 km line between Bishnupur and Gokulnagar of 55 km long Tarakeswar-Bishnupur project.

- The 66 km long Deoghar-Dumka new line project is expected at the end of this fiscal.

- 65% progress is reported on the 112km long Deoghar-Sultanganj project and 55% on the 130km long Manderhill-Dumka-Rampurhat new line project.

- Other important works include restoration of Azimganj-Jiaganj line with a major rail bridge over the river Bhagirathi and the Canning – Bhangankhali line under which a mega railway bridge over the river Matla is being constructed.

As Kolkata changes in coming years regaining its status for premier economic activity, ER will evolve too, gaining from current efforts in various spheres. Soul mates will march together. RB

# When "mechies" bounce, swing and yaw: the IRSME Day

The 1927 founded Indian Railway Institute of Mechanical and Electrical Engineers (IRIMEE), Jamalpur (JMP) , a professional railway training setup , celebrates its foundation day on Feb 14 e very year . Engineering graduates, including Mechanical, are recruited through a difficult Union Public Service Commission competitive examination but IR trains its own apprentices (SAM's) in Mechanical Engineering. The two recruitment streams have had a sometimes difficult coexistence in post independence years, a sort of low level management strife based mostly on perceptions and hearsay and occasional indiscretions by immature officers. Over the years an internal debate, sometimes objective and often times emotional, has lingered on whether IR need to continue with the scheme of special class apprentices as adequate mechanical engineering graduates are now available and the UPSC route of recruitment should be the sole route, as is prevalent in other streams on IR. Both sides have compelling arguments but decisions have often been swung on the need to keep "Jamalpur alive". One stream of thought would have JMP becoming a premier in-service training institute only. The debate shall range for some more years.

*Table Tennis Champions separated by 3 generations: R C Sethi (1951) greets Rohan Singh (2007)*

In a bold step, S Dh asarathy, then Member Mechanical in IR Board, directed in 2001 that 14 Feb would in addition be celebrated as the IR Mechanical Engineering Service (IRSME) Day. Various events besides traditional dinners all over the IR system mark the IRSME Day, a unique happening in the IR calendar.

Started as technical school in 1888 attached to the then mammoth Jamalpur workshop, IRIMEE has been training graduate engineers since 1927 .That was a period when other options were limited and training in England could be the most expensive option. One cannot help quote RR Bhandari: "Report for 1925-26 stated that selected candidates will undergo a course of training in Railway workshops for a period of 3 years followed by a 2 year higher Mechanical Course in the Bengal College of Engineering, Shibpur, or a further 2 years' practical training in Running Department …" For the first time the term "special apprenticeship "was used.

That the training was always not very effective was narrated in an anecdote by SN Mahant. It seems that a national boxing champion Laurie T Carr was recruited and continued to care more for boxing than engineering. Laurie was asked in his training interview as to various methods of manufacturing nuts and bolts and, after some considered thought, replied that the only method he knew was by foundry. Laurie was promptly removed from apprenticeship and seconded to be the hostel warden.

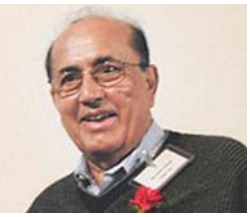
**Jamalpur: centre of IRSME earth**

As you cross the Rajmahal hills through a rail tunnel, the feeling is that not much could have changed since the 1920's except that the scars from quarrying on these hills have gone up. The upper story of the original double story hostel was lost in an earthquake in 1934. But as one interacts with the faculty and trainees changes come to the fore. For one the premises would look much swankier than in the early years. The halls and the gymkhana still reverberate with old boys' stories of methods employed to skip classes and workshop sessions, of the SC Misra days when trainees were a harried and helpless lot, of old tussles on the "battle grounds "of football and cricket , of the room service personnel like barbers and washer men now long gone. Young trainees these days dance more energetically to Bollywood numbers unlike their counterparts from the 1940's who were more likely to learn the ballroom and waltz options. PC Sen (1949) dominates whatever happens in the gathering and the rooms rebound with the booming laughter of SN Mahant (1951).

The IRIMEE day coincides with Valentine's Day but any coincidence is purely accidental as the first batch of trainees arrived in JMP on Feb 14, 1927. Among the guests this year was Hazel Ward from England whose India born father, VMS Bailey, retired as the second principal of the School. Hazel is attracted to Jamalpur as she retains vivid memories of her childhood: born in JMP in 1941, she makes it a point to visit her childhood home. One of Bailey's students reminisced that Bailey thought that "Jamalpur converts naughty boys into gentlemen". This very British concept of training engineers has distinguished SAM's for better or for worse.

Then much has changed in the way young SAM's look at their careers: an often asked worry is whether railways

*The 4G-2009 SAM batch left to right:*
*Rakshita Bagherwal, Anshu Priya, Smriti Rao and Aastha Sneha.*



remain a good career option. That thought would never have crossed the mind of SAM's in the middle of last century. Of course some trainees who left IR for different fields have done well. Of them Arjun Israni (1961) has specialised in management of innovation. Israni left IR in 1969 after a stint as Asst Mech Engineer at Ratlam and now, after an executive MBA from Stanford, is currently with National Semiconductor USA. He presented his thoughts on innovation management, being fairly stringent in his comments on lack of an innovation supportive culture on the IR. The most illustrious of these "repats" is RK Pachauri of IGPCC, the UN environment body that shared the Nobel Peace prize some years back. Pachauri was to attend the events on 14 Feb but was prevented by an injury. His video address to the gathering is easily the most reportable highlight.

IRIMEE now has an ongoing arrangement with BIT Mesra for teaching and certification of its special class apprentices. The effort in this direction was initiated some years back by Neeraj Kumar, currently Director General in IR's Railway Staff College, Vadodara. It is with the purpose of improving training expanse that IRIMEE has now entered into an MOU with Queen's University Belfast and a batch of apprentices has had a useful visit and interactions already. In service training last year was imparted to 225 persons, not an impressive number when looking at the about 1990 strength of in-service IR mechanical engineers. IR needs to look closely at training needs particularly as evolving technologies are inducted even more rapidly. Recognizing system expansion needs and that attrition rates will go up in coming years, a positive trend of induction of larger number of trainees can be noticed. The young batch of 2009 is 25 strong including 4 lady trainees signifying changes in Indian society.

### Strong on tradition

Tradition is being kept alive in Jamalpur as young trainees brighten the days for "old hands" by meticulous attention and retention of events like the rickshaw race. Of course each of the oldies tries to find his soul mate in the favourite spot during his apprentice ship. This could be the now defunct swimming pool, or the favourite bunking story or a long gone attendant. Pankaj Singh tried to locate his favourite rock atop the Kalipahari hills where he would retreat when learning engineering became a bore. Locating the rock proved difficult due to indifferent construction in his "hide spot". But his 9 year old son was impressed by his father's choice.

The K C Lall Seminar on 13 Feb was enlivened by PC Sen, a regular at the Institute, who traced the origin of the word manager to menagerie one for training horses. Among the speakers were RC Sethi, SN Mahant, S Sengupta and SA Singh. But if there was a slip it was more because of retained habits: none of the events mentioned IRSME Day specifically.

### Other locations

BNR club, one of the best river side properties on the Kolkata Hooghly (Ganges), planned for a technical seminar and fun-n-games. Unseasonal showers restricted the games but could not dampen any banter or the spirit of fun. The technical seminar had contributions from P Ramachandran and S Nath (Talgo Spain) besides concluding comments from Shakeel Ahmad on IR's slow PPP efforts. Legwork for the events was by S Birua and G Sumana.

The Chennai event like many others was held on 19th Feb with a forenoon seminar on new developments in coaching materials .The senior most officer present was K P Jayaram, SCRA '42, who at 87 years retains the erect gait and tall presence that marked his years in IR. S Dhasarathy, S Kasy Iyer and the recently retired NS Kasturirangan were amongst the host of seniors who attended.

Patna: The unmistakable KP Rao, CME led the arrangements with assistance from AK Chandra, Vinram Mishra and Aman Raj. RB

*Photographs show S N Mahant, P C Sen, R N Aga, Navneet Singh, Pankaj Kumar, Arjun Israni, Ranjit Gupta, S C Sengupta and Hazel Ward*

# What they do not teach them

- Every pipe is to be hollow throughout the entire length – do not use holes of different length than the pipe.
- The inside diameter of a pipe must not exceed the outside diameter – otherwise the hole will be on the outside.
- All pipes over 150 m in length or over 2m in diameter should have the words "LONG PIPE" clearly painted on each side and end, so the contractor will know it's a long pipe. Pipe over 3 km in length must also have the words "LONG PIPE" painted in the middle so that a workman will not have to walk the entire length of the pipe.
- Flanges must be used on all pipes. Flanges must have holes for bolts, quite separate from the big hole in the middle.
- Specify whether you want level, uphill, or downhill pipe. If you use downhill pipes for going uphill, the water will flow the wrong way.
- All pipes shorter than 3 mm are very uneconomical in use, requiring many joints. They are generally known as washers.
- Joints in pipes for piping water must be watertight; those for compressed air, however, need only be air-tight.
- Lengths of pipes may be welded or soldered together: not recommended for concrete or earthenware pipes.

(Contributed by Lalit Tejwani)

# A SAM's vision for IR and Jamalpur

**(This is an extract from Dr R K Pachauri's video message on IRSME Day 2011)**

### Environmental concerns

The overall interest of the nation is to bring about a major shift and technological revolution by which we use the resources of this country as efficiently as possible. It is certainly a matter of great regret and disappointment that over the years the share of rail traffic, both passenger and freight, has actually been going down and the share of road transport has been going up. This is clearly not a sustainable situation. Because we have a serious challenge of energy security and if we continue with this trend of greater and greater road transport, both passenger and freight, we are essentially increasing our dependence on oil imports. A detailed exercise that my Institute (TERI) has carried out, using fairly sophisticated modelling techniques, clearly shows that if we continue on a business as usual path then what we would find is that twenty years from now, this country would be importing something like 750 mt of oil per year and almost 1300 mt of coal. It is a myth to believe that India will remain self sufficient in coal for all times to come because that's certainly not going to be the case. So energy security is one major issue that we need to be concerned about.

We will have no choice but to ensure that our growth and development takes place through moderation of the emissions of greenhouse gases. And in the transport sector, clearly a shift to road transport really means an increase in net emissions per unit of transportation that's provided. So this is where the Railways have a major advantage and this is an advantage which has not been projected adequately either for the benefit of our policy makers or for the implementation of schemes whereby we can bring about major technological upgradation of the railways.

### New role for Jamalpur

If we really want to create an intellectual resource that supports the training of those who are passing through the portals of this Institution, we have to ensure that there's adequate research which is carried out in the Institution. If we were to create the Institute at Jamalpur into a resource where we carry out detailed research essentially of a software variety and based on policy analysis leading to technological assessment and analysis of options in the future, it would be a great benefit to decision makers. And those technologies don't necessarily have to be developed in Jamalpur, they could easily be developed by RDSO, we could make choices in terms of outright purchase of technology that would suit the interest of the railways.

Traction technology is changing very rapidly. We also know that the whole framework within which rolling stock is designed is changing rapidly. There are newer materials, there are new techniques and there are new methods whereby we can ensure the design and production of good rolling stock. Now all of this in my view needs to be assessed and I think if we were to do this in Jamalpur then for one thing it would raise the profile of this institute, it would be regarded as a serious technological think tank that could not only help the railways but the government and the society as a whole. There's no getting away from the fact that this is an Institution that has produced persons of enormous calibre and excellence who have clearly made a great difference to the running of the railways, to the expansion and modernization of the railways and also several other sectors of the economy.

### Wide career options

Many railway officers have gone to the other sectors of the economy. I myself am an example; I have been able to do very interesting things, stimulating things to me at least throughout my life only because I had the basic education and the culture that I imbibed in Jamalpur that has carried me through a whole lot of experiences in life.

I think this could really become an establishment where we carry out research and development on traction technology, on rolling stock technology and this of course will have to be done by keeping abreast of developments all over the world.

It is critically important that we refurbish and we revive the knowledge of those who are in positions of decision-making at different levels of the Railway establishment. It is not enough to just carry out training at Jamalpur in the initial stages and expect that people will learn throughout on their own. I think what you really need is an institution like Jamalpur that could carry out post-experience training at different levels of the organization.

And the final point that I would like to make is the need for networking. You cannot have institutions today living in isolation. It's not necessary that you link up with the IITs, it's not necessary that you link up with other railway institutions but I would say that it is extremely important for Jamalpur to have MoU's, to have agreements with institutions in other countries.

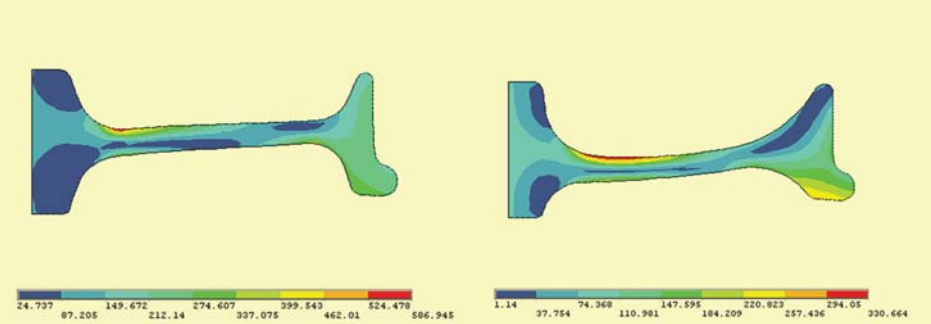
The challenges ahead are enormous and growing very rapidly and I have no doubt with the strengths, with the history, with the tradition that Jamalpur has, IRIMEE will be able to rise to the occasion and really perform yeoman service for Indian society in the years ahead. However I shall come to Jamalpur very soon, I hope on Club Day next year if possible. RB

Pachauri was born in Nainital, educated at La Martiniere College, Lucknow and at IRIMEE in Jamalpur. He belongs to the 1958 Apprentices Batch. Pachauri began his career at the Diesel Locomotive Works, Varanasi before deciding to pursue a different path. Pachauri was awarded an MS degree in Industrial Engineering in 1972 and a Ph.D. in Industrial Engineering and Economics in 1974. He was also on the faculty of Administrative Staff College, Hyderabad (1975-1981). His interest in environment has taken him to the pinnacle of policy making.

Dr. R K Pachauri Chairman UN's Inter-Government Panel on Climate Control and Director General The Energy and Resource Institute (TERI)

# Rail Wheel Factory: wheels of innovation

...R K Upadhyay




BG Forged Loco Wheel

BG Cast Loco Wheel (Cast)

Loading parameters: thermal load 25hp Vertical. load: 21.5t Time: 20 min

*Comparative finite element analysis of forged and cast wheels for locomotives*

The 1984 built Rail Wheel Factory (RWF) in Yelahanka, Bangalore started with a humble production of 5993 wheels, 4506 axles, and 1253 wheel sets in the first year. Successive efforts peaked in 2008 when production reached an all time record of 1, 96261 wheels, 64673 wheel sets and 84428 axles. These jumps were made possible by technological innovations and infrastructure improvement.

RWF uses cast wheels, a technology pioneered by Griffin, USA. In particular, several innovative steps during 2009 led to multiple successes. These included reconditioning of an old Arc Furnace, modification of ladle to hold 23.4mt up from 20t, reducing the automatic cycle time from 90 to 82 seconds per pouring, commissioning of a new ultrasonic testing system and a new boring machine.

Similarly, axle production was improved by reducing the radial forging machine cycle time from 310 sec. to 250 sec after carefully re-evaluating the impact of set up time. Simultaneous steps to improve process quality led to overall decrease in rejection levels:

- Systematic preparation and usage of ladle refractory.
- Ensuring adequate carbon boil to enhance steel cleanliness
- Monitoring mould temperature and preparation prior to casting
- Improved quenching of wheel rims by using booster pumps.

This increase in production becomes meaningful when viewed against the alternative of imports at increased costs and lead times. Some imported wheels proved to be substandard leading to wheel breakages in locos and associated problems in others. A very significant RWF achievement has been that none of its coach wheels has had a service failure like breakage or distress on run.

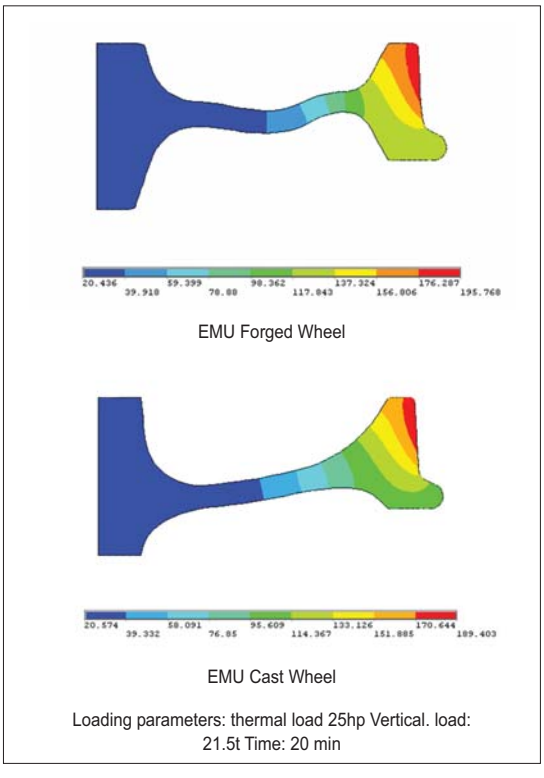
## New developments

With the setting up of a new wheel manufacturing "daughter plant " at Chapra, IR's wheel production capacity will go up later this year but demand has not picked up adequately due to slow progress of Dedicated Freight Corridor and lower wagon production. In view of limited forging capacity in SAIL Durgapur, other wheel types like LHB coaches, electric multiple units (EMU) & locomotives continue to be imported (about 40,000 forged wheels per year). RWF has used this lean demand period for developing and testing new wheel designs without any external transfer of technology or foreign assistance.

A cast wheel design for EMU was developed and sent for testing at the Pueblo test centre of American Association of Railroads (AAR). Original EMU wheels were of tyred design and the first replacements with forged solid multi-wear wheels were made some time in 2004. The RWF wheel passed all required tests and, in addition, AAR has acknowledged the superior metallurgy of RWF wheel as compared to other AAR class A wheels. The wheels have given satisfactory service so far. This wheel uses the same chemistry as for other coach and wagon wheels.

## $WDM_2$ Locomotive Wheels

RWF has designed micro alloy composition wheels for the 3600hp WDM range of DLW Locomotive. These wheels passed the TTCI/AAR testing and were put on field trials first on 1350 WDS6 class shunting locos and subsequently on other higher hp locos. The RWF wheel develops 44% less peak stress at 37hp input as shown by FEM analysis. RWF wheels will have greater resistance to gauge widening being experienced in other wheels.




EMU Forged Wheel

EMU Cast Wheel

Loading parameters: thermal load 25hp Vertical. load: 21.5t Time: 20 min

*Comparative finite element analysis for EMU wheel*

R K Upadhyay, General Manager, Rail Wheel Factory Bengaluru

FEA comparison of forged and cast wheels shows that there is a large stress differential in front and back rim fillets of a forged wheel, whereas the stress differential is comparatively less in the case of cast wheel. This stress differential results in creep causing gauge widening in forged wheels. By virtue of parabolic design of the cast wheels, comparatively thick mass available in the rim fillet acts as a larger heat sink during braking. Hence the thermal stress is also comparatively less in the case of cast wheels.

On satisfactory completion of limited field service trials, this design has been accepted by RDSO for unlimited service application. However, due to larger diameter and absence of bulk manufacturing equipment at RWF, production was constrained to 1000 of the first commercial order of 2000 wheels and these have been put in service. The micro alloy chemistry gave higher wheel wear resistance without proportionate increase in carbon and hardness. No cracks, breakages or untoward incident has been reported so far.

### LHB coach wheel

LHB coaches, originally of German origin and now produced in RCF Kapurthala, face a severe problem of wheel tread shelling due to which frequent tread turning is required. The problem has not been solved in spite of best efforts over several years. RWF has produced special micro alloyed wheels for these coaches which are on trial for the last five months. The intention is to develop an alloy which can reduce or eliminate the wheel shelling and limit wheel attention to intermediate overhauls only. FEM stress analysis has shown that the RWF wheel developed 14% less stress compared to forged wheel at 19hp input. Thermal stresses have been taken into consideration in spite of disc brake as shelling and spalling are often due to martensite formation by wheel skidding.

Since these trials have not yet concluded, it would be premature to predict the actual life of the RWF/LHB wheel but RWF is hopeful of a significant improvement.

### Reduced wear on coach wheels

A project to increase the life of coach wheels by micro-alloying, particularly vanadium, is now in hand. Additional alloying reduces the grain size without heat treatment, giving better wear resistance without increasing the hardness. Field trials so far have indicated about 30% less wear with the micro alloy wheels. These efforts to further improve the wheel life by better design are continuing.

### ABB and EMD Loco wheels

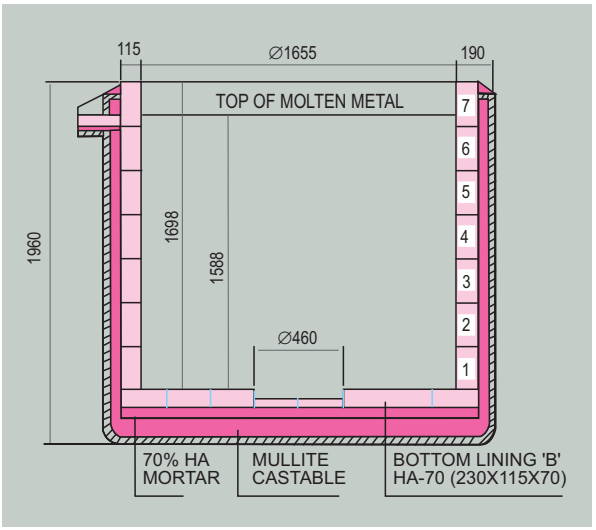
Wheels for high horse power electric (ABB/CLW) and diesel (EMD/DLW) locomotives are imported at present. Two designs for indigenous cast wheels for these applications have been developed and effort made to bring down the thermal Stress at 37hp thermal load input. FEM analysis shows that the RWF wheel has marginally 0.02% lower stress that is critical for reducing thermal cracking on braking in steep gradient sections. These wheel designs are now with RDSO for scrutiny and approval for limited service production and trial. These will be produced after sample testing and approval from a competent test house in India and abroad.

### Ingot casting for Axles

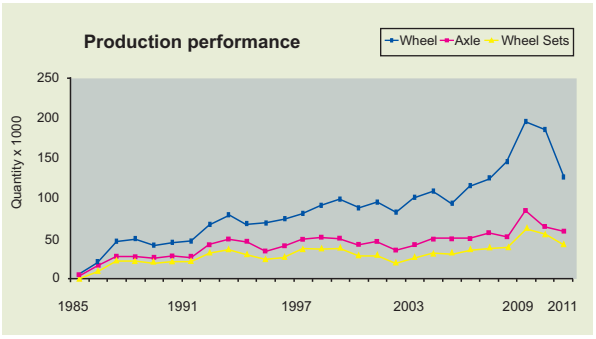
Efforts were also made to develop ingot casting for axles with a view to use surplus melting capacity in case Chapra production and lower demand limits the targets. In the beginning, considerable difficulties were faced due to uncontrolled ingot piping and led to higher rejection. However, with consistent efforts, the problems were over come and we were able to restrict the piping by use of exothermic hardtop and bottom discharge ladle for pouring. The axles made from these ingots were found suitable in all respects.

### Development of indigenous axle forging capability

IR imported around 15,000 axles a year. One radial axle-forging machine was lying out of order for long time at VISL/Bhadravati. RWF gave necessary technical assistance for commissioning the machine and VISL is now regularly supplying 1000 axles every month to RWF. Similarly, the Ordinance Factory at Ishapore was persuaded to improve its infrastructure and has started supplying 1000 axles per month thus restricting the need for imports substantially.




*Well type ladle lining with Mullite castable has increased metal capacity*




### Emission control

Hot metal ladles were being heated by HSD oil. Since a pipe line is expected in Bangalore in 2013, trials were made for replacing HSD oil with LPG. The results showed dramatic improvement in reduction of polluting emissions.

RWF has been able to promote variety and productivity by technical innovation, which will further help in making IR self-reliant and control costs.

Ladle pre-heating pollutnats

| Average pollutants ppm | | |
|---|---|---|
| | High Speed Diesel | LPG |
| SO2 | 42 | 13 |
| NOX | 143 | 93 |

RB

# Wagon prototyping: Kharagpur leads

...O P Chaube & S K Gupta

*BCNHL stainless steel wagons provide 34% higher train throughput on IR.*

The under construction Dedicated Freight Corridors will use wagons with higher axle-load (up to 32.5 t) and enlarged Maximum Moving Dimensions with an aim to substantially increase the throughput. There is also a need for railway systems to diversify freight services to capture non-bulk high-priced commodities such as automobiles. Introduction of bulk transportation wagons for bagged commodities e.g. cement can veer this traffic back to the railway fold. Railways also need to reduce cost of transportation through introducing new and varied wagon types with more profitable carrying capacities, higher speed potential, better braking and enhanced payload to tare weight ratio.

IR has thus far designed and developed its own wagon types, using private sector and its own workshops to manufacture these to its own approved detailed designs. The present wagon procurement policy does not give any incentive to wagon manufacturers for any investments in new designs (like assured purchase from that wagon manufacturer). For a 30 to 40 year product life and a developmental cycle of say 5 years for a new design, a number of product concepts need to be on the development cycle at any time. For various reasons, including lack of prototyping and development facilities, newer wagon designs are few and far between. Recent development of stainless steel wagon versions of the standard gondola (BOXN) and covered wagons (BCN), while a success in terms of bulk manufacture, has not been free of service problems. This shortcoming can be corrected by off-field development of wagon concepts and designs, before field running.

Development of any prototype is a time consuming and expensive proposition requiring multi-stage verification and prove out processes. Current technology permits software verification by virtual tools but requires highly skilled manpower to work with advanced software capable of developing 3-D models, simulated running, specialized machines for special processes, testing of the product which may require destructive testing and close interaction with the end-user throughout the development cycle.

The need for rolling stock prototyping has been a serious handicap for railway engineers and it is only recently that IR has decided to set up a Wagon Prototyping Centre (WPC) at Kharagpur. This ₹ 100Cr "Centre of Excellence for Wagon Prototyping" was a part of ambitious projects listed in the 2010 IR Budget. WPC will come up adjacent to existing Wagon Workshop using common facilities .

## Why prototyping?

Prototyping is an iterative process of building a model progressively leading to a final product. During the process of building, the prototype undergoes several modifications and refinements based on the difficulties encountered during the manufacturing process, test results during the trials and feedback received from end users. Prototyping is an essential aspect of any product development cycle and is used by most modern industries. New types of automobiles, for example, undergo a long painstaking process of gradual development with successive designs having to successfully pass through simulations and torturous field trials besides test marketing before being cleared for marketing.

Prototyping is an unavoidable "learning" process and, generally, an inefficient process relative to regular mass production process. Cost of producing a prototype is expected to be higher than the regular production process. Prototypes are essentially meant to reduce the subsequent risk of a design failure.

Prototyping comes in many forms: from low tech models made out of hard materials to high tech 3-D graphics made with the help of advanced 4th generation computer systems. Traditionally, physical modelling is cheaper but very cumbersome and time consuming and has limitations. With recent advancements in computer based modelling, analysis and integration of design process with manufacturing, it is now possible to cut short the development time drastically , eliminate delays in design developments and incorporation of changes without much hassles.

## Wagon Prototyping Centre

When developing a workshop for bulk manufacture of rolling stock, the design of the product is broadly known prior to determining the infrastructure. For a research and development facility like a prototype center, the endeavour is to finalise the infrastructure prior to the product that is going to be built subsequently. Broadly, the Prototyping Centre is expected to finalise the design, develop and test 2-3 wagon prototypes every year and then manufacture 100-150 wagons of each prototype for extensive field trial. After successful completion of the field trials, mass production is expected by the eligible wagon manufacturers. Thoughtful planning is therefore required while deciding the layout of the facilities, machine specifications, layouts, testing facilities, laboratories, design software: a bit of expert crystal gazing!

O P Chaube,
Chief Mechanical Engineer,
S.E. Railway

S K Gupta,
Chief Workshop Manager, Kharagpur

An added layer is the human resource requirement of engineering, software and other experts. Availability of such personnel in the Indian market is still limited and will pose a major effort.

A detailed plan has been finalized after some concentrated thought for SER Construction Organisation to proceed with. The facilities will include 2 manufacturing bays: one 225 m x 22 m, 9 spans each 25 m long bay for wagon manufacture. The span selection of 25 m is based on the maximum wagon length, which per IR's current schedule of dimensions is 21m. The second 165m x 18m bay will be for back up fabrication.

The thinking and filtration process for the machinery and plant requirements is now nearing fruition and specifications of some machines have been finalised. Expectedly new wagon designs will use stainless steel and aluminium and process development will count for these. A judicious combination of general and special purpose machines will allow flexibility as well as efficiency in the production process. Various fixtures and manipulators, required for fabricating under-frames and assembling of bodies, will be adaptable for wagons of varying length and complexity.

At the core of Prototyping Centre will be a team of experts willing to think beyond the obvious. Their imaginations will be supplemented with latest software having capabilities like solid modelling, assembly modelling, FEM analysis, motion simulation etc. The software will have the capability to integrate the designing and manufacturing processes. Computer aided design and manufacture will be a core process: IR's central R& D setup RDSO is in parallel upgrading its skill sets.

**AAR static tests for new wagon designs**

| Test | Purpose | Method | Measurement |
|---|---|---|---|
| Compressive end load for underframe | Rigidity and stresses under hor. loads at differing load conditions | Squeeze load by hydraulic jacks | Stresses by strain gauging and linear deflections |
| Coupler vertical loads | Stresses under lift on one end | Jack the coupler shank to release a bogie | Stresses and deflections |
| Offset track test | Clearances between underframe and bogie on curves | Offset track between two bogies | Linear clearances |
| Impact test | Structural strength under impact | Impact by another wagon on a ramp | Coupler and underframe stresses under impact |
| Jacking test | Stresses under lift at lifting pads | Jacking and strain gauging | Stresses |
| Twist load | Wagon body stresses on loaded wagons | Lift to get wheel clearance of 70 mm from rail | Wagon body stresses |
| Curve stability | Stresses on curves, using three wagons with test wagon in the center | Squeeze load on empty on a $10^0$ curve | No wheel lift, body stresses |

RB

# Development and test standards

...A K Banerji

IR is in uncharted territory for this prototyping centre. WPC has to play a very challenging role in delivering a product of enhanced capabilities. Very few other systems have a center of this type: nobody can perhaps match the American process and detail. Standardization of development procedures is still evolving and IR has as yet not formally adopted a detailed reference standard like the American Association of Railroads (AAR) M 1001 which details processes and verification stages for wagon development. IR has at various stages used elements of the AAR standards as well as various UIC, ISO, IEC and European standards for regulating development verification.

AAR M1001 details a well-defined definition of tests required for a new design. On receipt of a request for design approval the car construction committee determines the applicable category (A, B, C or D). Category A wagons are those that have major differences from in-service ones and require extensive evaluation of safety and operational aspects. Evaluation for this category is carried in three phases, with the first phase requiring all the specified tests. On successful completion wagons can be released for field service testing with the trial lot varying between 20 and 250 wagons. These wagons have to accumulate a minimum of 40,000 km each with not more than 50% of the run on empty haulage. The less severe tests are category B where only some of these tests need to be carried out. Category C wagons are those with minor differences from established designs that may have limited safety concerns and after only a limited number of tests, these wagons can move directly to the conditional approval phase. The least severe changes are in Category D with insignificant differences from conventional wagons and minimum or no testing is required for approval of such wagons. The work of the Prototype Centre can be said to be predominantly that of developing category A wagons which require complete range of tests.

The Prototype Center should have provisions for test facilities for conducting 7 static tests namely coupler vertical load test, twist load test, impact test, jacking test, track offset test, squeeze test and curve stability test. RDSO, as the approving authority, shall verify all these static tests within WPC .Subsequent field trials in dynamic conditions for studying the behaviour of wagon for pitching, bounce, yawn, rolling and swaying and braking tests will follow.

A K Banerji, Former General Manager, Central Railway

**AAR criteria for assessing track worthiness (typical)**

These AAR values are representative indicating a wider range of controls than currently followed by IR engineers. Newer criteria for prototype testing would need to be evolved to get better field performance from the new designs

| Regime | Criterion | | Limiting value |
|---|---|---|---|
| Hunting ( empty wagon) | Min critical speed | kph | 112 |
| | Max lateral acceleration | g | 1.0 |
| Constant curving ( empty and loaded) | 95th percentile L/V | 1.0 | |
| Twist, Roll | Max roll | deg | 6 |
| | Max sum L/V axle | 1.4 | |
| | Min vertical load | % | 10 |
| Pitch, Bounce (loaded) | Min vertical load | % | 10 |
| Yaw , Sway loaded | Max sum L /V axle | 0.6 | |
| Dynamic curving | Min wheel L/V | 1.0 | |

### Dynamic track worthiness trials

IR has a laid down standard under the "Criteria Committee report 2000" for determining on-run safety of a rail vehicle. Detailed oscillation trials with the instrumented prototype vehicle are conducted at progressively increasing speeds, up to 10% above the proposed operating speed.

In the absence of a test track, a test section conforming to the main line track standards in respect of track geometry, but somewhat in an inferior state of maintenance, is picked up for the trials. This assessment is based on a previous track recording and the selected test section should be such that 90% of the IR track is better than the section selected. Such a test section is required to include a straight stretch of about 1 km, a station yard and a 2 degree curve ( 820 m radius) of about 650 m length.

The test vehicle is instrumented to measure:

- Transverse and vertical forces exchanged between wheel and rail. The best method requires a Measuring Wheel but RDSO has so far not succeeded in this technology. Alternatively, the transverse forces are measured between the axle box and the bogie frame while the vertical forces are derived from spring deflections Measurements include:
- The transverse and vertical accelerations are measured on the floor of the test vehicle above the trailing bogie pivot.
- Relative body/ Bogie movements particularly the transverse swing of the bolster and the bogie rotation.

Basic transducers employed include Load Cells, Accelerometers and Linear Variable Differential Transformers. The assessment of stability against track distortion is based upon the transverse forces Hy exchanged between the Axle Box and the Bogie Frame: limit of Hy <= 0.85 (1 + P / 3) (P = Axle Load) is prescribed. The resistance to derailment through wheel flange mounting the rail is assessed from the ratio Hy / vertical load Q which should be less than 1. Transient forces lasting < 2 m in length or 0.05 seconds are ignored.

Trials are conducted both in the empty and the loaded conditions and normally include runs both with standard and worn wheel profiles.

The lateral and vertical accelerations are analysed to obtain the pattern frequency and the amplitude. While a maximum limit of 0.35g is commonly used, there is an approach now to veer away from maximum values to percentile value. Typically AAR specifies values for 95th percentile and IR will need to shift to this approach in future. Isolated instances where accelerations are recorded on account of response of the vehicle to a particular track defect are ignored.

In the absence of instrumentation for measurement of transverse and vertical forces at the rail level or at the axle box level, an assessment of riding stability is based upon evaluation of Ride Index (< 4.25 preferred). RI is a parametric assessment of rate of change of acceleration that measures human discomfort as well as "roughness" of a vehicle ride.

RB

# New diamonds on old tracks

...S K Jain & S N Agrawal

When two railway tracks cross each other, without grade-separation, a track diamond is formed comprising of two sets of acute and obtuse crossings. Discontinuity in running rails on both tracks has to be provided to accommodate flange way. Normal nonstandard diamond layout in the track poses severe speed restriction apart from other track maintenance problems. In order to overcome the problem of speed restriction, help smooth operation and to reduce maintenance efforts, an innovative design of nonstandard diamond has been developed, incorporating the concepts of one line running above the other line and flange supported travel. Though the initial cost is slightly high, but it gets offset very quickly by the recurring cost of maintenance and the indirect saving in the operational cost.

Main line track rail has been made continuous and the rail of other line has been raised by 25 to 35 mm for making the flange way. Approach ramps have also been provided to lift up the wheel by supporting the flange for transitioned traversing of wheel flange over the main line rail. The rail fixing is designed to isolate the main line rail from branch line rail to avoid transmission of forces and vibrations from one track to other. This has resulted in better speeds, safety & maintainability. Such diamond assemblies have been laid on East-West route between Mumbai and Kolkata about five years back.

*Experimental diamond assembly on concrete sleepers at Bhusaval*

## The geometry

In any Railway system, switching of trains from one route to another is an essential requirement. Normally, a route consists of double or multiple lines and at the approach to stations and major yards it becomes necessary to switch trains from one line to another line. Special track work called 'Turnouts' or 'Points & crossings' are provided if switching is required on the adjacent line. However, in multiple line sections, for switching of train not on to the adjacent line but to the lines beyond, the continuity of adjacent line cannot be maintained and a set of crossings forming the shape of a diamond are required to be provided . These diamonds consist of two sets of acute crossings and two sets of obtuse crossings. When the angle of crossing between two BG tracks is more than $6.75^0$, the wheel set while negotiating the discontinuity becomes unsupported in vertical direction and unguided resulting into severe impact on track and rolling stock. This necessitates a severe speed restriction, continuous maintenance inputs and frequent renewals. Such layouts are unavoidable in large rail networks handling mixed traffic.

The angle of the acute and obtuse crossings depends upon the angle of crossing of turnouts because generally the lines are running parallel. The turnout angles on Indian tracks are of 1 in 8½, 1 in 12 & 1 in 16 resulting in the diamond crossing angles of $6^0$ 42' 35", $4^0$ 45' 48" and $3^0$ 34' 35" respectively. Commonly, the wheel disc thickness is 127 mm, the required flange way clearance being 44 mm. These standard crossing angles above have been selected so that in all these layouts, some portion of the wheel tread remains always supported and at least one of the flanges remains guided. Therefore there is no need for any speed restriction in the normal direction on the intermediate track over which the standard diamond is provided. The speeds in the turnout direction are of-course restricted not on account of discontinuity of rail table but mainly on account of switch entry angle and curvature of lead curve.

## Limitations imposed

In addition, diamonds are also formed when two different routes intersect each other at surface. There are several locations where the routes intersect each other at an angle much larger than standard crossing angles and this results in situations where the wheel tread does not get support & has to necessarily drop in a gap and simultaneously remain unguided. Even with severe speed restrictions these track works require lot of maintenance efforts. Critical factors to be kept in mind while designing diamonds are: discontinuity of rail head and guidance to wheel flange. As the intersectional angle increases, the gap on the two rails is closer to the line perpendicular to the rails and thereby the guidance to the wheel flange is lost and a severe speed restriction is necessitated. A number of small rail lengths introduced at such crossings, connected to the sleepers by large number of small fittings, pose severe maintenance problems. Apart from the problems of frequent bolt snapping, loosening of packing due to hammering action etc., presence of such loosely held small rail lengths is undesirable.

## An innovative approach: Polaris

The diamonds can be eliminated either by providing flyovers or series of crossovers. However, both the solutions are very costly and consume restricted surface area. The diamonds, by themselves, are very efficient layouts from space considerations. In order to overcome such maintenance problems, an innovative design for the diamond has been developed with concepts of "one line running above another" and "flange supported

S K Jain,
Chief Administrative Officer (Con),
Western Railway

S N Agrawal,
Divisional Railway Manager, Nagpur,
SEC Railway

travel". The line carrying predominantly high speed, high density traffic (main line) has been made continuous and the other line crossing this main line has been raised slightly so that the wheels travelling on these non important lines, ride over the main line rail while crossing the main line track. For maintaining continuity of main line rail, discontinuity is to be created in the branch line track.

In order to accommodate the complete wheel disc and wheel play, a large gap of as much as 170 mm is to be provided. For safe negotiation of this gap, it is necessary to provide both vertical and lateral wheel guidance which is provided by flange supported travel and the check rails. On the approach of the discontinuity, the wheel flange is supported on a ramped check block provided along the chord line rail, which gradually raises the flange up to the level of the rail table on the main line. Wheel then travels on the main line head and again goes down on another ramped check block and comes to the normal position of supported travel. With this arrangement, a fully supported and guided movement is provided to the wheel while negotiating the discontinuity on the branch line. It also helps to avoid impact at the rail ends of the branch line track at the gap. The lateral guidance is further enhanced by providing suitable check channels. This innovative design has been named as 'Polaris'. The diamond assembly is location specific as design parameters depend on the crossing angle of the intersecting tracks.

### Run over concept

The concept of one rail running over another rail is similar to grade separation but instead of providing such separation in the full height of the moving dimension, the unimportant line is to be lifted only to the depth of the flange of the wheel so that flange way clearance is not required. Therefore, discontinuity in the main line rails can be avoided.

### Performance

| Location | Crossing Angle | MGT Main line | No. of Axles Branch line x000 |
|---|---|---|---|
| Bhusaval | 54°-12'-40" | 90.32 | 675 |
| May 2005 | 54°-12'-40" | 60.12 | 675 |
| Nagpur | 65° | 23.77 | 346 |
| Oct. 2005 | 65° | 23.77 | 335, |
| | 65° | 24.15 | 346 |
| | 65° | 24.15 | 335 |

On IR, the maximum permitted flange depth is 35 mm. Thus, the level difference of 32 mm has been created between the main line rail and the branch line rail, the branch line rail being kept higher. Packing plate has been provided below the branch line to create the required level difference.

The concept of run-over has been tried in a limited manner in the past in unimportant yards but has not been completely successful perhaps on account of lack of adequate detailing and designing. Due consideration was not given to the angle of crossing and it was tried on sharp angles of less than 120 which often resulted in derailments. The present design has been arrived after careful detailing and in depth study of rail wheel geometry and rail wheel dynamics.

### Flange supported travel

In the typical case, the crossing angle between the two tracks is $54^0$ 12' 40". A discontinuity of 170 mm has to be provided in the chord line rail. This gap of 170mm constitutes flange way clearance for main line track (40mm) and rail head of main line track (67 mm). The clearance required for the wheel disc on non gauge face side, dependent on the angle of crossing, comes to 63 mm with an angle of $54^0$ 12' 40". In order to mitigate this gap of 170mm without having adverse effect of hammering or battering on the rail ends as well as to provide properly guided movement of the wheels, ramps have been provided along the chord line rail on either side of the main line rail. These ramps help in smooth transition for transfer of load from wheel trade to wheel flange at the crossing. The wheel flange, after rising on the ramp, travels on the head of the main line rail and negotiates the gap provided for flange way clearance on the main line. At this point of time, the second ramp comes into the play thus providing a smooth exit without any hammering or battering of the rail ends.

### Support & fixing arrangement

Complete assembly is fixed on a specially designed base plate. The connection is so designed that the main line is structurally isolated from the branch line with the result, the forces and vibrations of the main line track are not transmitted towards branch line track and vice versa. The discontinued rail pieces of the branch line track are structurally connected through this base plate for a smooth transition and transfer of tractive and braking forces. This structural segregation of two tracks has resulted in better maintainability.

### Field implementation

Two such diamond assemblies, fabricated in Manmad Workshop, were installed in the Bhusaval yard where the East-West route is intersected by a goods bye pass line.

Initially, the design was developed for use with wooden sleepers. Subsequently, the design was improvised for use with prestressed concrete sleepers and four such diamond crossings with an angle of crossing of 65 were fabricated for another major yard at Nagpur.

Field experience for the traditional design showed frequent snapping of bolts, loose ballast packing resulting into disturbance of cross levels and fracture of the running rail. The assemblies at Bhusaval and Nagpur required replacements at about 18 months. Diamonds with new design ware laid at Bhusaval in May 2005 and till now almost 146 traffic has been carried on the Up line and 99mt on the Down line. The branch line has so far carried 1048210 axles. There has been no problem reported so far and there has been not a single case of snapping of bolts, loosening of packing or breakage of rail. A groove has been formed on the head of the rail main running line whose depth has been stable at about 2.5 mm. Thus, there has been considerable saving in the maintenance efforts required at this location. In addition, severe speed restrictions of 10 Km/h at this mainline location on both the roads have now been relaxed to 75 Km/h. On this electrified section, certain improvements in OHE were also required. In addition to splicing of the contact wires, dampers have been provided to avoid intermingling of contact wires under wave action.

### Performance

Two sets of diamonds were laid in Bhusaval yard in May 2005 crossing the two main lines with a crossing angle of $54^0$ - 12'. This was the first prototype assembly being laid after the development and therefore, the assembly was laid on wooden sleepers which continued up to Nov 2007. During this period the UP line assembly carried about 147mt on the main line and DN line assembly carried about 70mt of traffic on main line and about 8,52,390 axles. These assemblies were then replaced with concrete sleeper layouts and up to Jan 2011, have handled 146mt on UP line, 99mt on the DN line and 10,

*Test site at Nagpur yard*

**Cost benefit**

| Parameter | Traditional concept | Polaris |
|---|---|---|
| Cost per location ₹ lakh | 3 | 5.5 |
| Life in months | 18 | 60 Not replaced yet |
| Expected maintenance savings pa ₹ lakh | - | 6 |
| Speed restrictions kph | | |
| Mainline | 10 | 70 |
| Branch line | 10 | 20 |

48,210 axles on the branch line side. Similarly in Nagpur yard where 4 sets of diamonds existed because of crossing 2 double line tracks, the crossings were also replaced with the new design on concrete sleepers in Dec 2007. These assemblies are continuing in service till date.

There has been no case of bolt snapping or rail fracture. Need for ballast packing and attention to cross level variation has also come down drastically and is noted at par with the normal track with similar track structure.

Considerable reduction in wear and tear of rolling stock would have resulted. The train crew, quite comfortable while negotiating the assembly, has reported that the riding on the assembly is very smooth, enhancing safety.

**Applicability**

The design will depend on the crossing angle, relative importance of traffic on the two lines, type of rolling stock, axle loads etc. Therefore, it may not be desirable to transfer the full discontinuity on one line and provide the level difference of 30 mm in all cases. Depending on the crossing angle, the level difference has to be regulated resulting in partial discontinuity on the main line also. Some limitations are:

- Avoid crossing angles between $12^0$ and $18^0$
- Crossing angles $18^0$ to $32^0$ and $58^0$ to $72^0$, level difference 25 mm: main line speed to be restricted to 60 kph, chord-line speed 10 kph.
- Crossing angle $30^0$ to $60^0$ : Main line speed unrestricted and chord line speed 20 kph. RB

# Kutch Railway Company: setting up a benchmark

...Budh Prakash


*Kutch Railway Corporation serves a growing traffic to and from Gujarat Ports*

Budh Prakash, Managing Director, Kutch Railway Corporation

Kutch region in Western India has two important ports namely Public Sector Kandla & Private Sector Mundra. Prior to 2005 these ports were not well connected by railways to the broad gauge rail system in Northern & North Western India and connectivity was limited to a meter gauge line between Gandhidham & Palanpur (301 kms) which necessitated trans-shipment at Palanpur for North bound traffic. These ports were connected towards south as a BG line was existing between Gandhidham – Shamakhiyali further going down south via Dharangdra – Viramgam – Ahmedabad. Any north bound B.G. traffic had to take a long route via Sabarmati (Ahmedabad). Gauge conversion of Gandhidham – Palanpur meter gauge line was sanctioned in 2000. After Rail Vikas Nigam Limited (RVNL) came into existence, this bankable project was transferred to RVNL in October, 2003. One of the important mandates of RVNL is to improve port connectivity.

RVNL entered into partnership with Kandla Port Trust, Mundra Port & SEZ and Gujarat Government and the Kutch Railway Company Limited (KRC) came into being as a Joint Venture.

| | | |
|---|---|---|
| • Rail Vikas Nigam Limited | - | 50% |
| • Kandla Port Trust | - | 26% |
| • Mundra Port & SEZ Limited | - | 20% |
| • Government of Gujarat | - | 04% |

The company, KRC, registered in January 2004, was formed essentially to take up the gauge conversion project. A 30 years Concession Agreement with IR in November, 2005 and a Construction Agreement with Western railway (WR) were negotiated to kick start the project execution.

The project cost, estimated at about ₹ 500 Cr, was funded through shareholder equity ₹ 200 Cr and ₹ 300 Cr loans raised from public sector bank (₹ 200 Cr from Oriental Bank & ₹ 100 Cr from United Bank of India).

## Construction

The first phase of gauge conversion i.e. between Palanpur-Shamakhiyali (248 kms) was completed in March, 2006 and the second phase i.e. between Samakhiyali-Gandhidham (53 kms) in November, 2006. The line between Gandhidham – Shamakhiyali was constructed into a double line. Goods operation on the converted sections restarted in full swing in November, 2006.

| Salient features | |
|---|---|
| • length km | 300.8 |
| • Crossing station/halts | 33/2 |
| • Bridges<br>339 ROB: 05 | Major : 19 Minor |
| • Level crossings | 213 |
| • Loading/unloading stations | 3 |
| • Track Structure | Rails : 52 kg, 90 UTS, LWR/CWR,<br>Sleepers: Concrete,<br>Density: 1540/km |

The project line is fit for double stack containers and will be a feeder route to the Western Dedicated Freight Corridor.

An Operation & Maintenance Contract with WR, which includes revenue sharing clause on the inter-railway revenue sharing pattern, was signed in August, 2007

## Efficient traffic streams

Main traffic streams are coal and fertilizer with container traffic showing remarkable growth. Kandla & Mundra Ports have benefited as they have proper railway connectivity leading to faster evacuation of cargo, making these ports more productive & competitive. The customers have a shorter, economical & faster route for the north bound cargo.

IR has benefited in the form of revenue & long distance traffic. The company has already paid the entire loan of ₹ 300 Cr and shareholders are getting dividend on investment. A survey for doubling the line is in progress with the report expected this month. The plan of doubling is based upon the expected growth of traffic as both Kandla & Mundra Ports have very ambitious expansion plans under implementation. Both these ports are connected to Gandhidham by broad gauge double line. Further, the meter gauge line between Bhuj-Nalia

| Performance parameters for Kutch Railway Corporation | | | | |
|---|---|---|---|---|
| | 2007-08 | 2008-09 | 2009-10 | up to Dec. 10 |
| IR Revenue ₹ Cr | 1439 | 1833 | 2330 | 1900 |
| KRC's revenue ₹ Cr | 173 | 201 | 291 | 224 |
| O&M Cost ₹ Cr | 94 | 114 | 160 | 126 |
| Net million Ton-km | 212 | 248 | 293 | 297 |
| Total Trains Run | 8142 | 9670 | 11141 | 9336 |
| Goods Trains:Container | 1025 | 1737 | 1985 | 2232 |
| Coal | 572 | 1237 | 1884 | 1551 |
| Fertilizer | 2557 | 3300 | 3104 | 3051 |
| Dividend % | – | 3 | 10 | Not yet decided |

is being converted into broad gauge and extended to Vayor to give connectivity to coming up cement plants in the area. KRC expects the trend in traffic and revenue growth to sustain over the coming years, making this JV effort as one of the best in the growing needs for private investment in the rail sector in India.

For execution of this project, all parties focused on business to maximise revenue. There has been significant reduction in costs by adopting better engineering practices. Kutch Rail is a benchmark case showing a win-win situation for all the stakeholders. RB

# IR Budget: an economist's view

S Sriraman,
Walchand Hirachand Prof. of Transport Economics,
Mumbai University

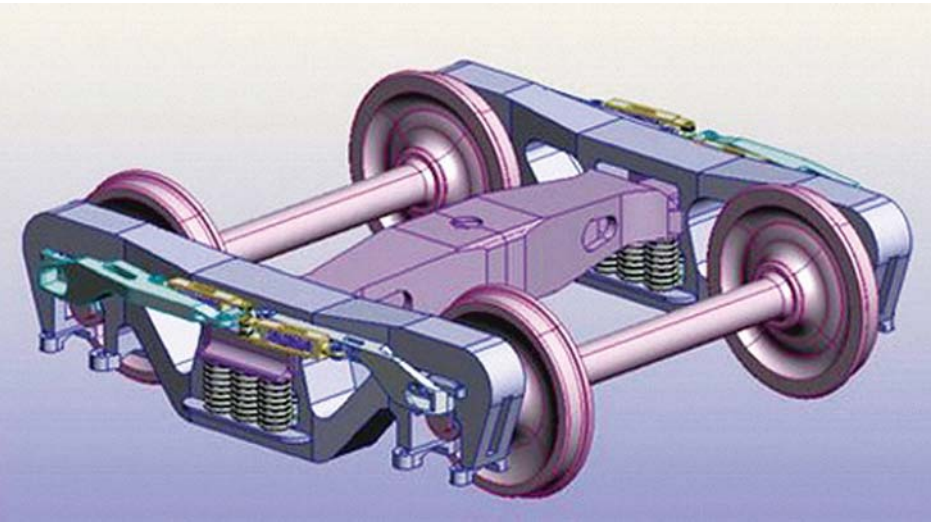
As an economist, I would emphasize the need to take up passenger fare revisions - maybe with some differential pricing such as focus on mail/express second class especially long-distance. It is estimated that an increase of 10% would contribute to about ₹2000 Cr. This would be a step in the direction of reducing losses on coaching services, especially in segments which are used by people who can afford such fares.

A bad trend noticed is the introduction of a large number of new trains - it is still not clear whether these would be in sections where freight capacity would be reduced. Another trend is the additional surveys for new lines, when there is a huge backlog of lines which have been provided very limited funds earlier but cannot be abandoned halfway either. RB

# Established competence in rolling stock design

RITES
THE INFRASTRUCTURE PEOPLE

...Pradeep Gupta



*RITES steering bogie concept*

Pradeep Gupta,
Group GM,
Rolling Stock Design,
RITES

RITES, the Indian Public sector unit, engaged in infrastructure engineering/ management consultancy, third party inspection and allied functions worldwide, has now an established capability for conceptual and detailed design of various types of rolling stock. RITES has traditionally been a project based consultancy organization, carrying out pre-feasibility and feasibility study of infrastructure projects and also their management. When RITES was set up in 1974 to provide consultancy to give a fillip to the rail linked industries in India, one division was exclusively set up for thermal power projects. Rail interface and raw material handling is one important component of thermal power projects and we have to carefully plan rail transport facilities. Moreover, considering the coal volumes required to be handled, all thermal plants have an extensive rail network, as well as wagons and locomotives. For example, a 500MW plant will consume more than 5 mtpa of coal every year which would translate to about 5 BOXN wagon coal rakes per day. Rail network became even more important for pit head power stations in the 80s when RITES successfully worked with NTPC and developed the concept of merry-go-round coal operation for NTPC, Korba, later executed by IRCON. RITES Thermal Power Projects Division created the specifications of NTPC's merry-go-round rolling stock.

Movement of heavy power equipment has been another challenge. BHEL manufactured power equipment boilers at Trichy and generation equipment at Bhopal-required transportation to power station sites. This was a critical activity as road movement had limitations like weight, capacity, size constraint on account of bridges, movement inside cities, safety etc. and in many cases rail was the only alternative. RITES helped in matching the railway net work capabilities with transport requirement of BHEL with regard to necessary mandatory development and clearances from IR, speed certificates and coordination between RDSO and BHEL for design of special purpose wagons. In many cases, the wagons were designed by RDSO ab initio and in others, the designs were brought by BHEL from its technology providers and suitably tailored by RDSO to suit IR requirements.

### Wagon designs

RITES entered wagon design field at this stage in 1985 when it designed a 20 axle wagon jointly with RDSO and a Swedish expert agency for transportation of a 250t transformer. In this special design, the transformer was supported in a suspended manner with beam type arrangement using a combination of 3 axle and 4 axle bogies and on-board lateral shifting arrangement. This wagon was later manufactured in India. RITES continues to design special purpose wagons and has since designed a 24 axle wagon in 2010 for carrying 600 MW boiler weighing 300 t. This design, approved by IR/RDSO, is now under manufacture at BHEL, Jhansi.

The Defence services also need special wagons especially for heavy artillery transport capacity and RITES has been involved in transport of India's own design, the Vijayanta Tank. Army assets like various transport vehicles are normally transported on general purpose flat wagons like BRH. Tanks like T-72 and Vijayanta are much heavier and bigger and need a special purpose wagon for piggy back rail transport. RITES, jointly with RDSO, has designed a special purpose flat deck wagon with 3 axle bogies, 15.7 m length , 3.5 m width and 75t carrying capacity. A prototype was manufactured by Texmaco, Kolkata in 2000, and then, BEML, Bangalore manufactured 328 wagons in 2 lots, with last wagons delivered this year. These wagons are provided with end flaps to permit circus style loading from one end of the train. RITES associated with the army in final service trials of these wagons that have now been successfully inducted into service.

In the late 90s, RITES decided that there was a need for a standalone Rolling Stock Design unit as the requirement of special purpose wagons over the railway system in India was expected to grow. That was the stage when the special streams of traffic like containers, automobiles etc. had started to open up. RDSO and RITES teamed up to develop and market new wagon designs to private operators, including designs which need new technologies from abroad. Basically, RDSO and RITES complement each other, with RDSO providing the design depth while RITES has capability to market and also move rapidly in developing designs, which is often the need of the private operators. Availability of such new wagon designs opens transport

capacity of IR for special commodities.

### Container flats

In a parallel development, the Container Corporation of India (CONCOR), set up in 1988, obtained World Bank funding for procurement of new rolling stock for carrying ISO containers. RITES supported RDSO in design of new rolling stock for CONCOR which has many unique features like low wheel diameter bogies (840 mm wheel diameter), 100 km/h speed potential, slack less draw bar automatic twist lock. There was specific requirement of having low weight underframe which was designed using FEM. RITES marketed this design, called BLCA/BLCB, to CONCOR in competition with various other designs from other international designers. This BLCA/BLCB wagon design has become a standard for subsequent container wagon procurement by all other private operators.

### IR specific requirements

IR has operating requirements not very different from other large systems; one is the restriction on train length on account of loop line length and other being restrictive height requirement imposed by the overhead electric lines. Therefore, BLCA wagon was optimized for minimum possible length. It is primarily a flat bed wagon as against well type wagons used elsewhere but has sufficiently low floor height to fit in the space envelope stipulation (MMD) on height considerations. This has been managed by introducing the '5 car consist' concept that has been now cleared by IR even for double stack container operation on diesel hauled routes. Further, considering the overwhelming economics of operation with BLCA wagon, as compared to well type wagon, even the Western corridor DFC route is being planned with extra height OHE so that BLCA wagons can operate. RITES was specifically involved in the FEA of under frame as well as development of special equipment like slack less draw bar, draft gear and automatic twist lock.

Subsequently, CONCOR had requirement for container wagons to carry longer (45 ft.) containers and these were designed by RITES in partnership with RDSO using standard IR sub assemblies like bogies, brake system, draft gear, etc.. More than 325 rakes of BLCA type and BLL type wagons have been procured by CONCOR and other private operators, which translates into total value of about ₹ 2800 Cr worth of rolling stock. This is indeed a success story where RITES complemented RDSO's strength, leading to delivery of a world class product. RITES being a PSU has inherent advantages like flexibility in operation, focused approach to a project, access to latest technology available worldwide, capacity to absorb the technology and long term stability.

### Frameless tanks

Another interesting project taken up by RITES was the design of frame less tank wagons. Traditionally, tank wagon designs have an under frame, which is designed to take draft and buff loads as well as support the barrel. Although barrel is quite strong from the pay load considerations, it is not considered for buff and draft loads. Taking advantage of the barrel strength, a frame less tank wagon eliminates the under frame that also takes draft and buff loads. With this design philosophy, it is possible to drastically reduce the wagon tare weight. RITES prepared design of frame less tank wagon under technical collaboration with a Ukraine based company. This approach not only delivered the design but also the design technology for making such wagons. BTFLN wagon has been designed with a pay to tare ratio of 2.45 as compared to pay to tare ratio of 2.01 for BTPN wagons. A prototype has successfully passed strength tests. This wagon is also provided with standard Indian Railway sub-assemblies for bogie, brake and coupling systems. IR has now contracted for series production of these wagons by Braithwaite and IR's Golden Rock Workshop. This project was completed at a miniscule cost as compared to normal TOT projects and RITES now has design and prove out capability for other types of frameless designs as well.

### Bulk grain transport

RITES with RDSO designed special purpose wagons for carrying food grains in a project developed by Adani Agro. The requirement for this wagon came up as Adani Agro worked with Food Corporation of India for an ambitious project involving bag less movement of food grains using modern terminals and storage silos. This is moisture and rodent proof covered hopper wagon which can be used for loading from silos through special type of loading hatches provided on top.

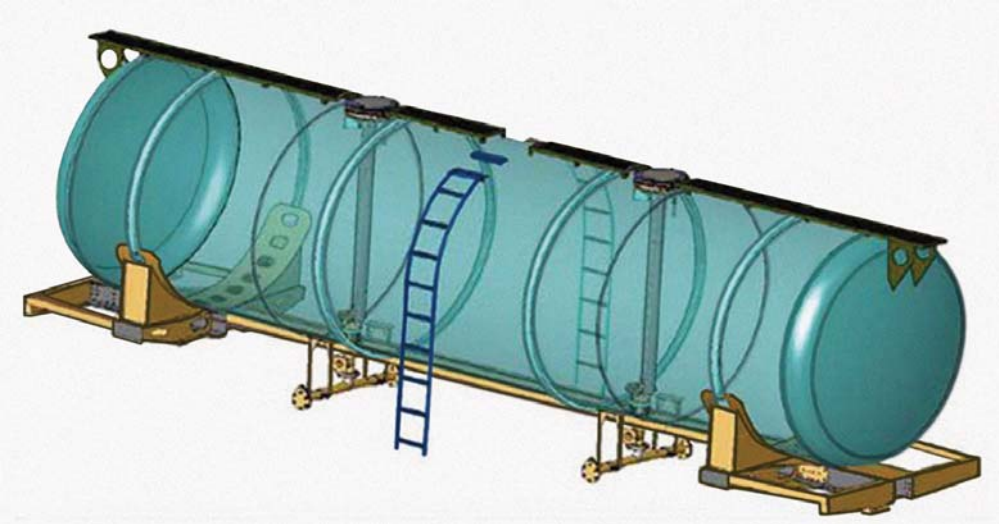
Such a wagon is also provided with bottom discharge special type unloading gates Oscillation trial of the wagon has been successfully completed by RDSO. This wagon was designed and optimized using FE Method.

211 wagons, now under operation, are giving trouble free services and one more rake has been ordered recently. This wagon has carrying capacity of 61t and a length of 12.8 m.

RITES had been marketing BTAP wagon design of RDSO for carrying alumina at 2 bar pressure. However, BALCO, a major Indian aluminium producer, considered faster turn round for operation at 6 bar pressure. RITES carried out FE analysis and re designed the barrel portion of the wagon for 6 bar operation. This wagon BTAP-HP is in successful operation.

### On-going projects of wagon design

- High capacity wagon for transportation of liquid ammonia under 22 bar pressure. The wagon barrel will be thermally insulated with ammonia at -33$^0$C. Special steel having low temperature impact properties is being used for the barrel. The carrying capacity of the wagon is 43t, about 25% more than existing wagons.
- High capacity wagon optimized for movement of fly-ash. This is a covered hopper wagon with air fluidizing discharge system. This wagon has volumetric capacity of 93.5 m$^3$ and can carry 65t of fly ash giving



*Frameless tank wagon design*

rake throughput of 3275 t. Air fluidizing system optimized to reduce the dead volume has been successfully tested on a mock up.

- Covered hopper wagon with gravity discharge for carrying cement clinker. Movement of cement clinker is gaining importance as the cement plants are now working on a model of establishing mother plants for manufacturing clinker near the mines and putting up grinding units for cement near the consumption areas. This means that clinker has to be regularly transported from the mother plant to the grinding units. This wagon has been designed with volumetric capacity of 57 $m^3$ and can carry payload of 67t. The wagon is about 11 m long and gives a rake throughput of 3800 tonnes.
- High capacity milk-carrying wagon with carrying capacity of 50,000 litres, which will be an improvement by about 25% over existing wagons. These wagons are 12.6 m long and have speed potential up to 100km/h. These are provided with transition coupling so that they can operate on pure centre buffer trains also. The wagon is provided with PUF insulation as milk will be moved in chilled condition.

RITES has been carrying out FE analysis for all types of wagons designed so that their structure are optimized for weight. All these projects are being done jointly with RDSO and all standard safety components like bogies, draft gear, couplers and air brake systems are used in them.

### Crash worthy coaches

In 2004, IR took an initiative to develop passenger coaches with crashworthy features so that they have much higher passive safety. RITES was tasked to develop such a design as well as to develop a centre of excellence for crashworthiness studies at Lucknow. Again RITES leveraged its strength of flexible operation, capacity to rapidly involve foreign experts wherever necessary and capacity to handle uncertainties in complex projects. RITES recruited a team of 8 IIT engineers and set up a High Performance Compute Cluster facility having 464-bit CPUs with massive parallel processing capability. The project was planned in a way that a large portion of it could be done in-house and foreign expert agencies were associated only in the high-end parts of the project where it was essential to get new technology. RITES took the responsibility to manage the project and integrated the various facets of the project, including the responsibility to handle uncertainties because this project was basically of R&D nature. This arrangement worked successfully and the coach model was prepared using TRUEGRID and solved on LSDYNA for energy absorption, accelerations and permanent deformation during a crash simulation under guidance of expert agencies. Based on these studies, design of energy absorption scheme as well as energy absorbing elements with deformation initiators was carried out. A crash test was conducted to validate the design near Lucknow. Carrying out such crash tests in controlled conditions and be able to record the desired parameters, requires specialized technology and equipment. All this was obtained from foreign expert agency and passed on to RDSO. Test was successfully conducted and the design validated.

### Special projects

This project gave a lot of confidence to RITES team in handling complicated design project within a defined time frame. This is another success story where complex technology is now available indigenously with IR at fraction of a cost of the imported option. Additional work is now being done in this area to develop occupant protection designs as well as developing capability of making such designs using dummies and further extend crash worthiness features to locomotives.

RITES has been carrying out other special projects also which require design understanding of rolling stock. One of such projects was developing the fatigue test facility for bogies at BEML which indigenously developed bogie for metro systems and needed assistance to carry out fatigue test as per UIC-615-4. RITES helped BEML in designing a proper set up for the test, designing of the fixtures for simultaneous application of various loads (vertical, lateral, twist and longitudinal) and the various loads were synchronized at different frequencies. The work was successfully completed in 2009. This involved FEM analysis of the bogie frames, selection of load cases based on applicable standard, gauging scheme for fatigue test and development of the fatigue test scheme based on the applicable standard and service requirement. The project included both static and fatigue test for 10 million cycles. 100 channel Somat e-DAQ data acquisition system was used along with n Code software for stress analysis and fatigue life estimation.

RITES has also worked in 2003 on a project for designing track friendly self steering bogies. This was a very challenging project as it required development of self steering mechanism technology which was not available in India. The mechanism was designed with the help of a foreign expert agency. Modelling, Vehicle dynamics simulation and FEA were carried out in India. Suspension, bogie frame and self steering mechanism of the bogie have been successfully developed. This bogie has capability to drastically improve wheel wear. RB

# Synchronous power supply for electric traction

...D K Bansal

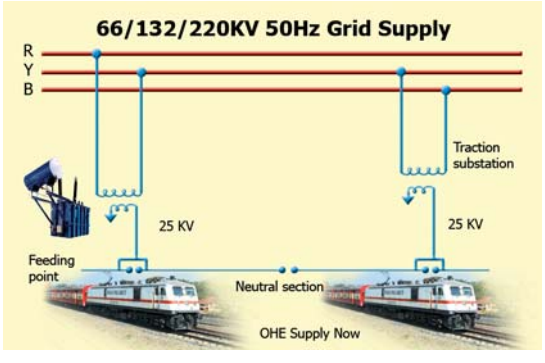
Energy from power companies 3 phase network , generally State Electricity Boards (SEB), is fed to 25kV single phase overhead wires (OHE) for electric traction, tapping a different phase combination every 50km or so. The power from adjacent Feeding Posts (FP) is insulated by a Neutral Section (NS). The train driver's attention is frequently distracted at NS besides the problems associated with the resultant transients. Long term improvement through an innovative idea is now proposed to feed power at all FPs , after converting SEB three phase supply to synchronized single phase, via a direct current link. This will eliminate the need for neutral sections.

IR's network is electrified at 25kV 50Hz single phase, adopting the French (SNCF) system. Majority of IR's locomotive fleet consists of conventional 4000+hp, silicon rectifier fed and direct current traction motor drive. The current is drawn by these locomotives at a substantially lagging Power Factor (PF) drawn from the power company's Extra High Voltage (EHV) network tapping two line wires at 66/132/220kV 50Hz, stepped down to 25kV in a single phase transformer at Traction Sub-Station (TSS). A different set of EHV wires is tapped at adjacent FPs to balance the current load on three phases. The power is tapped from all three phases in Scott connected transformers TSS but the loading remains unbalanced. The current from adjacent FPs is isolated from each other by providing a NS at Sectioning Post (SP), midway between two adjacent FPs.

The train driver is required to switch off the locomotive power supply on visual clues and coast through the neutral section, approx. every 25kms, before resuming powered driving. There could be, say, 40 such interruptions in a day's run of around 1000 kms. The switching transients introduced by such switching cause a significant proportion of the on-line locomotive failures. In situations where the locomotive handles power supply for the train ( " hotel load"), supply for train service use like heating and air-conditioning gets interrupted at the neutral section, inconveniencing passengers.

## Power supply variations

Supply voltage at the locomotive could vary between 27.5 and 19kV, with the lesser voltage occurring due to potential drop in 25kV OHE and 5.5% permissible variation in EHV supply. In extreme cases it could go down to 17.5kV under extended feed conditions and shoot up to 29kV at no load. Supply frequency used to vary between 46 -54Hz till five years ago, when differential tariff for energy supply to the EHV grid by the generators was introduced. There is no credit for energy supplied above 50.5 Hz system frequency, while sumptuous bonus is paid for supply at 49Hz on a sliding scale.




*Traditional 25kv power supply system*

*Overhead power supply is a critical element of electric traction systems.*

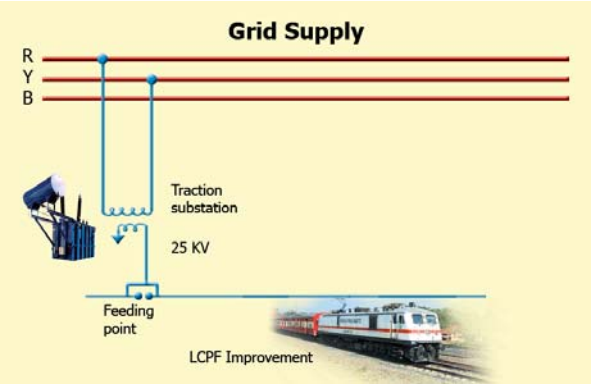
The high voltage 3 phase supply is connected to a single phase transformer primary winding and stepped down to 25kV at TSS. The current is drawn from two of the three lines of EHV grid. A different pair of wires is tapped at adjacent TSS to balance the load on three phases. The FP is usually located 50 kms apart and power is supplied to overhead traction catenary system over a distance of 25kms in either direction, up to the next NS. The unbalance in current drawn from the grid may vary between 20 to 50% depending on the placement of the TSS points in the grid, network terrain and time of the day.

## Tariff

Power supply companies charge railways for the energy consumed at a rate higher than other users due to unbalanced current between three phases, penalty for Power Factor (PF) below 0.95 and a surcharge for higher peak demand. The PF for 25kV supply ranges between 0.7 and 0.8 due to phase difference and current distortion caused by non-linear load of rectifiers on the locomotives. Total Harmonics Distortion (THD) in the locomotive current could be 17% on full load.

IR has installed passive tuned LC filters at the TSSs to improve PF to 0.95 over the billing cycle, usually a month. However, many SEB's do not accept power factor below 0.95 (even a leading one) and a penalty is

D K Bansal,
Electric Technology Consultant



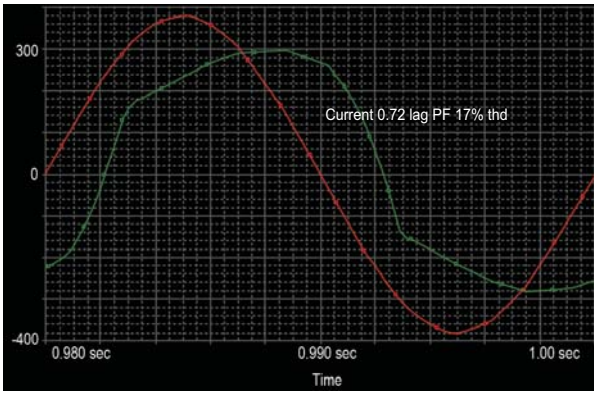

levied @ 1% for every 0.01 below. Railways have tried expensive GTO/IGBT based dynamic PF improvement units rated at a few MVAr, in addition to passive LC filters to improve the PF.

The load factor for electric traction supply from a TSS may vary at most places from 0.3 to 0.4, as power requirements for the moving trains vary. Train scheduling puts its own footprints as many passenger trains from metropolis are scheduled to leave in the evening and arrive in the morning. On the other hand, bulk of freight trains is exchanged at check points over the night. These operating requirements make the power drawn to peak at different locations at different times. The load factor could be improved to 0.4-0.6 if the power supply from different TSSs could be paralleled and the moving train load fed from a synchronized 25kV grid supply, levelling the peaks.

### Other options

In light traffic situations, the spacing between the NS could be 60-80kms and the neutral sections used only under exceptional circumstances of a shut down or necessity to extend feed from next FP from either direction. The operation of heavier and longer trains warrants switching off at the NS to enable to feed each portion with an independent transformer.

A moving NS, in which the feed is automatically extended from the "leaving" phase and then from "entering" phase with a wink of less than 25 millisecond, has been introduced on Japanese high speed Shinkansen service. This permits a nearly interruption free supply to the train. This is a very expensive system as a parallel OHE system extending over 1.6 km has to be laid at each moving NS location.




*Typical digital trace showing 17% Total Harmonic Distortion in loco current*

European manufacturers have experimented with shorter length Teflon insulated NS, in which power to the train need not be reduced or switched off. IR has not had a positive experience with the experimental on-load NS crossing trial near Karnal on the Northern Railway. On the Delhi Metro also, experience with automatic detection and interruption of power supply at NS has not been trouble free

### Alternative approaches: proven technology

Three phase electrical energy received at TSS could be stepped down, rectified to DC and inverted, before stepping it up to 25kV 50Hz AC. The converter could ensure unity power factor and minimal THD in power supply from SEB. Such application is working reliably on on-board 3 phase drive 5MVA electric and diesel locomotives. A 1500 MW electric power tie line connects 400kV three phase grids at Rihand (near Varanasi) and Dadri over a distance of 800 km. Power is rectified to 500kV DC and transmitted over the 800 km distance to cut losses and inverted at the other end. It is also used to stabilize AC networks at the two ends by injecting reactive power. The technology has proven reliability and optimum cost, proven over the last 20 years and an efficiency of about 97% has been achieved.

### SCADA type control

The 25kV feed from adjacent FP could be synchronized and paralleled, much like the generating stations of conventional three phase system. This is not very much unlike young students' laboratory experimentation of paralleling alternators using three dark or bright lamp methods. The fault "islandisation" in paralleled 25kV system could be computer controlled by operating the interrupters across the NS at FP and SP, in addition to existing Sub-Sectioning Posts (SSP).

Such a control scheme had been successfully implemented a few years back in Bengaluru power distribution system and by the Mumbai based Tata Electric Company. A working model of such computer based fault "islandisation" had been designed and implemented by a young trainee at the material testing laboratory of Indian Railways Institute of Electrical Engineering at Nasik Road some years back. It used to automatically clear manually created OHE faults and display the action by Light Emitting Diodes showing live and dead isolated sections of the system on a huge display board while logging the events in software memory.

### How will it help?

Uninterrupted power supply to the trains would:

- Improve passenger service quality.
- Enhance locomotive reliability.
- Minimize frequent distractions to train engine driver.
- Eliminate failures at neutral sections.

Synchronous stable power supply would have the advantages of:

- Reduced voltage drop, as power is fed from both ends in parallel.
- Improved locomotive performance.
- Balanced load and improved load factor of SEB grid supply.
- Elimination of poor power factor and peak load penalties in energy bills.
- Reduced contract demand due to load levelling by parallel fed 25kV 50 Hz grid supply. It is expected that 25MVA demand may come down to 15MW at TSS.

### Investment and likely benefits:

- Additional Capital Investment in two 15 MW converters at TSS may cost about ₹ 25 Cr cost may be reduced to half for bulk supplies.
- Power factor surcharge ₹ 0.8 Cr per year (based on 10% of annual energy charges) may be saved annually.
- Contract demand charges ₹ 2.5 Cr may be saved every year by reduction in contract demand from 25MVA to 15MW, by levelling of peak demand by parallel feed from adjacent TSS and unity power factor by 4 quadrant control of converters.
- Elimination of a TSS due to halved voltage drop by feeding from both ends saving ₹ 25 Cr in capital investment for new construction projects.
- Reduced energy charges due to improved load factor and balanced

power tap at each TSS would need to be negotiated with the SEB. Estimated savings may be ₹ 1 Cr.

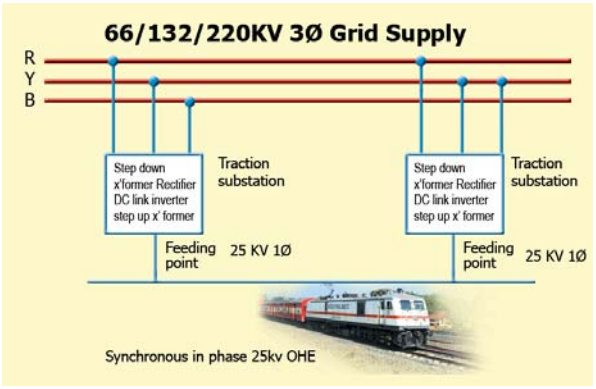
- The TSS DC links located 50kms apart may be used to stabilize the grid by meeting reactive power requirement. Grid authority/SEB could pay for this service; monetary gains cannot be apportioned at present stage of development.

The above estimates and actual savings may vary based on SEB tariff and load pattern in the system, however rough annual savings may be ₹ 3.3 Cr on an investment of ₹ 25 Cr.

### Action Plan

- Technical feasibility of conversion from 66/132/220kV three phase to 25kV 50Hz single phase to be studied for the location where maximum troubles are experienced at the neutral section. This should be done with the cooperation of an electronic power converter industry with independent development capability.
- Computer Simulation of synchronous power supply system, train loads and fault isolation system.
- Estimation of cost and time frame for installation of a prototype 15 MW converter at an existing TSS in NCR and programme for bulk production.
- Evaluation of performance of the synchronous feeding post in parallel with conventional existing ones.

The first step could be a fabrication of a low kW each working model of such network of a few TSS's , capable of feeding a simulated nonlinear locomotive-like load, in parallel at medium voltage and drawing power at near unity power factor, with fault "islandisation" similar to the IRIEEN model. This will not cost a fortune but the dividends from a successful power supply method would eliminate much of the disruptions that are a reliability concern. RB




# Appointment

GN Asthana has taken over as General Manager in the West Central Railway, Jabalpur

# IR based manufacturing projects

Factories at New Jalpaiguri, Adra, Jellingham and Kulti have been announced in collaboration with SAIL, NTPC and Rashtriya Ispat. IR has also been working on a number of projects involving long-term supply contracts for locomotives, coaches and critical loco components at Madhepura, Marhowra, Kancharapara and Dankuni. Since these project models are being attempted for the first time, "due diligence" is the buzz word. A Core Group of corporate officers has been tasked with the onerous job of resolving policy disagreements but key decisions can be taken only by the board or the broader political establishment.

IR has often taken the easy route of converting a PPP-linked project to self funded one, often to avoid taking a hard decision. Such a course in turn internalizing IR inefficiencies does not instill confidence in the stated aim of generating above 1000 Cr in 2011 FY through the PPP route. IR is executing works departmentally at Budge Budge, Dankuni, Anara, Tindharia, New Cooch Behar etc. 5 factories have been promised even though many wagon builders the private and government sector indicate contract-starved capacities in the 29 manufacturing units on current approved list. In addition IR has indicated that "...work on the wagon factory in Orissa will also be taken up once the site is finalized." Even then two more wagon units under JV/PPP mode, one each at Kolar and Alappuzha, Kerala and one more at Buniadpur are planned. In addition "... whatever problems are there will be sorted out and we will set up the Palakkad coach factory. Railways are interested to partner with Autocast and SILK at Cherthala ( Kerala), for which business plan is being revised to bring it in line with the current needs of the railways". In effect there is a surfeit of proposals each in a limbo and little to show of till now.

IR has so far not adopted approved ancillary route for its numerous needs for components and spares and instead tenders each requirement, often limiting actual purchase form a list of pre-approved vendors. The new policy announcement of setting up new Industrial Parks is again deficient on detail and methodology and could add to the growing list of such pronouncements. A definition of the process and policy routes of IR is required for any of these goals to be met. RB

# Long rail movement: productivity through rationalisation


*This Bhilai maintenance team led the effort for wagon rationalisation and improvements*

N S Kasturi Rangan, Ex.GM/SECR

B P Swain, Divisional Railway Manager, Raipur

Bhilai rails were transported all over the Indian railway system using rakes formed by individual zonal railways with suitably modified flat wagons of BRNA class. In the absence of any single effort, these wagons were modified to varying designs that had different carrying capacities and lacked interchangeability even in the limited numbers. Maintenance of these rakes, termed End Unloading Release ( EUR), was carried out by two groups in series i.e. mechanical staff attending the under gear and the track workshop staff looking at the rail carrying superstructure, resulting in detentions on every trip . A prime reason for detentions prior to release for loading was the remoteness of the Track Workshops from the Bhilai yard locations.

On several occasions, partially loaded rakes had to be dispatched because of incomplete / poor attention of superstructure. Based on allotment of rails, the zonal rake would be moved to Bhilai and be used only for that allotment. It is no surprise that allotments and rake availability would often not match.

Based on a suggestion from the South East Central Railway, Wagon Depot at Bhilai has now been nominated as the single point owner and maintenance agency. This has resulted in faster turnaround at Bhilai and enroute, better user satisfaction as well as reduction of the number of rakes required. IR Board had directed for such action in 2008 but lingering doubts in taking over this work at Bhilai yard resulted in a delay of about 18 months.

### Raipur Division takes the initiative

All the rakes are now Bhilai based with single point responsibility. Adopting single ownership and responsibility for these rakes was beset with some legacy impediments that have been resolved successfully by SECR.

- Varying designs out of uncoordinated efforts at various locations. Two basic designs, the ordinary stanchion structure and the modified lever arm design, existed with dimensional variations amongst these also.
- Speed restrictions, mainly on account of damaged bulk heads, were enforced ( 45 kph on straight and 25kph on curves) resulting in poor turnaround.
- Out of a fleet of 22 rakes only about 13 rakes were loaded per month at the Bhilai Plant indicating idling at locations which had no allotment of rails in that period. There were several occasions when rakes of a particular railway were detained at Bhilai waiting for rail availability even as another one destination was waiting to get a rake. With the centralized maintenance it will be "FIRST IN FIRST OUT" system with full compliance to the allotment sequence. This obviously cut down rake requirement.
- Any wagon detachments for periodic or defect attention delayed the entire rake as lack of design harmonization prevented wagon interchange.

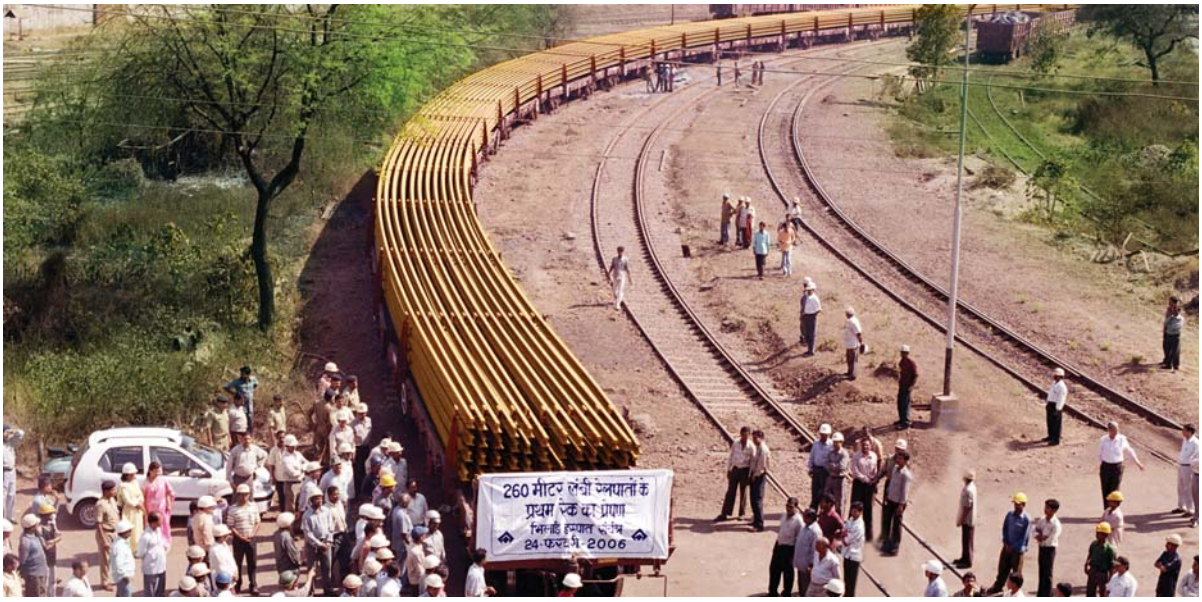
### Impressive improvement to show

Prior to rationalisation, different zones owned 22 rakes and even then satisfaction level was poor. With rationalization, Bhilai is managing current traffic levels through centralized 12 rakes. 9 of these have been standardised and 3 more will be attended as maintenance time slots permit. IR Board has since authorised Bhilai to incur additional required expenditure for harmonizing design and attention to deficiencies so that full convertibility on the 12 rakes is achieved.

BHILAI rakes are now suitably marked for identification (BR i.e. BHILAI rails) with a proper tag in the networked freight monitoring system (FOIS) for better monitoring. Rakes retained by railways for their internal movement including for single rail sections to flash butt welding plants have not been considered for centralized maintenance.

9% wagon detachments were reported for superstructure and undergear maintenance prior to rationalisation, a figure that stands currently at 8 %. Bhilai engineers expect this attention to reduce further as inputs currently under way are completed. Weak links include bulk heads, welded bases of stanchion plates etc.

Adding another first in this effort, BHILAI has recently successfully added the 13 th rake (EUR) to the fleet of centralized maintenance. This rake has basic modifications over the South Central Railway Design.




*The first 260m long rails leaves the SAIL Plant, Bhilai in February 2006*

The new standard design adopted is a 12x5 matrix design carrying 60 rail lengths on every rake.

Problems with wagon superstructures, particularly the bulk heads, are limited operational speeds aggravating running over the system. With strengthened designs, these restrictions have been relaxed to 75 kph in empty condition and 65 kph in loaded, the general standard for other IR wagon classes.

This common maintenance agency concept has brought down the average detention on account of maintenance from earlier 8 days to current 3 days. The system responsibilities are now clearly earmarked and usage improvements have been impressive.

As construction projects around the country gather pace and Bhilai adds further capacity in 2013, these improvements would have prepared fairly fluid transportations system in time.

( Report based on inputs received form SECR and support from Sudhanshu, Sr Divisional Engineer incharge). RB

# Talgo: iconic design for improved speed

...Subrat Kumar Nath

*A Talgo high speed train on run in Spain*

Subrat Kumar Nath, India representative, Talgo, Spain

As India looks to technologies for increasing passenger train speeds within the existing infrastructure, a key component will be rolling stock design that is able to accommodate track inefficiencies and add inbuilt safety. Alternatives for high speed ( 250+ kph) also need to be scanned as planning decisions are taken for the upcoming corridors. Amongst railway engineers the Talgo pendular train is a well known iconic design that merits attention as it presents a viable option for increasing speeds on existing infrastructure. Talgo trains are unique Spansih development , unmatched in its concept and a success story of innovation and commercialisation that has now touched the very pinnacle of high speed and passenger comfort . The Spansih AVE high speed network is broadly based on Talgo trains now .

In August 1941, a Spanish engineer, Alejandro Goicoechea, successfully carried out tests on a unique railway axle guidance device composed of an articulated rolling frame formed by isosceles triangles. The base of each triangle was an axle with two independent wheels and the upper apex of each triangle was assembled in the middle of the previous triangle base. It was hauled by a steam locomotive reaching a speed of 75 kph on the Leganés-Villaverde line in Spain . José Luis de Oriol y Urigüen felt confident about the feasibility of Goicoechea's idea and in October 1942 he established Talgo (Tren Articulado Ligero Goicoechea Oriol). From the beginning, it has been a company whose activities include all stages of the production process: design, manufacture and maintenance. This integration has allowed a focus on the entire technological circle, optimising safety standards and passenger comfort.

## Evolution of the Talgo design

The original idea of the Talgo trains was the replacement of conventional 26 m long coaches with shorter carbodies, supported at the rear on two independent wheels and at the front end centrally on the rear part of the preceding coach. A sequence of virtual triangles is built whose vertexes are connected to the base centre of the preceding triangle, being at the same time a support and a traction point. Through this arrangement a triangle steering system is achieved. As a consequence of it, the wheels run parallel to the rails and, in curves, the wheels which run on the outer rail have a negative angle of attack.

In order to demonstrate the feasibility of this idea, a sequence of short triangular structures was built, consisting of no more than flanged wheels mounted on slightly cranked axles and joined by light girders making up the other two sides of the triangle, which was hauled by a locomotive reaching a speed of 75 kph. The possibility of constructing light rail vehicles which provide traction energy savings and reduce damage to the track had been proven.

With this, the principles of the Talgo technology had been established with independent wheels and articulated coupling between vehicles, made up of: a central coupling that transmits the traction and braking effort, without transmitting vertical efforts; two bars in the vertical direction that support the front end of the vehicles and provide the assembly with torsion rigidity.

The success of the tests carried out with the Talgo I in Spain at 135 kph with a wheel load of 1250 kg led to the decision of manufacturing a train suitable for commercial service. The new project had to be carried out in the United States because of the effects of the second World War. Each short coach unit of this train was of monocoqe construction, built of duralumin.

Talgo I was a prototype. Talgo II, built in USA, was in commercial service from 1950 to 1960. Talgo III, an evolution from Talgo II, started service in Spain in 1960 and continued till 2010.

## Talgo III

Due to its steering system, the Talgo II was only able to run in one direction. This handicap impeded a generalised acceptance of this train, as it was necessary to have reversing triangles to change the running direction at the end of each journey. To solve this inconvenience, the triangular steering system was substituted by a radial design, with two bars joined to both adjacent bodyshells and to an equaliser beam situated on the virtual axle of the wheel. This steering system provided a zero angle of attack. This new steering system for the Talgo III allowed increasing the length of the vehicles from 6.15 m to 11.10 m, offering more space to increase the commercial performance and reducing the number of bogies per metre of train. By that time, the Talgo vehicles were completely developed and manufactured in Spain.

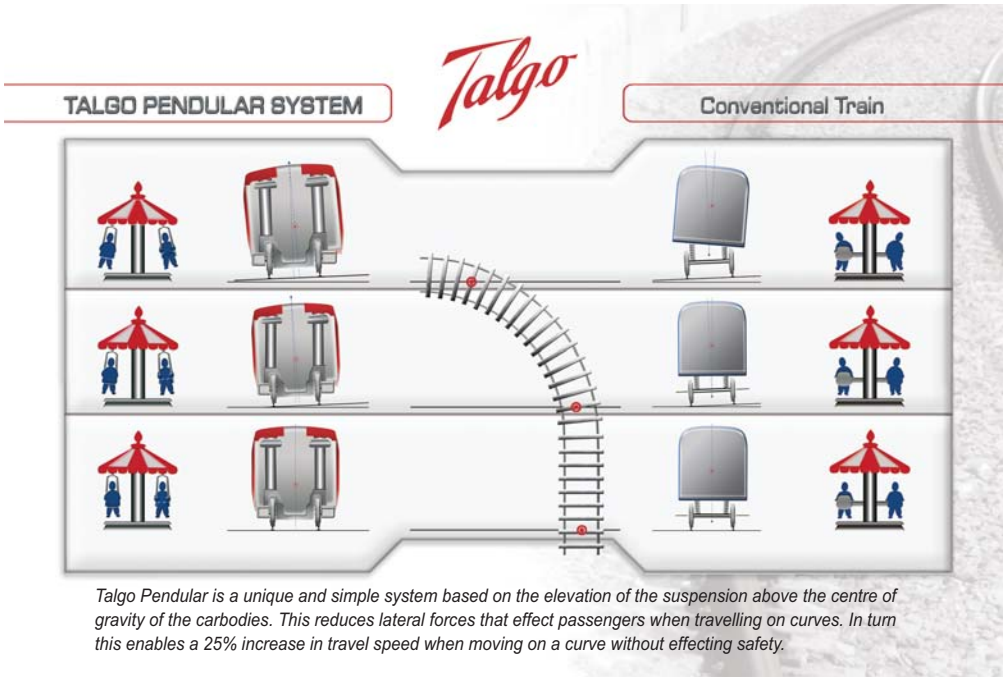
The wheels were joined through a structure in the form of a yoke on which rest the suspension springs that support the bodyshells through links. These links, with the help of lateral hydraulic dampers, provide the lateral suspension and the centring of the body.

### Gauge change on run

Due to the difference between the European and the Spanish track gauge, up to 1968 it was necessary to change trains at the border. The passenger transfers in the international journeys were uncomfortable and their time cost was very high. Talgo engineers therefore designed a system (Talgo III : 1968) that allowed the train to pass through a facility situated between the two tracks of different gauge at low speed (15 kph). The operation is very simple, reliable and completely reversible and it is done without any service interruption and automatically.

### Talgo pendular

During the 1970's the natural tilting train, Talgo Pendular, was developed with the aim of making the service more attractive by reducing the journey times. This reduction of time was achieved by increasing the speed of the train in curves without diminishing the comfort of the passengers.




*Talgo Pendular is a unique and simple system based on the elevation of the suspension above the centre of gravity of the carbodies. This reduces lateral forces that effect passengers when travelling on curves. In turn this enables a 25% increase in travel speed when moving on a curve without effecting safety.*

### Technical description

- Maximum speed - 250 kph, with fully acceptable stability
- Kinematic envelope - UIC kinematic envelope 505.1.
- Tilting -The intermediate cars are able to circulate at manoeuvring speed around curves of radius up to 100 m.

### Talgo train sets XXI

The current trend in railways is the construction of multiple unit trains on which the traction is integrated in the trainset by means of two power heads, one at each end, working in push-pull mode. Due to this Talgo started in 1996 the development of a non-tilting power head for 220 kph, specially adapted for articulated lightweight trainsets. This power head is running on one single bogie whilst its rear end is suspended perpendicular on the next coach. Power head and train are coupled permanently, the coupling acting as an articulated joint in the same manner that is applied between the coaches of the train. The traction can be electrical or diesel, with a power supply up to 1595 KW per unit, allowing a residual acceleration of 10 $cm/s^2$ at 220 km/h. The power per tonne of an 8 coaches trainset with 229 seats is 14 KW. If necessary these power heads could be equipped with powered bogies capable of changing the gauge automatically.

### LOCOMO VE L-9202 TRAVCA

This is the first electric locomotive in the world with Talgo automatic variable gauge system and dual voltage for High Speed services. This locomotive is a 100% Spanish development by Talgo in collaboration with IDD in the design and the support of the Spanish Government. It has an automatic variable gauge system, which makes it possible to haul Talgo trains with variable gauge. It is designed for maximum speed of 260 km/h and in curves with a maximum lateral acceleration on rail surface of $1.2\ m/s^2$.

### Talgo 350: very high speed

Trains with integrated traction, formed by two identical High Speed Talgo Power Heads and a High Speed Talgo trainset, made up of a variable number of passenger coaches with a maximum of twelve.

### High Speed Passenger Coaches

- Carbodies: Lightweight, airtight, pressurized. Low weight per seat.
- Coupling between cars: Articulated with anti-overturning and anti-vertical hunting mechanisms.
- Very low Center of Gravity.
- Rolling assemblies : Single axles, with independent wheels and primary suspension located between cars.
- Rolling assembly axles: Permanently steered that keep the wheels parallel to the track on both straight and curved stretches.
- Main suspension: Talgo Pendular type, pneumatic, with natural carbody tilting.
- Braking: Pneumatic over four discs per shaft. Anti-lock brake system.
- Air-conditioning units: located in underframe.
- Safety and control: Intelligent computerized system.

### Talgo 250 intercity train

The Talgo 250 was originally developed to meet RENFE's needs to operate the latest generation of high speed trains in an indistinctive manner within the Spanish rail network. It is important to

| Spanish high speed AVE train sets | | |
|---|---|---|
| Maximum commercial speed | : | 350 km/h |
| Maximum lateral acceleration in curve | : | 1.2 m/s2 (7.2 inches Cant Deficiency) |
| Traction | : | Electric |
| Traction units | : | 2 |
| Passenger cars (Maximum) | : | 12 |
| Tractive axles | : | 8 |
| Maximum number of axles per train | : | 21 |
| Maximum axle weight | : | 17 tons |
| Type of operation | : | Single trainset or multiple mode |


bear in mind that Spain's traditional gauge is 1668mm with the electric supply at 3000 V DC while the existing high speed lines have been designed and built in the 1435mm standard gauge and 25 kV AC current. Thus, we can say that Spain is one of those unique countries with two different systems in terms of gauge, electric supply and signalling within the same network and Talgo has been able to provide a solution to this "uniqueness". The Talgo 250 meets all these requirements: dual voltage (AC-DC), multiple signalling systems and variable gauge system "Talgo RD", to be able to run on both gauges with a total adaptability.

Spanish RENFE's version of the Talgo 250, named as S-130, is composed of two power heads and eleven intermediate coaches with a total length of 185 meters. The power heads incorporate Bombardier traction equipments and the intermediate coaches use Talgo's main technological principles of aluminium welded body shells, articulated union between cars, independent wheels, permanently guided axles and natural tilting system. The Talgo 250 has been designed to run at speeds of 250 km/h on the 1435mm high speed lines on AC current and 220 km/h on the 1668mm conventional network on DC current.

Talgo is now an established alternative coach design, proven for high speed service, competitive and reliable. Talgo presents a viable option for cost optimisation and very high service level. RB

## LAST WORD Project in search of land

This story of location of an IR wagon component factory is symptomatic of the reasons why IR projects have a habit of becoming stale. To begin with it was announced that a ₹ 100 Cr steel foundry would be set up in Majerhat in Kolkata (covered under item in the IR budget papers presented to parliament). Large volume of Steel castings required mainly for center buffer couplers and wagon bogie components are at present supplied by a number of private sector and PSU vendors. At present there are serious concerns on service quality of these assemblies. Frequently contracts are also delayed on negotiations for prices and IR would like to get out of this 'delay circle' through internal manufacturing. It is of course never considered that internal manufacture in railway workshops is always more expensive and inefficient. Management expedience has often overruled efficiency and core value concerns in recent times.

It quickly dawned on the IR planners that the site chosen was located in the midst of the metropolitan area and a steel foundry could never be located there. Alternative sites within West Bengal were quickly surveyed for. At that stage it was also announced that IR would set up five wagon manufacturing units. Concurrently a diesel based car set (DMU) factory was also announced for Sankrail, about 20 km from Howrah (Kolkata). Since local interests are easily able to swing such decisions and , within a month or so, the diesel multiple unit factory was relocated to a site where originally a wagon factory had been planned. The wagon component factory has now been announced to be setup on an abandoned site in village Gangrachar (char in the local language means sandy beachhead). The location, labelled Jillingham, was suitable for the workload when it was adopted by Burn Standard in 1980's.

A factory manager who worked at this site between 1983 and 1993 indicated that this location was chosen for fabrication of heavy offshore and port-based steel structures for which a maritime approach was necessary. This location is on the beach head on Hooghly River downstream of the Haldia riverine port. The location was prepared by strengthening the weak sandy soil with few feet deep stonework. The fabrication work was carried out in the open utilising mobile heavy duty 200t cranes and most of the material movement was by riverine barges. In those days road approach to the fabrication site was extremely difficult and inhospitable, not much different form today. The location was abandoned around 1993 as the owner Burn Standard ran out of profitable businesses for feeding this location and was in general in financial difficulties. In a way the dwindling fortunes of riverine transport connected with Haldia port may have contributed to the closure of the site. Or perhaps the expectations of finding oil in the region did not materialize and the expected fabrication business ran out of steam. The location stood alone with little or no industrial or urban developments around it.

BURN STANDARD ,since been taken over by IR, manufactured heavy steel fabrications including railway wagons. The site at Jillingham having been abandoned has now been identified for the wagon component factory. Apparently the name had its origin in a buoy in the days when riverine traffic leading to upstream ports in Kolkata was regular and important. Railway officials were not very clear about the mechanics of development of this facility but it is understood that Burn Standard could invest in association with the steel major SAIL. There has been no confirmation so far from SAIL for their willingness to invest at this location.

For a foundry of this nature a rail head is not necessary but a decent road approach, basic infrastructure and residential facilities in nearby locations would be considered necessary. This site suffers from absence of all and the only leverage is the availability of land. In the words of an old CEO who knows the site and its origins intimately, this location is prone to heavy cyclonic weather and unfit for a foundry or factory sheds. It is likely that the project will add to the growing number of IR works which are languishing for completion or for allotment of adequate funds. The story is symptomatic and repeated in various projects and repeated many times under differing political dispensations.

And finally, it has been announced that a Railway industrial park will also be set up in Jillingham.

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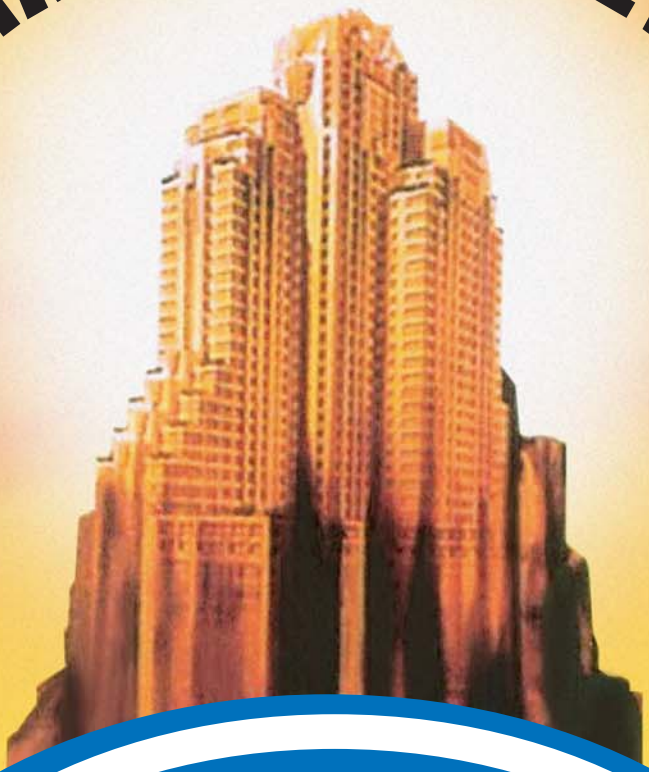

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Small AC Motors



Vigilance Control Device



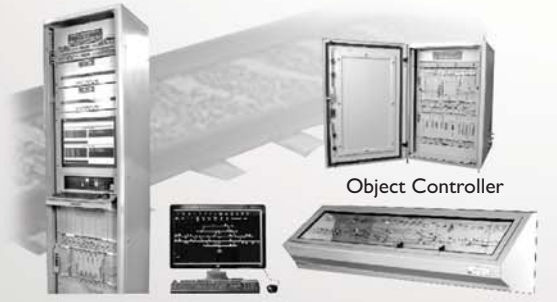
Digital Tachographs



Microcontroller based Electronic Governor

Auxiliary Power Unit

**Electronic Signaling Interlocking System (CENELEC SIL-4)**



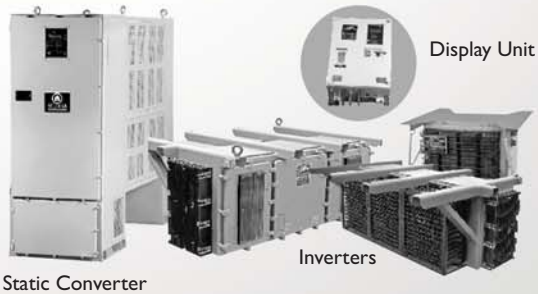
Object Controller

Central Interlocking Unit

VDU

Control Cum Indication Panel

**Inverters / Converters (2.5 - 500 kVA)**



Display Unit

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Static Converter

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