Yamaha Motor Monthly Newsletter

The "FAZER" Industrial-use Unmanned Helicopter

Spotlight: Industrial-use Unmanned Helicopters

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Industrial-use Unmanned Helicopters

A “robot” to work aloft in place of people

A counter-rotating rotor type helicopter prototype commissioned by the Japan Agricultural Aviation Association. To help prevent major damage to the helicopter body in case of flight failure, tests were conducted with an arm-fitted operational practice device. (1985)

In October 2013, Yamaha Motor Co., Ltd. unveiled the “FAZER,” its latest industrial-use unmanned helicopter. This new model is powered by a fuel-injected, 4-stroke, horizontally opposed twin-cylinder engine, and gains 50% more payload capacity than the current model. It also features a new control system that takes controllability and operability of the machine to the next level. In Japan, the industrial-use unmanned helicopter was originally developed in the mid-1980s for the purpose of improving the methods of spraying crops with agrichemicals like pesticides. There are approximately 2,500 Yamaha “R-50” and “RMAX” series unmanned helicopters (number of total registered units in 2013, including OEM models) now in use in agriculture throughout the country, contributing to labor-saving and making farm work more efficient. As the successor to these models, the new FAZER will help in realizing the Japanese government’s “aggressive agricultural policy” while also serving as the main product for developing the company’s UMS (Unmanned System) business into a variety of new areas of use and expanding it globally - an important point outlined in Yamaha Motor’s new medium-term management plan that began this year (three year period). In this issue, we look at the history of Yamaha Motor’s development and commercialization of industrial-use unmanned helicopters and their potential for the future.

Creating an “airborne spraying device” anybody can operate

Yamaha industrial-use unmanned helicopters are remote controlled and capable of being flown freely through the air to dust crops with agrichemicals or sow seeds over broad expanses of farmland or terraced rice paddies in the hills. They can be outfitted with specialized equipment to enable them to fly autonomously along pre-determined courses and can also perform non-agricultural tasks such as aerial filming/photography or data gathering with sensory equipment. With the sleek beauty of their bodies, they look so cool that they could have been pulled right out of a

Japanese *manga* or *anime*. After all, Yamaha's industrial-use unmanned helicopters were once called "aero-robots."

Yamaha Motor is known for its main products and vehicles used on land like motorcycles, and on the water with outboard motors, boats, etc. But, if you trace back the company's roots, you will find that the connection to products for the sky is actually older than both of these. During World War II, Nippon Gakki, Co., Ltd. (then-parent company of Yamaha Motor, currently Yamaha Corporation) was commissioned to manufacture wooden propellers for trainer aircraft. The "YA-1," the first Yamaha motorcycle and the product that prompted the founding of Yamaha Motor Co., Ltd., was actually manufactured using the same machining equipment that had been used for manufacturing propellers and had stood idle since the end of the war years.

The catalyst to the birth of Yamaha Motor's industrial-use unmanned helicopters was a commission in 1983 from the Japan Agricultural Aviation Association (an external organization of the Ministry of Agriculture, Forestry and Fisheries) to develop a remote control aircraft capable of performing aerial (airborne) spraying of agrichemicals. For farmers, the task of spraying pesticides and other agrichemicals on rice paddies and other crops in the hot months of summer had long been a hard, labor-intensive job that involved trudging through the flooded paddies carrying a sprayer and its heavy tank on the back. On the other hand, the alternative of using manned helicopters or light aircraft for crop dusting had its own serious drawbacks in the unwanted spread of excess chemical spray drifting onto surrounding property. A remote controlled airborne device capable of spraying closer to the ground would be a technological breakthrough that would solve the problems of both these existing methods.

However, once development work began, it soon became apparent that it was difficult to even maintain stable flight attitude of the craft in operation, much less meet the commission's requirement that it be "a device that anyone can control and operate at will" with the conventional counter-rotating rotor type of helicopter the commission called for. This made fitting an automatic attitude control device to the helicopter essential. After this realization, the development leader at the time proposed separately developing a helicopter different from the conventional counter-rotating rotor type. "Let's try using the already proven technology in radio-controlled model helicopters for hobby use to develop a regular type of helicopter for crop dusting that doesn't require an automatic attitude control device to operate." Enlisting the cooperation of Japan's top maker of model helicopters, the team then set about the work of drawing up basic design plans.

Then in 1986, the prototype "R-50" unmanned helicopter powered by an 11 hp, 100cc engine from a Yamaha racing kart was successfully flown for the first time. After further progress was made in the maturity of the R-50's systems, an in-company presentation was held with members of top management in attendance and the outstanding performance of the helicopter was demonstrated.

Crop spraying with the "R-50" industrial-use unmanned helicopter. This photo shows how downwash from the main rotor helps distribute the spray of agrichemicals. The sprayers and other components mounted are all specially developed for each body type to further increase operational efficiency.

Eventually, the Japan Agricultural Aviation Association also recognized the R-50 as a model to replace the conventional type of crop dusting helicopter.

The decision was made to commercialize the R-50 and 20 units were produced for test marketing in 1987. Then, with the release of the improved mass-production type R-50 in 1989, the market grew rapidly. Later, the Yamaha RMAX series (released in 1997) and now the FAZER have continued to be the standard models of industrial-use unmanned helicopters in Japan.

"The advantage of the R-50 was the compact body it had despite its hefty 20 kg payload capacity. It's just the right size to fit in the back of a light pickup truck for

taking it to the fields to be sprayed, which makes it very easy to use," explains the development leader. "Also, the strong, lightweight fully covered body can be painted in colors that stand out from a distance when in use on larger fields, important in ensuring good visibility for the remote control operator. The sense of size and the design concept of that original body has been inherited by our later models, even as they underwent major advances in performance and multi-functionality," he adds with a proud smile.

The people and skills for "assurance in operation" were the key

Using unmanned helicopters for spraying agrichemicals makes it possible to use the downwash from the main rotor to minimize unwanted blow-off or drift of the spray, and get an even spread of the chemicals on the target area. Also, the aircraft's capability for tight turns shortens work time and greatly reduces the workload on farmers, giving them more time for other tasks. It is said to take an average of 160 minutes to spray a hectare of rice paddy with a conventional motorized sprayer, but with the latest FAZER model, the same job can be done in about ten minutes. In Japanese agriculture where there is a lack of workers and the average age of farmers continues to rise, the appearance of unmanned helicopters was clearly good news for the industry.

However, there was one big obstacle inhibiting the spread of these helicopters' use: getting people to acquire the skills necessary for operating one. Among the various types of radio-controlled models, helicopters are the most difficult to operate. Compared to radio-controlled standard helicopter models of less than a meter in length, the movement of the R-50 is smoother and gentler and thus easier to fly, but it is still not as easy as operating a farm tractor. For this reason, in addition to gathering experienced model helicopter operators from around the country to form teams of contracted crop sprayers, Yamaha Skytech Co., Ltd. was established in 1988 to specialize in sales and maintenance of the R-50. Working with the agriculture cooperatives, agricultural machinery companies, etc. around the country, a nationwide service network was set up and the "Skytech Academy" was organized to train operators. This enabled agriculture cooperatives and farmer groups in regions all over the country to acquire and operate their own unmanned helicopters without depending completely on the teams of professional crop sprayers.

The "Skytech Academy" caused a big increase in the number of qualified unmanned helicopter operators. This is a group receiving on-site training in helicopter operation.

Another thing that helped accelerate the spread of the R-50 was the completion of the Yamaha Attitude Control System (YACS) in 1995. If the operator makes a mistake while flying the helicopter, this system automatically returns the helicopter to hovering, simply by removing the fingers from the controller. The system gave the operator great assurance when flying the aircraft and brought the unmanned helicopter a giant step closer to the original goal of creating "a device that anyone can control and operate at will."

With this technological advance, the number of qualified operators grew from roughly 3,000 at the time of the YACS introduction in 1995 to some 6,000 in 2000, particularly with a rapid increase in the number of farmer wives and next-generation farmers becoming operators. Recently, there has also been an increase in the number of agricultural colleges that teach unmanned helicopter operation as part of their curriculum, bringing yet another bright source of inspiration to the future of agriculture. These types of know-how contributing to the spread of unmanned helicopter use will also play an important role in promoting sales and expanded use of the helicopters overseas as well.

Providing a solution and presenting endless possibilities

With the implementation of YACS and the big leap in flight stability it enables, Yamaha began pioneering markets in new fields other than agriculture. Mounting equipment like cameras and sensors instead of liquid or powder sprayers, it was possible to develop markets offering solutions for filming or conducting surveys, etc. by taking full advantage of the benefits of an unmanned helicopter to fly over places where people couldn't go.

The initial impetus came from research launched in the mid-1990s to observe rice paddies from the air in order to monitor the growth of the rice crop and provide early detection of pests threatening the crops. If operations are within the range of view of the naked eye up to about 150 meters, the helicopter can be flown to the target point and finer operations not clearly visible can be aided by means of cameras and GPS, but operation is not possible for flights beyond the range of vision or in misty or smoky conditions. So, in order to enable operation beyond the range of the naked eye, advance research and development was begun on an autonomous flight system that would make it possible for the helicopter to fly along a pre-programmed course automatically.

Once the prototype equipment was developed, continuous tests were being run on the autonomous flight system within visible range, and then an unexpected opportunity arose to try out the system in practical use. In March 2000, there was a volcanic eruption at Mt. Usu on Japan's northern island of Hokkaido. The eruption threw up huge amounts of rocks and ash that enveloped the surrounding area. In the no-entry zone, frequent small eruptions and release of noxious gases continued, making it impossible to even do surveys of the area for more than half a month.

At the request of the Public Works Research Institute of the Ministry of Construction (at the time), Yamaha Motor brought its "RMAX G0" unmanned helicopter equipped for autonomous flight to Mt. Usu. It was then sent up on approximately one-hour flights over a pre-programmed course of 1.5 km each way sending back video footage and still images of the topographic and geologic conditions on the mountain in real time to the ground operations base. This great achievement of practical use of an autonomous flight-equipped unmanned helicopter beyond the range of human vision was a world-first at the time. This achievement brought official recognition and one year later, the Hokkaido Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism placed an order for two RMAX G0 autonomous flight-equipped unmanned helicopters. The successor models to these units are in use today, performing surveys of rivers, observation and surveying at natural disaster sites, demonstrations at disaster preparedness events and more. In other examples, autonomous flight-equipped RMAX series helicopters have been used for surveillance of illegal dumping of wastes in the foothill areas around Mt. Fuji (2002) as part of preparations for its eventual registration as a World Heritage site, environmental surveys of the tidal flats on the coasts of the southern island of Kyushu and placing seismometers and measurement of terrestrial magnetism on the Shinmoedake volcano in Kirishima, Kyushu. The great potential of these helicopters was also shown when they were used in flights to monitor radiation released around the damaged nuclear power plant in Fukushima after it was hit by the Great East Japan Earthquake and Tsunami and closed off as a no-entry zone.

A scene from when an unmanned helicopter was used in the town of Hirono in Fukushima Prefecture to monitor the amount of radiation released.

However, the primary uses of the industrial-use unmanned helicopter are still in

agriculture. The total number of registered Yamaha unmanned helicopters for agricultural use was about 120 units in 1991, and the total area of cultivated land they were spraying was about 8,000 hectares. By the year 2000, those figures had reached 1,100 registered units covering more than 260,000 hectares. As of 2013, a total of 2,458 Yamaha industrial-use unmanned helicopters are registered, primarily of the RMAX series models, the successor to the R-50. In terms of rice paddy spraying alone they cover a total area of over one million hectares, or around 35% of the country's rice paddy area under cultivation. By simple calculation, this means that one in every three bowls of rice served in Japanese homes has been grown with the agrichemical pest control spread by a Yamaha unmanned helicopter.

In fields of agriculture other than rice paddy cultivation as well, Yamaha Motor has been working with a variety of research institutes and organizations to expand the use of unmanned helicopters. The aim is to contribute to the development of agricultural technology that improves efficiency and profitability as well as relieving farmers of some of the hard and stressful work associated with farming. While expanding the range of crops that can be sprayed to include fruit orchards, vegetables, wheat/barley and soy beans, etc., Yamaha has also been working to consolidate a rice paddy cultivation system in which all of the work except the final harvesting can be performed with an unmanned helicopter.

The direct sowing of rice seeds to paddies is one area that has drawn particular attention in the industry recently. In Japan, rice is generally grown by transplantation in which the rice seeds are first germinated in nursery trays and raised there into seedlings of a certain size before being transplanted to the flooded rice paddy. If the seed rice, once coated with iron powder or hydrated lime, could be sowed directly into the rice paddies by an unmanned helicopter, this method would eliminate the cost and labor of raising seedlings in nurseries. It would also reduce the percentage of failed planting (the seedlings' roots fail to take hold in the paddy soil and the seedling ends up floating in the paddy). Although there have been few examples of this new sowing method in use and the methods have not yet been perfected, the Japanese government formally adopted a growth strategy in June 2013 that calls for achieving a 40% reduction in the cost of rice production compared to the current national average, which adds impetus to efforts to perfect the method. About the future developments of Yamaha's UMS business, a sales representative says, "The new FAZER model introduced in 2013 adopts new technologies and reflects feedback from the development of our autonomous flight technology until now. It also achieves easier and safer operation than ever before in functions like speed control. Our next objective is to put the technology and know-how we have developed here in Japan to use in the skies of countries around the world. In the Republic of Korea, where rice paddy cultivation is done on a large scale, we have introduced more than 150 units of the RMAX in the last ten years and they are now used for things like spraying agrichemicals and spraying disinfectants for preventing foot-and-mouth disease on livestock farms. In 2011, we also introduced our helicopters in Australia, where they have been put to use in weed extermination on ranches, mining sites, on dam walls, around high voltage power lines and more. Experimental use aimed at eventual adoption of the helicopters has also begun in the U.S. for growing grapes at vineyards and in Thailand for rice paddy cultivation. Our hope is to see expansion into even more areas of business. I think this can be realized by using the FAZER and RMAX as platforms, and combining the equipment, software and know-how for operation from the agricultural and solutions fields in ways that suit a variety of purposes and environments."

In Australia, the helicopters are being used for weed extermination in places that can't normally be reached by people.

Message from the Editor

Rice is the staple food of Japan and you'll almost always find it on the dinner table here. The history of rice paddy cultivation in Japan goes back to ancient times, and for centuries rice was the symbol of wealth and the standard means of taxation. Even in Japan today, rice remains one of the central factors in the relationship between agriculture and politics. It's so meaningful to me to see how a Yamaha product is contributing not only to the smooth growth of delicious rice but also helping to reduce the burden of labor on the farmers. In this way, Yamaha Motor products have a reach that extends to the sea and the sky. And now, we're about to see Yamaha's new vehicles for the future unveiled at the Tokyo Motor Show. The Yamaha Motor press conference will take place on November 20th (JST) and we will be sending you information complete with free downloadable photos. As we move on from the past and into the future, I hope you'll look forward to seeing the new challenges Yamaha Motor is taking on.

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