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EVALUATION OF ECONOMIC EFFICIENCY OF PROCESS IMPROVEMENT IN FOOD PACKAGING

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Abstract

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In general, we make gains in process by the three fundamental ways. First, we define or redefine our process in a strategic sense. Second, once defined or redefined, we commence process operations and use process control methods to target and stabilize our process. Third, we use process improvement methods, as described in this paper, along with process control to fully exploit our process management and/or technology. Process improvement is focused primarily in our subprocesses and sub-subprocesses. Process leverage is the key to process improvement initiatives. This means that small improvements of the basic manufacturing operations can have (with the assumption of mass repetition of the operation) a big impact on the functioning of the whole production unit. The complexity within even small organizations, in people, products, and processes, creates significant challenges in effectively and efficiently using these initiatives tools. In this paper we are going to place process purposes in the foreground and initiatives and tools in the background as facilitator to help accomplish process purpose. Initiatives and tools are not the ends we are seeking; result/outcomes in physical, economics, timeliness, and customer service performance matter. In the paper process boundaries (in a generic sense) are set by our process purpose and our process definition. Process improvement is initiated within our existing process boundaries. For example, in a fast-food restaurant, if we define our cooking process around a frying technology, then we provide process improvements within our frying technology. On the other hand, if we are considering changing to a broiling technology, then we are likely faced with extensive change, impacting our external customers, and a process redefinition may be required.
The result / aim of the paper are based on the example of the process improving of a food packaging quality. Specifically, the integration of two approaches: statistical process control (SPC) and quality control based on stochastic principle. Both approaches are represented in the quality control of food packaging. Based on the obtained data set of weld strength packaging films (in units of MPa) was tested by the statistical hypothesis that innovation in the implementation of the weld has a positive impact on the quality of the finished weld. From basic data analysis, which focused on the assessment of normality in the distribution of values of the parameter using the Shapiro-Wilkes test it can be seen (on Figure) that the values of A or B (is not part of the figure) welds have not a normal distribution. For the purpose of the statistical hypothesis testing Wilcoxon's test was used, which is similar to the nonparametric t-test used for dependent samples.

economic efficiency, process improvement, quality control, statistical process control, packaging technology

Packaging is the science, art and technology of enclosing or protecting products for distribution, storage, sale, and use. Packaging also refers to the *process* of design, evaluation, and production of packages. Packaging can be described as a *coordinated system* of preparing goods for transport, warehousing, logistics, sale, and end use. Packaging contains, protects, preserves, transports, informs, and sells (Burke, 1990). In many countries it is fully integrated into government, business, and institutional, industrial, and personal use.

While various factors (e.g., packaging, type of scanner, operator interaction) influence the ability to scan barcodes quickly and accurately, barcode print quality is most important. A special piece of equipment called a barcode verifier is used to check barcodes. The verifier takes nine precise quality measurements that cover various aspects of barcode print quality. The overall quality is expressed in either a numerical or a letter grade ranging from zero (F) to 4.0 (A). The higher the grade, the more likely that the symbol will scan successfully. GS1 standards set minimum quality measurements for each type of symbology and application. For example, UPC-A symbols (the most common barcode scanned at retail checkout) requires a minimum passing grade of 1.5 or a C.

The purposes of packaging and package labels

Packaging and package labeling have several objectives:

- **Physical protection** – The objects enclosed in the package may require protection from, among other things, shock, vibration, compression, temperature (Brighan, 2006), etc.
- **Barrier protection** – A barrier from oxygen, water vapor, dust, etc., is often required. Permeation is a critical factor in design. Some packages contain desiccants or Oxygen absorbers to help extend shelf life. Modified atmospheres or controlled atmospheres are also maintained in some food packages. Keeping the contents clean, fresh, sterile and safe for the intended shelf life is a primary function (Joshi, 2009).
- **Information transmission** – Packages and labels communicate how to use, transport, recycle, or dispose of the package or product. With pharmaceuticals, food, medical, and chemical products, some types of information are required by governments. Some packages and labels also are used for track and trace purposes (Roger, 2007).
- **Marketing** – The packaging and labels can be used by marketers to encourage potential buyers to purchase the product. Package graphic design and physical design have been important and constantly evolving phenomenon for several decades. Marketing communications and graphic design are applied to the surface of the package and (in many cases) the point of sale display (Roger, 2007).
- **Security** – Packaging can play an important role in reducing the security risks of shipment. Packages can be made with improved tamper resistance to deter tampering and also can have tamper-evident features to help indicate tampering. Packages can be engineered to help reduce the risks of package pilferage: Some package constructions are more resistant to pilferage and some have pilfer indicating seals (Joshi, 2009).

MATERIALS AND METHODS

Statistical hypothesis means an assumption about the parameters or the shape of the analysis of the statistical distribution of characters in the population. On the basis of random selection, acquired from the examined population is examined, whether identified by the statistical hypothesis is true or not. Statistical hypothesis being tested is called the null hypothesis H_0 and call her. We build an alternative hypothesis H_1 building hypothesis H_0, which denies the validity of the null hypothesis H_0 (Seger, 1995). Statistical hypotheses can be tested for using two sets of tests: parametric and nonparametric. Parametric tests are based on certain assumptions about the nature of the distribution (normality distribution) random variables studied. For a number of characters is violated normality distribution, it is appropriate to verify the validity of this assumption, the appropriate test (e.g. Shapiro-Wilkes-test). Nonparametric tests are used to verify hypotheses concerning the claims of the law division of the population (without knowledge of its parameters). These tests do not meet any or almost no assumptions about the nature of the distribution of studied variables. Usually only requires the distribution of random variables examined were continuous type (Seger, 1995).

For the analysis the statistical software Statistica, version 8 was used, which was chosen for testing on the significance level $\alpha = 0.05$.

RESULTS

Based on the obtained data set of weld strength packaging films (in units of MPa) was tested by the statistical hypothesis that innovation in the implementation of the weld has a positive impact on the quality of the finished weld. From basic data analysis, which focused on the assessment of normality in the distribution of values of the parameter using the Shapiro-Wilkes test it can be seen (on Figure) that the values of A or B (is not part of the figure) welds have not a normal distribution. For the purpose of the statistical hypothesis testing Wilcoxon's test was used, which is similar to the nonparametric t-test used for dependent samples.

The results of the test given in Table II show that the type of weld made provides no statistically significant difference ($p = 0.13615$). Innovations in the implementation of the welding process do not affect its strength.

Economic Evaluation of investment into production technology innovation

Net Present Value Method is based on discounting, i. e. on the re-count of cash flows from various periods to the same period from the point of view of time (usually to the year of the investment outset), (Tsao, 2011). The calculation is realized by means of interest rates (discount rates). Net Present Value expresses the difference between the present

I: *Results from weld strength experiment*

Standard trial **Randomized trail**	1 23	2 5	3 14	4 6	5 12	6 1	7 39	8 24	9 8	10 25
A weld [MPa]	2.147	2.32	2.323	0.283	0.275	0.2195	0.293	1.958	2.38	2.275
B weld [MPa]	x	x	x	x	x	x	x	x	x	x
Standard trial **Randomized trail**	11 26	12 13	13 29	14 36	15 22	16 7	17 37	18 28	19 32	20 30
A weld [MPa]	2.056	3.008	3.064	2.841	4.249	3.23	3.2849	3.274	2.947	3.62
B weld [MPa]	x	x	x	x	x	x	x	x	x	x
Standard trial **Randomized trail**	21 42	22 45	23 17	24 46	25 9	26 43	27 2	28 31	29 41	30 11
A [MPa]	4.415	2.255	1.981	x	x	x	x	x	x	x
B [MPa]	x	x	x	2.057	2.575	1.701	2.075	2.23	1.951	2.074
Standard trial **Randomized trail**	31 35	32 15	33 27	34 34	35 33	36 18	37 44	38 3	39 38	40 40
A [MPa]	x	x	x	x	x	x	x	x	x	x
B [MPa]	2.589	2.053	2.259	1.979	4.456	4.246	2.901	4.533	4.002	3.984
Standard trial **Randomized trail**	41 16	42 20	43 4	44 21	45 19	46 10	47	48	49	50
A [MPa]	x	x	x	x	x	x	x	x	x	x
B [MPa]	4.274	3.407	3.82	3.266	1.883	1.924	x	x	x	x

II: *Results of statistical test*

Pair of criterion	**Wilcoxon paired test** **Marked tests are significant at the level p < 0.05000**		
	No	**Test Criterion**	**Level of p**
"A" Weldr & "B" Weld	23	108.0000	0.361533

value of yearly revenues flowing from investment and source expenses for investment.

In general, Net Present Value (NPV) is determined according to the following relation:

$$NPV = CFS - IN, \tag{1}$$

where:
IN .... Total Investment Costs
CFS.. Present Cash Flow (Present Value of Cash Flows).

Present Value of Cash Flows is determined by the sum of cash flows in single years cleared by real decrease of nominal values through discount rates:

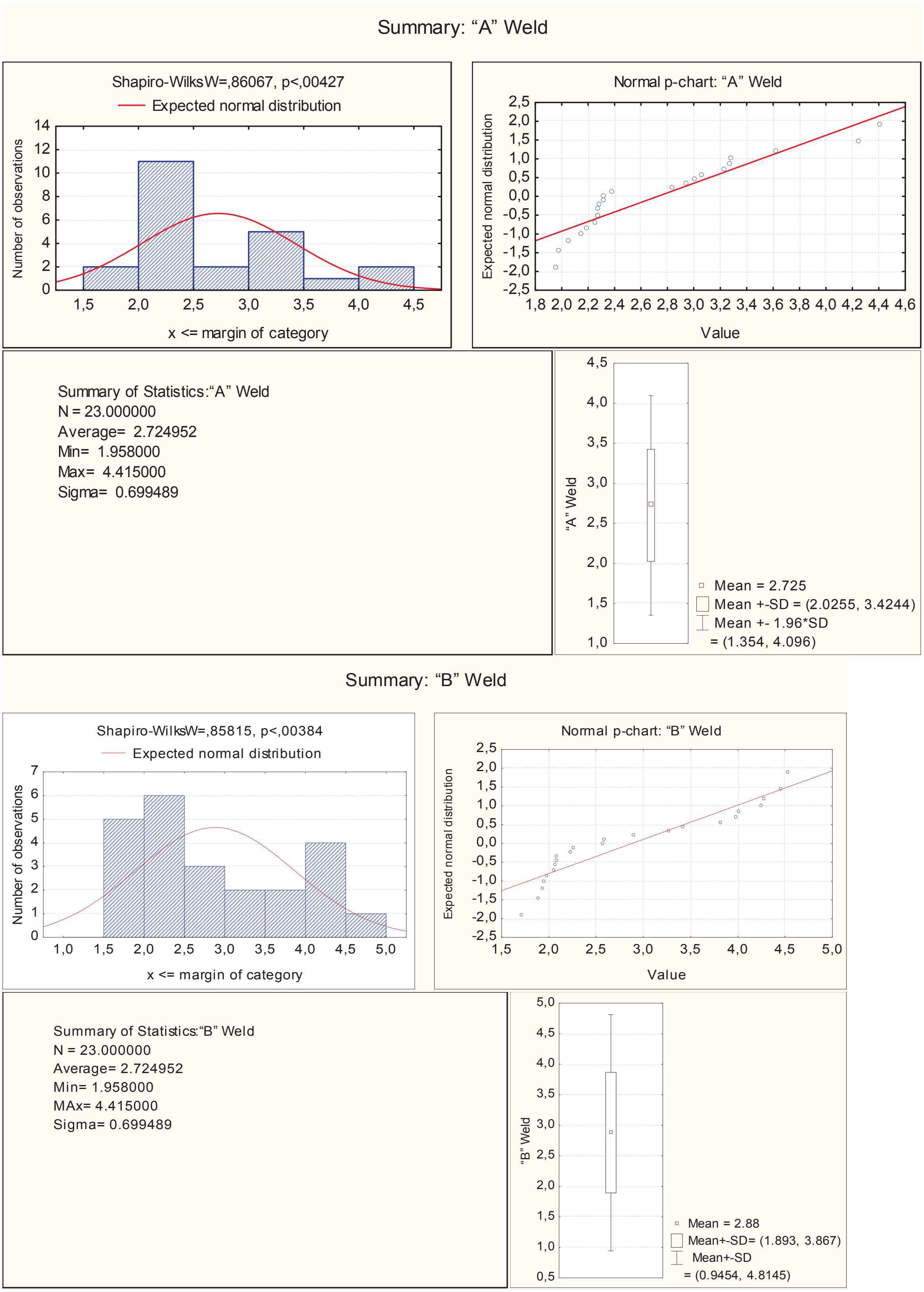
$$CFS = \frac{CF_1}{(1-r)} + \frac{CF_1}{(1-r)^2} + \ldots + \frac{CF_n}{(1-r)^n}, \tag{2}$$

where is:
r........ Interest Rate,
CF_t ... Cash Flows in time periods, in years t (t = 1 to n)

Investment projects, whose Net Present Value (NPV) is bigger or equal to 0, are acceptable from the point of view of economic profit.

DISCUSSION

We cannot remain in old structures and formalized methodologies rigidly during changing external environment, so as in management, technology, etc. In a rapidly changing outer environment, it is not possible to rigidly persist on obsolete proven structures and formalized methodologies, whether it is the way of management, manufacturing, product assembly etc. Only those enterprises that are ready and able, if need be, to accept innovation processes at the right time and immediately realize them, have the chance to survive and develop themselves successfully in the conditions of turbulent changes of ambient factors. Innovation processes are not the exclusive domain of an entrepreneurial sphere. It is not possible to realize every innovation because the sources of the organization are limited. That is why it is important first of all to verify the purposefulness of innovation for instance by means of statistical testing if another production technology represents the significant improvement of a qualitative feature of production. Furthermore, it is proper to verify if the qualitative feature, which we have improved, represents the factor to which potential customers sensitively react (by means of market research). If we verify the purposefulness of innovation in this way, it is necessary to verify its economic effectiveness; for instance by means of the application of a proper method for investment into innovation evaluation.



1: *Graphical interpretation of the statistical test*

SUMMARY

The complexity within even small organizations, in people, products, and processes, creates significant challenges in effectively and efficiently using these initiatives tools. In this paper we have tried to place process purposes in the foreground and initiatives and tools in the background as facilitator to help accomplish process purpose. The aim of the paper was based on the example of the process improving of a food packaging quality. Based on the obtained data set of weld strength packaging films (in units of MPa) was tested by the statistical hypothesis that innovation in the implementation of the weld has a positive impact on the quality of the finished weld. From basic data analysis, which focused on the assessment of normality in the distribution of values of the parameter using the Shapiro-Wilkes. For the purpose of the statistical hypothesis testing Wilcoxon's test was used, which is similar to the nonparametric t-test used for dependent samples. The results of the test given in Tab. II show that the type of weld made provides no statistically significant difference ($p = 0.13615$). Innovations in the implementation of the welding process do not affect its strength.

If in a statistical test another technology in the realization of the seam was proved to be purposeful (i. e. significant increase of the seam firmness would occur), we would reach a decision-making problem. This quite frequent decision-making problem is based on the consideration whether technically significant improvement of a product will be economically effective. Net Present Value Method of Investments is relevant to a conventional way of judging economic efficiency of the investment.

Net Present Value is based on discounting, i. e. on the re-count of cash flows from various periods to the same period from the point of view of time (usually to the year of the investment outset).

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