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APPLYING SYSTEM THEORY TO IMPLEMENT QUALITY MANAGEMENT SYSTEMS

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ABSTRACT
A system, consisting by linked processes is designed and implemented for the purpose of efficiency, to control external perturbations in the most convenient way so at the end to get the maximum profit. In this paper are explored the similarities and the differences between designing an automatic system and implementation of quality management system within an organization. The understanding of this subtle resemblance assume at the beginning an analysis of the specific methods applied within the system theory and quality management, and then a consequently tracking of the membership of the quality system theory as a subordinate class of the system theory, in general. Basically, the structure of an entire organization is scanned to track all the parallel, but connected systems that activate to achieve the prescribed performances: financial, logistics, productivity, motivation, quality, marketing and development.
Keywords: process approach, poka-yoke, FMEA, system design

1. INTRODUCTION
Based on networks and communications theory, with a growing impact on day-to-day life, automation is the center of nowadays society. From coffee-making to abroad communication, everything includes the self-adjustment concept, 6-sense technology or predictor-corrector method linking separate items of a community into a complex and solid system. Home-cooking devices, hardware and computer software, cars and aircrafts, machineries and components must assume no defect or flaw. To achieve this goal, the manufacturers apply consequent two methods: automation and quality assurance procedures. The first method is studied for a long time as a part of the system theory and many breakthroughs were attained, improving productivity and efficiency of the manufacturing process. The second method is in place to prevent defective products to reach the next process. Many studies, articles, books were written by different engineers and scholars, parallel methods or theories were developed by independent companies (Motorola, General Motors, Ford, Toyota), sometimes with the same purpose and on the same ground (for example mistake-proofing and poka-yoke), but this work looks rather inconsequent and spread all over the world. A systematically approach, deletion or unification of the similar methods and subordination to the superior class of system theory will give transparency and consistence, making the quality management systems attainable for all companies. The purpose of this paper is only to mark several milestones between quality system theory and automation and point out some of the method’s resemblances.

2. PROCESS APPROACH

The first similarity that strikes any person that studies the system theory and is familiar with quality management systems is process approach – black-box model (fig 1). Basically, to understand and control with success any system, it must be split into simple processes, that alter in one step the input into the output [1].This transformation is usually described by mathematical equations, named transfer functions.

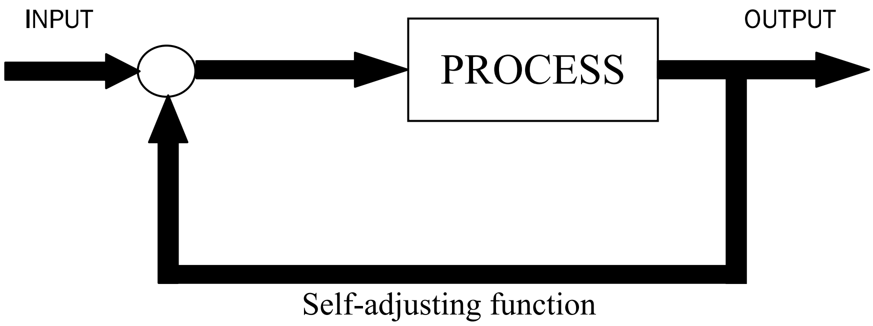

Figure 1. INPUT-STATE-OUTPUT model with feedback function

In the same manner the manufacturing process (including logistics, financial, controlling and development) is seen as a continuously and inseparable chain of processes and sub-processes, that concur to achieve the same target – acceptable end product/ service [2].

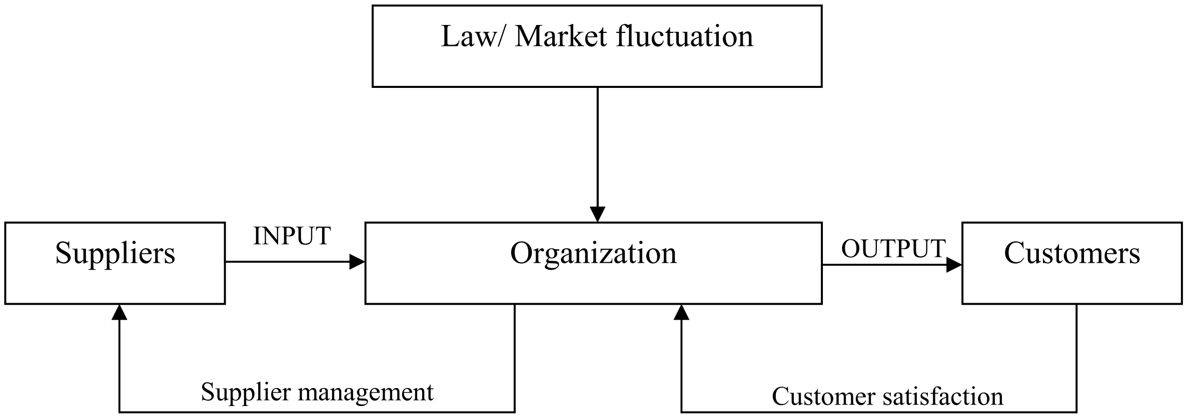

Figure 2. Process aproach

The systems assume the use of control strategies for a fast transition and a dynamic adjustment of the output to different external perturbations and to distinct specifications, depending on the inputs. Kélada [5, 6] consider that any organization setup a series of strategical objectives (economical, social, technical, commercial) that are achieved through operational objectives. Following the operational objective and dividing further the organization into sub-processes, we will detect a series of base-units that add step by step value on the input to the output, have a supplier-customer relationship and accomplish singular functions [3]. To this point converge all M's (Method, Man, Machine, Materials, Milieu, Measurement) of the cause-effect diagram (Ishikawa [7]) and if are applied to this point the preventive solutions for 0-defects are the most effective.

3. SYSTEM DESIGN

Starting with development of a certain product, in different stage of production are established inspections to avoid defects. These checks are gathered in the control plan and for each operation a RPN (risk-priority-number) is defined. This is the designing phase of a production process, but the validation of the model come up only after is tested under normal condition and its robustness is proved by critical tests. From the designing table it is impossible to foreseen all possible failure modes, but what is important is to develop a process with feedback function, in order to be possible corrections and improvements with minimum costs. In the same way as an automation engineer design the control system with modular structure, an organization must define and split its processes in such manner that a malfunction in one base-unit has minimum impact to the entire system and improvements are implemented with low efforts.

The variables of a quality management system are different by nature: machinery and design failure – systematical; human mistake and customer satisfaction – subjective; market fluctuation and risk management – random and uneven occurrences. This multi-variable, stochastic system with incomplete inputs requires a fuzzy approach, more then a classic control theory. If all variables that input a process are seen as a single, complex stream and each variable address and activate different process steps and the output as dual: product and information, the entire system can be illustrated as following:

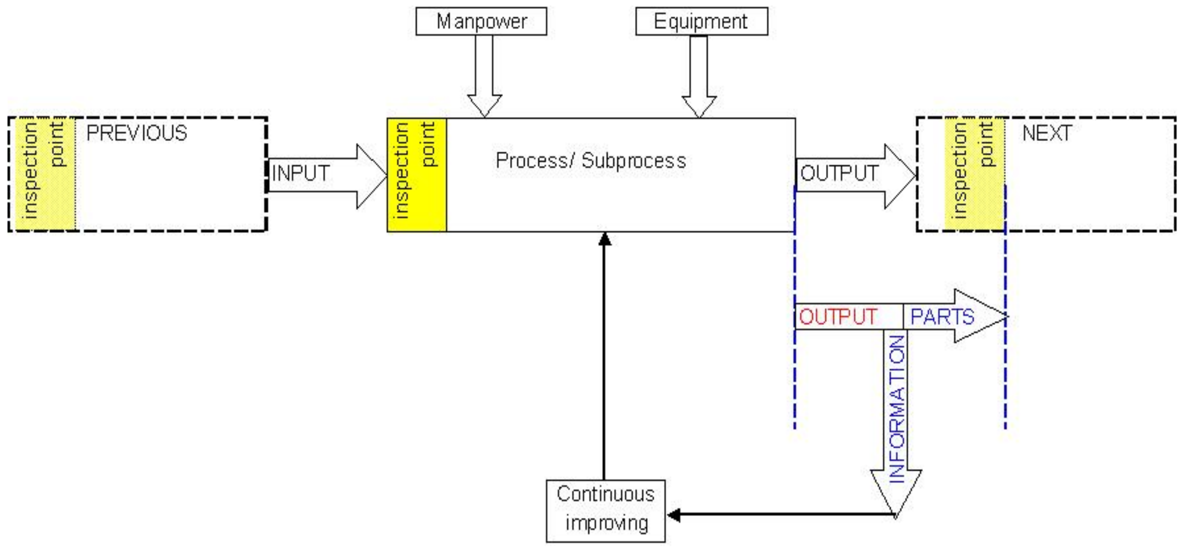

Figure 3. Base-unit of the manufacturing process

For each processes the developers create a FMEA (Failure Modes and Effects Analysis), where the process is further divided into single operation and steps and for each operation a quantified probability of failure is assigned (RPN). Based on the FMEA the control plan (CP) is defined with individual points for items with the highest RPN and the frequency of the check. The binomial FMEA-CP acts as a network for the input stream (mainly materials) that must filter all errors, in order to attain 0 defective parts at the end of the production process and minimum scrap. Every defective part, that passes out of the manufacturing organization or high scrap numbers are a failures of this network at each production stage. Getting back to the initial comparison a defect part out of a quality system is similar to an abnormal function of an electrical system under normal condition. In the nodes of the network are individual operation with a RPN assigned and the connectors giving the normal flow of the product (the correct sequence of steps). Improving such a network means to take the nodes with highest RPN and to define an error proofing application (Poka-yoke) in order to have low activation (low error-risk when the material passes). The error proofing application can change not only the operation itself, but also the layout of the network and the material that enter the network. This improvement process is continuously due to the fact that a change of the process structure can bring other error source. In the same manner as an automation engineer has a stationary error target when he design and implement a system, a manufacturing process must setup a quality target (usually counted in ppm – defective parts per million [4]) and regular measurements of the quality level (annually – monthly – weekly) help the management to take the proper decisions to reach the targets. Under the pressure of the market, the customer demands narrow to 0-defects and low prices, meaning that as a living been, an organization must develop further instruments to face this ever-changing environment or to sharpen the currently used methods to the limit.

4. CONCLUSIONS

Different organizations developed different solutions and methods to face the harsh market fluctuations, to increase productivity and reliability of the processes, to meet the customer requirements and to achieve supremacy over the concurrency:

- Toyota production system (5-way's – to detect the root cause; 5S – to reduce waste and to increase the productivity; KAIZEN – to improve the processes and the work environment and to involve all employees in the product responsibility;
- 6-SIGMA developed by Motorola to reduce the internal scrap and to attain 0-defects at the Customer [4];
- FMEA used first time by the US military to evaluate the risks of the missions;
- APQP, MSA and SPC by GM, Ford and Chrysler tools that proved over the years the efficiency in such way that all North-american and European companies submit to use them;

In this moment, on the market, are present 2 quality schools that develop in parallel methods and tools, sometimes only the terminology making the difference (the US-quality school with the arrowhead represented by AIAG and the Japanese school illustrated by Toyota production system).

5. REFERENCES

[1] Ştefan Dan: Teoria Sistemelor, Braşov, Romania, 2005.,

[2] Natalia Filip, Cristin O. Morariu, Ion Popescu: Ingineria şi managementul calităţii, Braşov, Romania, 2003.,

[3] Deming W. E.: Quality, Productivity and Competitive Position, Cambridge , UK, 1982.,

[4] JURAN, J., M.: Ouality Control Handbook, McGraw – Hill, New York, USA, 1988;

[5] KÉLADA, J.: La gestion intégrale de la qualite. Pour une qualite totale, Edition Quafec, Québec, Canada, 1990.,

[6] KÉLADA, J.: Qualité totale et gestion par extraversion, in "Gestion", feb.1991.,

[7] ISHIKAWA, K.: What Is Total Quality Control? The Japan Way, New York,1985.