AGILE MANAGEMENT BASED ON MODULARIZATION OF PRODUCTS AND PROCESSES

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Abstract

Currently, to withstand on the market and especially to make profits, companies must be able to modify their production strategies in order to respond quickly, with quality products at minimal costs. The company's management should be innovative and agile. Modularization is a key strategic option in order to enables production to integrate new consumer demands quickly and efficiently. Considering these issues and succeeding to create an interdisciplinary collaboration between economic and engineering fields, we made an analysis to verify if the modularization can be widely adopted, at convenient cost and offering a high technical precision. With this paper we consider that we done a step forward to find optimal solution so that modularization become a successful response in an agile environment.

Keywords

agile management, modularization of products and processes, modular design, economic efficiency.

JEL Classification

L15, L23, M11, O14, O32.

Introduction

Open and honest orientation towards solving customer problems is the key that opens the door to management success. In business, there are two main ways to create and sustain superior long-term performance: exceptional customer care and constant innovation.

A company that adopts the concept of agile management as a philosophy sees the principal driving force behind its work, considering that the business can survive only if it manages to satisfy the customers' needs. In a modern economy, buyers can choose what, when and where to buy or whether to buy a product or not.

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Thus, to be successful in attracting consumers, the logical starting point for the company is to identify what customers want and then try to meet these requirements in a more efficient manner than the competition. In order to do that, the *company's management should be innovative and agile.* Market dynamics determined organizations to develop a new approach called *Agile Performance Management* combined with agile manufacturing and based on the skills, attitude and the ability of the employees to innovate and drive changes. These skills should be built over time and performance management that is successful will be focused on constantly developing.

Agile management, or agile process management, or simply agile refer to an iterative, incremental method of managing the design and build activities for engineering, information technology, and other business areas that aims to provide new product or service development in a highly flexible and interactive manner (Moran, A, 2015, p.254).

In 2001, Jim Highsmith set up the basic principles of agile management included in his Agile Manifesto. According to his view, there are 12 principles, as can be seen in figure 1.

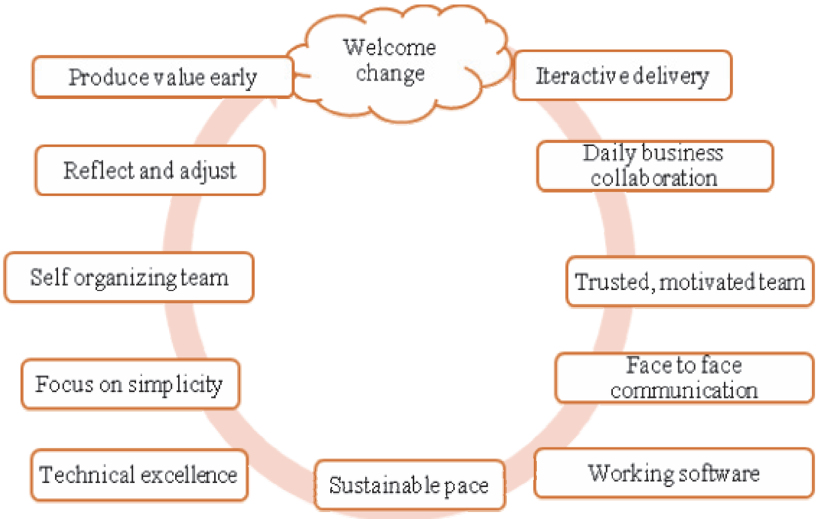

Fig. no. 1. The main principles of agile management

In the knowledge-based economy, 21st century organizations learn how to adapt their human resources, products and manufacturing processes to the rapid changes occurring in consumer demand. Thus, it appeared and developed the concept of *agile manufacturing based on the modularization of products and processes*.

Agile Management based on modularization of product and processes are designed for the new world of work, it shifts the focus from annual evaluation and rankings to continuous feedback and development. It is more collaborative, social and faster moving.

The importance of customer satisfaction became a main focus when competing with other products as only the companies that consistently satisfy customers survive in the competitive market. In such a situation, competitive companies not only segment customers to several groups, but also they provide customized products for each customer as well. In such context, *modularization of products and processes is an appropriate operational strategic option.*

The basic principles of agile management are: flexibility to the customer requirements; cooperation with the customers and internal collaboration; business values (cost, quality, parameters); teamwork; simplicity and speed of production.
The most effective practices included in agile processes are: innovative products and processes; modularization; new design and architecture; creative technologies; continuous adaptation.
The key elements mentioned above are integrated within a *methodology of agile management and manufacturing* and need an interdisciplinary approach.

Damien Power, Amrik Sohal and Shams-Ur Rahman divided the Australian organizations involved in their survey in ”more agile” and ”less agile” organizations. They provided some interesting insights into factors differentiating “more agile” organizations from “less agile” organizations.
In accordance with these aspects, we have developed an *interdisciplinary approach of agile management and agile manufacturing based on products and processes modularisation.*
However, since modularization, when implemented, is so situation specific and every project differs each time, the roles and the structure of the modularization project is very important to allow influence from all functions in a firm. The approach and adaptation of each function can be described in order to obtain *maximum synergy effects of modularization at minimal costs in resources.*
Mikkola (2003) also describes modularization quite thoroughly in her aptly named article: Managing Modularity of Product Architectures: Toward an Integrated Theory. Mikkola derives at a very scientific and concise mathematical formula of how and to what extend to modularize, which is supported by two case studies.
Later on, a structural model incorporating modular design was theorized and tested by a group of researchers from Seoul (Hwang and Choi, 2011, p.791-796). Sang-Chul Hwang and Young Choi explained why modular design methodology is a very important design methodology that allows production of the maximal types of products with the minimal types of components and extending the components’ compatibility to different types of products in order to satisfy a variety of customers.
In our view, *modularization is a key strategic option that needs interdisciplinary approach in order to enables production to integrate new consumer demands quickly and efficiently.*
In the next section of our paper we propose a specific way of approaching agile management based on modularization of products and processes.

2. Research methodology

In this article we analyzed the efficiency and also some technical and economic restrictions imposed by modular architecture products.
From an economic perspective, we done a study on the level of flexibility that companies can afford, depending on the overall cost and also, depending on amortisation period of time.
From engineering perspective, was analyzed the modular structure in terms of causes that can lead to errors. It has been shown that if the modules contact surfaces are not designed in order to avoid the clearances between modules, this aspect can lead to errors. Taking care

about this sensitive point for modular structures, we proposed a solution designed to reduce these specific errors.
This solution is based on an invention developed in University Politehnica of Bucharest (Sturzu and Popescu, 1997), and applied on modular devices.
We also argued our approach using visual properties of a Porter diagram for a qualitative analysis, based on previous research carried by authors, in which clearly highlights both the benefits and restrictions of modularisation of products and processes.

3. Studies one fficiency in modularisation- economic and engineering perspectives

3.1 Economic perspective

As shown in previous researches (Valter, Duca and Enache, 2015) in the circumstances of Agile Manufacturing, the shortening of the response time limits to the beneficiaries' requirements can be met by promoting the modular construction inside the production systems. But the modular structure has a sensitive point that should be taken into account to remain in the area of economic efficiency: the correct determination of maximum efficiency in use.
In figure 2 is emphasized area of maximum efficiency for a modular device used to control multiple pieces of types and sizes.

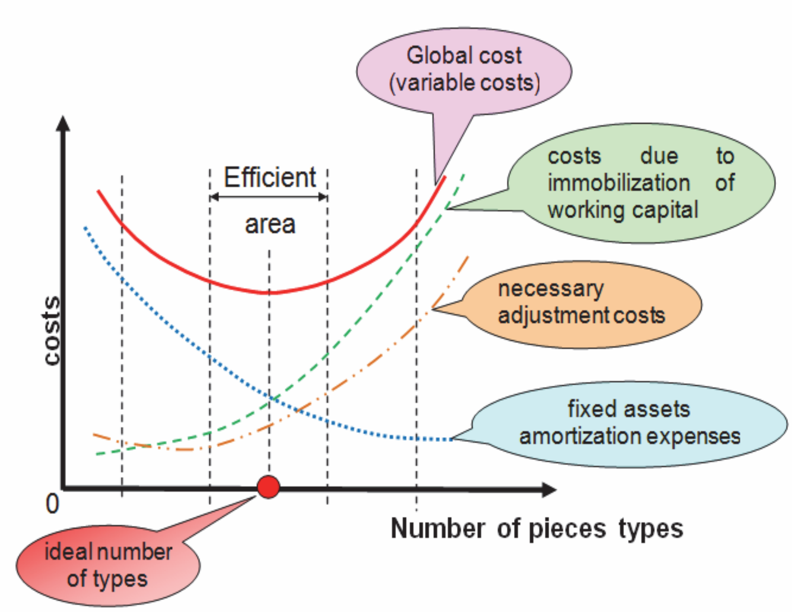

Fig. No. 2 Correct determination of maximum efficiency for modular design due to global costs and due to number of various pieces types
Source: Sturzu and Popescu, 2006

In this case study the flexibility of the system is measured by a higher or lower number of different types and sizes - named in Figure 2 "*ideal number of types*", that the modular system can serve (can process or control).

Thus, if desired to serve a large number of various types and sizes, aimed to compensate very fast the specific expenses, *can fall into a dangerous area, increasing the complexity of modular construction.* This complexity produces an unhealthy growth of necessary adjustement costs. This is a bad influence for entire global costs.
On the other hand, as is shown in Figure 2, if the flexible system with modular structure is not designed to serve an ideal number of types and sizes, *the expenses related to this process are no longer accordingly amortized.*
Extrapolating the calculation of the efficiency done allready for modular control devices (Sturzu and Popescu, 2006), we can write the formula for the efficiency of a modular architecture, by reporting to an optimal amortization period:

$$E_{ec}=C_i - C_{mod} \quad (1)$$

$$P_{am} = \frac{I_{mod} - I_i}{E_{ec} / year} = \frac{I_{mod} - I_i}{NE_{ec} / piece}, \quad (2)$$

where: C_i - cost of the process that use specialized devices - without flexible structure
C_{mod} - cost of the process that use modular devices
I_i– investments due to process by means of specialised devices- without flexible structure
I_{mod} - investments by means of modular devices;
N – annual production program, pieces/year;
E_{ec} – economic efficiency per year in ROL or in currency.
We affirm that it better to adopt a modular construction only if this relation is fulfilled:

$$P_{am} \leq P_{am_{ad}} \quad (3)$$

where Pam_{ad} is the acceptable amortisation period, which in the case of modular control devices, for exemplification is equal to ≈ 10 years (Sturzu and Popescu, 2006).

In conclusion, we can consider efficiency for a modular architecture, with high flexibility, versus a specialized architecture, without flexibility, only if the amortization period will be found in the Pam_{ad} accepted limits.

3.2 Engineering perspective
The products with modular structure and especially modular devices serving technological processes and control processes have a sensitive point that often is ignored. This have a sensitive point is named *specific error* and it is found in scientific literature noted with *ΔM* (Sturzu and Popescu, 2006).
It is known that modular structure is specially designed to enable repeated assembly and disassembly and for this reason this specific error appears due to solutions applied for mounting the modules together. In this case, often occur orientation (ε_o) and fastening errors (ε_p). At these errors is added also the error due to wear (ε_w), that occurs during entire lifetime of the analysed modular product.
The error (ε_c) that occur due to the clearances between the contact surfaces, represent the main component of ΔM and is very dangerous because may increase all may increase other errors that compose specific error ΔM. So, in case of fixed or mobile units (modules) with repeated assembling and disassembling, the specific error ΔM can be written:

(4)

$$\Delta M = f(\varepsilon_o,\ \varepsilon_c, \varepsilon_w,\ \varepsilon_p)$$

where: ε_o- the orientation error; ε_c- the error due to clearances; ε_w- error due to wear; ε_p- error due to the lack of precision of reciprocal position.

Ignoring this sensitive issue can have a bad influence in the entire process that using modular devices, by entering a critical parameter uncertainty within the serviced process.

3.3 Engineering solutions- proposal

The main task for the researchers is to find out some precise orientation and fastening methods of modular parts, in order to reduce or even eliminate the specific error ΔM.

Moving from practical studies on modular construction devices (Sturzu and Popescu, 1997) in this paper we propose to use an innovative solution of combining modules, whenever possible. In this way, the experiment proposes to use where is necessary, for orientation and fastening the modular parts the innovation called: *"the Secure Assembling principle" – SA.*

The *SA principle* (Sturzu and Popescu, 1997) consists in the *one direction taking over of clearance* (figure 3b), by using a clamping force, both in fixed and mobile mechanisms as well.

Thus, the *errors due to clearances will be totally eliminated*. Concomitantly, the errors of assembling, reciprocal position and wear will be also substantially reduced, as shown in some case studies performed. To better understand the phenomenon described above, figure 3a, shows the simplified sketch in which is observed the occurrence of the specific error ΔM in the case of classical assembly to the modules. We observed the existence of clearance that leads to other fenomenon- the wear, under the action of contact forces between modules, in case of repeated assembly and disassembly.

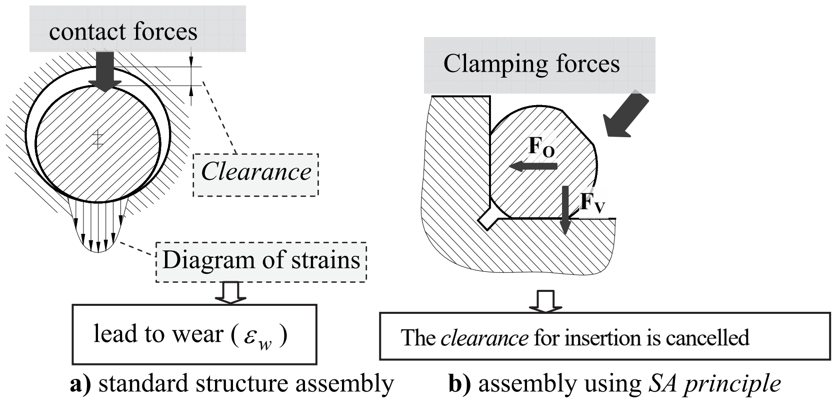

Fig. no. 3 Draft of drawings for the assembly principle between a shaft and a bore
Source: adapted based on Sturzu and Popescu, 1997

Table no 1 Strengths and advantages of modular devices with SA principle included

1	Precision and productivity advantageous elevated to perform control operations
2	Simplicity, rigidity and hightechnological construction
3	Excellent maneuverability (operation, orientation and fixing in required position of the module is in about 3-10 seconds) and safety in use.
4	Elevated flexibility and universability in use: in about 5-10 minutes may be switched from the control of one type of part to another without affecting the control precision; no high qualification needed
5	Reducing the consumption of raws and reducing the storage space of about 50-60%
6	Execution, maintenance and easy services
7	Reliability and long term usage
8	Are suitable to be total standardized or typification (at company level) and produced cost-effectively and to a high quality
9	Allow computer drawing based on certain strategies and patterns established control technology. This is based on the ability to create databases with standardized elements or typification.
10	Shortening cycle research - design - production - implementation and service, with about 60%.
11	Adaptability. Can be equipped with measuring and control devices manufactured in the country or imported.
12	High level of ergonomicity
13	Profitability 100% for small production series and prototypes; with minor adaptations can be used effectively in mass production.
14	Very large application field - in all engineering firms in for small production series and prototypes

In figure 3b, it schematically presents the *SA principle*, applied to the surfaces that serve to joining the modules. *SA* solution transforms contact surfaces in small flat areas, and the secret consists in applying a clamping force that will be decomposed in two perpendicular directions on these plane surfaces. In this ingenious way the clearance between modules is cancelled. Research done before demonstrates that the principle SA used for the design of mating surfaces of the modules, confers rigidity and high precision for entire modular ensemble.
Table 1 shows the main features, both technical and economic, modular control devices, from which we started our research.
These devices have been designed so that the modules joint surfaces to be designed and built according to the Secure Assembling principle (SA), where needed, to guide and fixed the modules with a specific error ΔM as small, even zero.
Based on Table 1 we elaborated a Porter diagram, in which has been made a comparative study between two devices; one modular and another, specialized one.

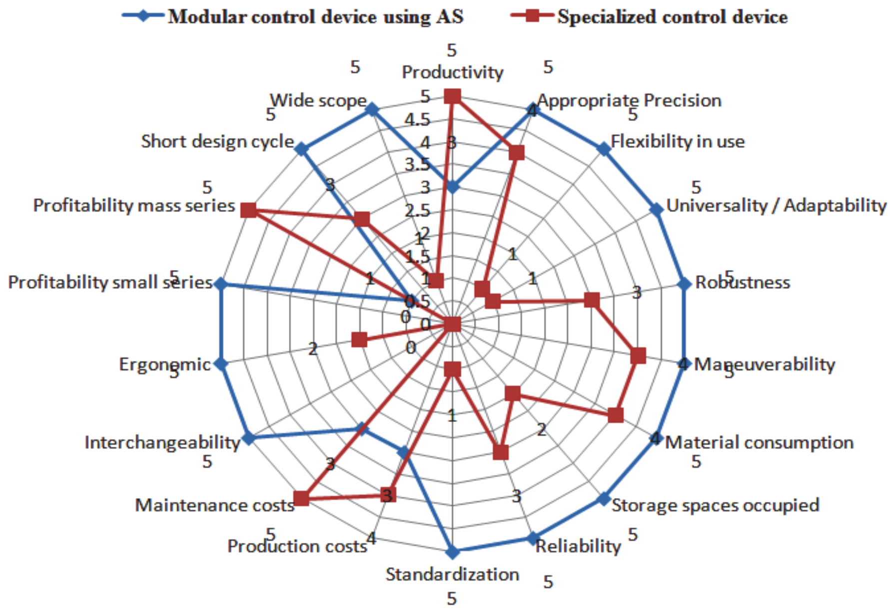

Fig. No. 4 Comparative study between two different control devices serving the same purpose

This diagram mapping clearly the advantages and disadvantages of modularization and this approach provides an important lever in agile development. This qualitative analysis using visual properties of Porter diagram, can become a practical tool in the hands of managers in order to determine if is appropriate to move towards the agile management.

Conclusions

The companies who want to give a quick answer on specific markets have to embraces the modularization of products and processes, in order to be agile. This paper argues in this sense.
We have done the study on two different directions, both in economic and engineering terms, to find a solution that combine economic efficiency with precision, in the field of modular products.
We argued the efficiency of modular architecture depending on amortization period. The modular architecture is justified to be adopted *only if the amortization period* of modular product will be found in the accepted limits. For example, in case of modular control devices, this limit is under ten years. Companies intending to use modular devices in order to increase their agility are recommended to keep in mind this aspect that we argued in this paper.
From the engineering perspective we provided a solution that will bring tangible benefits in eliminating errors that appear inherently in combining modules.
The proposed engineering solution is simple and very effective. This solution has already proven in the case of control devices. This engineering solution brought economic and technical benefits where it was used already.

Due to these arguments we want to promote this solution to be used on various types of modular products, in order to get quality and fast response to customer demands, with reasonable costs.

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