ANNALS OF FACULTY ENGINEERING HUNEDOARA
- INTERNATIONAL JOURNAL OF ENGINEERING
Tome IX (Year 2011). Fascicule 3. (ISSN 1584 - 2673)

[1.] Peter FILÍPEK, [2.] Ladislav GULAN, [3.] Gregor IZRAEL

THE EVALUATION METHODOLOGY OF MODULAR STRUCTURES OF MOBILE WORKING MACHINES BASED ON TECHNICAL AND ECONOMIC INDICATORS

[1-3.] SLOVAK UNIVERSITY OF TECHNOLOGY, FACULTY OF MECHANICAL ENGINEERING, SLOVAKIA

ABSTRACT: Very important for a mobile working machine producing company is the information about the degree of the utilization of particular building modules, but also the information about the relation between costs invested on design activities and return on investestments from produced machines. Article deals with the methodology of flexible variant solutions, their evaluation and finding of technically and financially acceptable variants representing future production program. The modularity enables us to achieve required diversity of products, a large number of variants and configurable options. In this time, the trade field is highly saturated, so the theme of creation of a modular flexible design is very needed for next development of a prosperous modern company.
KEYWORDS: module, platform, modularity coefficient, coefficient of financial efficiency, modular structure

❖ THE MODULAR STRUCTURE OF MOBILE WORKING MACHINES

Currently, the companies engaged in the development of mobile working machines pay attention to the creation of variants of modular structures. Variants based on a common platform of basic building modules allow efficient creation of different types of mobile working machines, which are suitable for a variety of working technologies. In other words, it allows creating universal working machines, which variation is achieved by using of range of tools. In economic terms, creating a modular structure offers the following advantages:

- ☐ simplify the process of design the variant tasks,
- ☐ shortening the time needed for processing requirements,
- ☐ allow parallel work on multiple versions of the machine,
- ☐ adapt solutions to a wide spectrum of user requirements.

In practice, the modular architecture based on a common platform, flexible for user requirements, not only allows the creation of competitive solutions, but also shorten the time needed for design and technological preparation of production. These factors positively affect the logistic production chain of company, which is significantly reflected in several industries branches, especially in the automotive industry. Several factors and variables that determine the sought effective solutions affects to create a modular structure (representing the possible variants of the machine), which will be the basis for creating of a real production program. The variant solutions must meet the following conditions:

- ☐ respond to market requirements,
- ☐ create a common platform as regards of architecture modules,
- ☐ represent a technically and economically efficient solutions.

❖ EVALUATION METHODOLOGY OF MODULAR STRUCTURE USING THE THEORETICAL INDICATORS OF METHODOLOGICAL CONSTRUCTION

A Project - APVV 100-06 "Research of modular platform for oriented segment of mobile working machines" solved by the Institute of transport technology and engineering design to Faculty of mechanical engineering in Bratislava in cooperation with co-workers PPS Group, a. p. Detva deals with the task of creating a methodology of modular structures design. The result of application of this methodology for the design of modular structures in the framework of this project was to design a modular structure of the carrier HON 200 (Fig. 1), what represented the basis for determining of production program from the perspective of machine types and their sizes. The right choice of a basic machine of building series is the very important condition for creation of the most appropriate production program of the appropriateness of various machine variants. Choice may be influenced by

several factors (the chosen technology of work relating to market needs, customer requirements, the availability of the various modules manufacturers in the region, etc...). The task of the described methodology was to choose among of available variants of machines, which in various combinations together with a basic group (trinity, group of four, ..., n-tuple) are the most effective solutions for manufacturers. In order to objectification of modularity coefficient and coefficient of financial efficiency was „Modul-3M“ program created. It consists of two separate modules - MODUL1-k_m, MODUL2-k_{fe}. Their aim is to quantify these coefficients for the various variants of the production program. The program also includes an integration module MODUL3-k_c (Fig. 2). It serves to evaluate the achieved levels of technical and economic indicators of considered n-tuples.

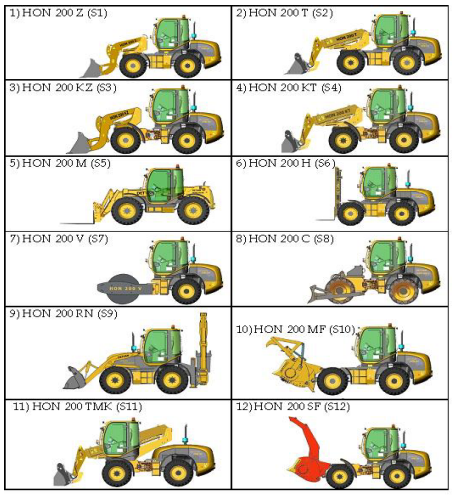

Figure 1: modular module-k_c

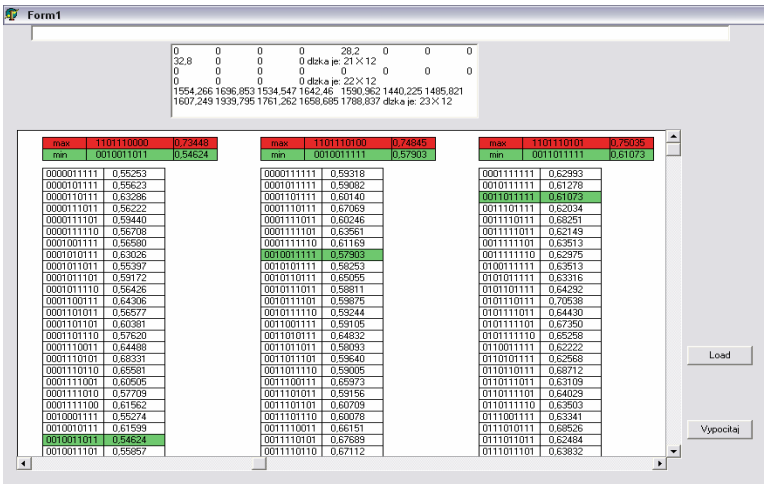

Figure 2: dialog window of program structure HON 200

In order to assess the degree of utilization of building modules and efficiency of their assembling into functional units it is needed to divide each machine to the individual subgroups - modules, forming autonomous, functionally independent parts of system, compatible with other units. Then functional assembly is composed from them. These groups of used variants of building modules are classified according to purpose to tender lists of available modules, [5]. Individual modules are simpler units. Their design is the subject of partial solutions of design tasks, or they can obtain as subcontracts from producers.

For the invitation lists of available modules for the purpose of quantification and objectification of platform we can display the individual variants of machinery through a map of modular problem [5]. This displays the utilization of basic building modules in different types of solutions. This map represents the basis for creation of a morphological matrix in the "MODUL1-k_M" evaluation program. The task of the program based on equation (1) is to determine from quantity of different variants of n-tuple of machines, which in combination with the basic machine of building series (or group) achieves the highest value of the utilization rate of building modules [5]. To determine the modularity rate a modularity coefficient -k_m was introduced for which applies:

$$k_{Mi} = \frac{PM_{ai} - PVM_{ai}}{PM_{ai} - \max_i\left(PM_{ai/jl}\right)} \quad [-] \qquad (1)$$

Coefficient "k_M" achieves positive value, $k_M \in (0 \div 1)$ and grows with the increasing usefulness of individual modules.

For a production company is very important not only the information about degree of utilization of particular building modules, but also about relation between costs, which have to be spent on design activities and revaluating of these costs into products produced in frame of a particular production program, [3]. This information is needed for assess the perspective production program, but also for decision which other products or modifications have to be included in this program. For this purpose, it was defined coefficient of financial efficiency - k_{FE}, which may provide relevant information for deciding about create a new or expand existing production program. The proposed evaluation methodology can be realized by using modified "map of modular problem", [3]. The map forms the basis for creation of a morphological matrix needed to use of the "MODUL2-k_{FE}" evaluation program. Task of this program based on equation (2) is to determine from among the different variants of n-tuple of machines, which in combination with the basic group achieves the highest value of the coefficient of financial efficiency. To determine the coefficient of financial efficiency we use the relation:

$$k_{FE} = 1 - \frac{S_V}{S_{ZM}} \quad [-] \qquad (2)$$

Coefficient "k_{FE}" achieves a positive value, $k_{FE} \in (0 \div 1)$, which grows with increasing number of identical modules in each combination of n-tuples.

From a practical point of view is rational in assessing the effectiveness of the selection of production program variants to take into account the effect of both the above criteria (k_M, k_{FE}). Their graphic representation is a "semantic evaluation of efficiency of the production program (Fig. 3). Mutual interactive assessment is decisive in selecting the most favorable n-tuples of individual variant solutions. Hierarchy of the "MODUL3-k_C" evaluation program takes into account both of the theoretical indicators of methodological construction. On this basis, we can select from the available variants, which represent "the best combination" within the meaning of relation:

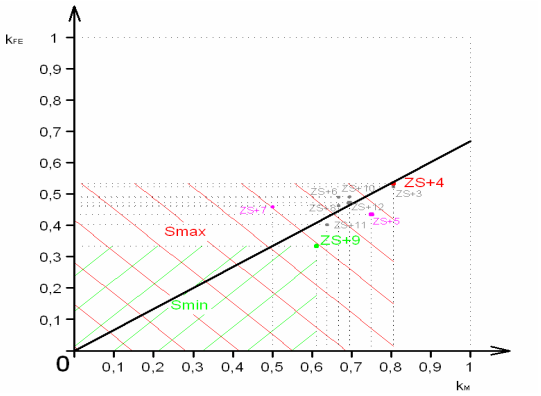

Figure 3. Semantic evaluation of the efficiency of production program of modular structure for the carrier HON 200

$$k_{Ci} = k_{Mi} . k_{FEi} \quad [-] \qquad (3)$$

Coefficient "k_C" achieves a positive value, $k_C \in (0 \div 1)$, which grows with increasing technical and economic level of individual combinations of n-tuples.

Presented evaluation methodology of the production program is about finding compromise solutions between the technical and economic aspects. It is not a rule that with increasing modularity coefficient would also increase the coefficient of financial efficiency.

The decisive factor will be the price of building modules if they are subcontracting and the cost to re-development of modules own provenance, respectively.

❖ CONCLUSIONS

To use the proposed methodology in the mechanical engineering design process machinery is necessary to know the actual situation in the field of market and the level of competition. It is necessary for company to continual monitor new and changing requirements of potential customers and on the basis of these a current production program will be created. A complex system of evaluation of possible variants of the production program based on the theoretical indicators of methodical design allows a permanent monitoring of the process of development and innovations. The contribution deals with application of the methodology of the variant structure creation on a specific mobile working machine HON 200. Application of this methodology in this case has brought the design of an effective production program, representing by a group of four till six products, their size structure included.

❖ REFERENCES

[1.] GULAN, L.: Structure Creating of building modules for a group of mobile working machines, STU Bratislave, 2008, ISBN 978-80-227-2948-2

[2.] GULAN, L., MAZURKIEVIČ, I.: Mobile working machines theory and design methods, STU Bratislava, 2009

[3.] GULAN, L., ZAJACOVÁ, Ľ., IZRAEL, G., FILÍPEK, P.: Rating of financial effectivity of modular design of mobile working machines. In: Hungarian electronic journal of sciences [online]. - ISSN 1418-7108 - HEJ Manuscript no.: MET-090212-A, nestr., Hungary, 2009

[4.] SALERNO, M., CARNEIRO DIAS, A.: Product design modularity, modular production, modular organization: the evolution of modular concepts, Politecnica USP Produção, Sao Paulo – Brazil, 2005

[5.] GULAN, L., BUKOVECZKY, J., ZAJACOVÁ, Ľ.: Verification of modularity ratio on the set of mobile working machines. In: Proceedings of the XV European conference of material handling teaching professors. 22. - 26.9. 2004, Novi Sad, p. 18 - 23. Serbia, Republika Crna Gora, 2004

ANNALS OF FACULTY ENGINEERING HUNEDOARA
– INTERNATIONAL JOURNAL OF ENGINEERING