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DETERMINATION OF BASIC TECHNOLOGICAL PARAMETERS OF MOBILE WORKING MACHINES IN MODULAR STRUCTURE

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Abstract:
The contribution deals with the use of similarity criteria and dimensional analysis in determining of main technological parameters in the process of mobile building machines design. The verification of determined criteria was performed on the set of telescopic manipulators.

Key words:
modularity, similarity criterium, basic technological parameter

1. MODULAR MOBILE WORKING MACHINES

In the design of a new structure of a mobile working machine nowadays apply mainly knowledge, which takes into account new trends of development in the area for the nearest future. In the design praxis flexible assemblies of machines assembled from unified modular building pieces apply broadly. Such structures enable positively to influence production chain in a company. Machine design responding to logistic requirements decrease production costs and substantially simplify production process itself.

By the integration of a new structure into existing logistic chain of a company, a high flexibility and ability to adjust to various requirements of users, that is variants creation, is required. Maximal use of such modular building sets contributes to competitivness of a product and maximal decrease of costs. These building sets are composed of complete sets of functional units, enabling creation of various structures with relevant and apriori defined technological parameters, reliability and safety. A modular structure solution uses modular units for particular building sequence, which in a goal-oriented design can assure required variability of products , high number of variants and possibility of many configurations. A platform creation, which includes as big number of building modules common for all products of a company's production program as possible, is an important aim of a producer in effort to improve economical indices of a company [1], [2], [3], [4].

A producer of mobile working machines usually produces several sorts or types of machines in several sizes and power classes [5]. A platform creation of basic building modules is the basis for an effective design in the sense of requirements of

user and has very positive impact on the economic indeces of a company. Lately, in leading companies dealing with the development of mobile working machines, emerge new machine concepts, named telescopic manipulators, Pic.:1. They can be characterized as universal mobile working machines, determined for manipulation with various sorts of material, using broad assortment of attaching working equipment.

Design of telescopic manipulator structures – usable in agricultural sector – require knowledge of initial criteria, gained from comparison of main technological parameters of manipulators produced all over the world. Optimal values of technological parameters can be gained by objective systematic methods like the similarity theory and physical modeling. This method was in the field of earth machines applied for the process of mining and crushing of soils on the group of excavators and loaders.

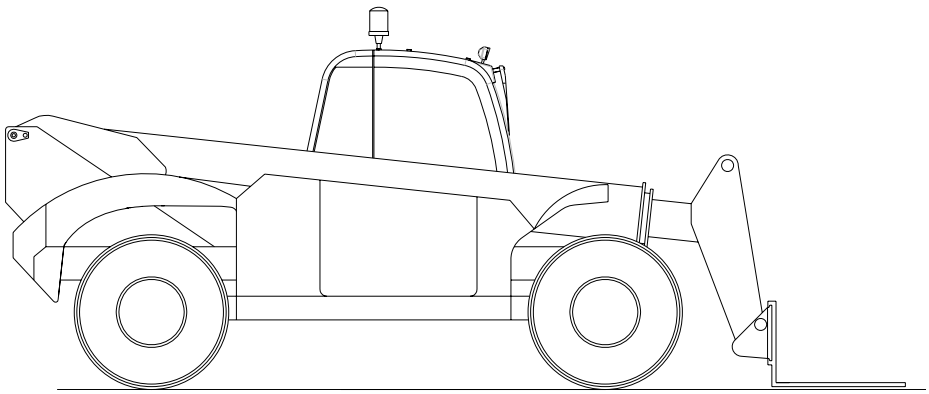

FIGURE 1: TELESCOPIC MANIPULATOR UTM 11.34

Application of this method was performed at our workplace on the group of telescopic manipulators , the youngest group in the area of mobile working machines, which was never perfomed at some other workplace before we did it. Respecting this fact, it can be considered, that results described in this contribution will require more attention and verification in consent with the development in this area.

2. SIMILARITY CRITERIA

In similarity criteria determination of telescopic manipulators it is necessary to allow for uniqueness of their working regime which distininct with load variability, frequent changes of ride directions, swift loads and frequent exchange of working equipment. The aim is to determine and specify criterial dependencies of main technological manipulator parameters with the help of similarity theory and dimensional analysis. The condition of similarity theory usage is, that all the derived criteria have to be in dimensionless shape The qouted similarity criteria resp. simplexes were derived from stability condition of manipulator, condition of limit adhesion and dimensional analysis. The dimensional analysis was used in the motor power comparison with machine overal mass (simplex π_5^C) in determination of machine dimensional characteristics. It has to be remarked that the range of chosen parameters was conditioned by data, which producers generally qoute in accessible company literature. Verification of determined similarity criteria, resp. simplexes was performed on the group of nowadays produced and accessible manipulators. The world market is supplied by 19 companies, which produce more

than 120 manipulator types. The data collected about this machine group were summarized into charts and the basic databasis of the concerned technological parameters for statistical evaluation was created. The determining parameters gained from the newest company literature. are easily monitorable and their credibility is assured.

For determination of functional dependencies and their subsequent use in the stage of manipulator technological parameters determining, the following determining parameters were specified:

manipulator nominal loadability		$-m_{b,lnom}$	[kg]
manipulator maximimal loadability		$-m_{b,lmax}$	[kg]
manipulator motor power		–P	[kW]
manipulátor overal mass		$-m_c$	[kg]
maximal reach	$-l_{max}$		[m]
nominal reach	$-l_{nom}$		[m]
axle distance		$-r_A$	[m]
track gage		$-r_0$	[m]
turning radius		–r	[m]

The derived similarity criteria and simpexes are denoted using the symbols:

$$\Pi_n^{x,yz}$$

were:

n – is the ordinal number of a criterium, or simplex 1,.....,7,

x – sorting according to design uniqueness characterised by the following symbols:

1, 2, 3, - number of telescopic boom sections,

K – manipulators with crab walking,

C – the whole group of manipulators ,

yz – used system of stabilisation characterised by the following symbols,

00 – without arrestment of rear axle and without front stabilisation supports

A0 – with arrestment of rear axle and without front stabilisation supports

0S – without arrestment of rear axle and with front stabilisation supports

AS – with arrestment of rear axle and with front stabilisation supports

TABLE 1: OVERVIEW OF SIMILARITY CRITERIA AND SIMPLEXES

Similarity criterium $\Pi_n^{x,yz}$ [-]	Functional dependency	Correlation coefficient R [-]
$\Pi_1^{2,00}$	$m_c=2,3367m_{b,lmax}+3086,5$	0,9022
$\Pi_1^{2,A0}$	$m_c=2,2301m_{b,lmax}+3663,6$	0,9464
$\Pi_1^{3,0S}$	$m_c=1,1445m_{b,lmax}+6983,9$	0,8697
$\Pi_2^{2,00}$	$a=0,1639l_{max}+0,5063$	0,8374
$\Pi_2^{2,A0}$	$a=0,0696l_{max}+1,0644$	0,8269
$\Pi_2^{3,0S}$	$a=0,0765l_{max}+0,57269$	0,8324
$\Pi_{41}^{2,00}$	$m_c=2,2088m_{b,lnom}+545,65$	0,9093
$\Pi_{41}^{2,A0}$	$m_c=2,1342m_{b,lnom}+984,08$	0,9319
$\Pi_{41}^{3,0S}$	$m_c=0,9647m_{b,lnom}+5877,8$	0,8379
Π_5^{C}	$m_cg=1,1808P+1002,1$	0,8221
Π_6^{K}	$r_0=0,6267r_A+0,2312$	0,8776
Π_7^{K}	$r_0=0,4415r+0,1893$	0,9011

With the use of described symbols, the functional dependencies for the subsequent similarity criteria and simpexes : $\Pi_1^{2,00}$, $\Pi_1^{2,A0}$, $\Pi_1^{3,0S}$, $\Pi_2^{2,00}$, $\Pi_2^{2,A0}$, $\Pi_2^{3,0S}$, $\Pi_{41}^{2,00}$, $\Pi_{41}^{2,A0}$, $\Pi_{41}^{2,0S}$, Π_5^{C}, Π_6^{K}, Π_7^{K} were described (Table 1). Verification of theoretically derived criteria and simpexes was performed by the method of

statistical evaluation and regression analysis. For the assessment of derived dependancies, every pair of data was aproximated by a line, the correlation coefficient of which expresses the grade of correlation of the line with the aproximated data. Evaluation of data, statistical computations and grafical outputs were performed in the Microsoft Excel 7. For the above qouted similarity criteria and simplexes, regression lines have correlation coefficients close to 1.

3. CONCLUSION

In the design of a new mobile working machine a designer often comes out from the comparison with existing similar machines. The process of creation of a particular project has to rely on an objective input information. This can be gained by statistical evaluation of parameters of existing machines. On the basis of such evaluations, it is possible to create a database of input data for specification of general similarity criteria. In this way determined technological parameters serve then to a designer of a mobile working machine in specification of input data and objectivisation mainly in introductory phases of design proces.

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