УДК 62-112
UDC 62-112

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THEORETICAL PREREQUISITES FOR SYSTEMATIZATION OF STANDARD SIZES OF MINI TRACTORS

This article presents the results of the analysis of technical characteristics of modern mini tractors. A mini tractor is a power device which is also the most popular equipment for farms, private farming, horticulture and greenhouse farming in modern conditions. The study showed that constructive schemes of machines are constantly improved with the changing of their subsystems. Accordingly, there are some relationships between the parameters of mini tractors.

It is the relationship between the functional purpose and the operating parameters. The relationship between design parameters and design and operating parameters is the basis for their systematization in order to classify models of mini tractors. It is also the basis for their typification in order to establish optimal parameters in the design process and the choice of functional purpose. It was put the concept to simplify the systematization process forward regarding the possibility of choosing one significant parameter that determines the size and functionality of the tractor. Changing a significant parameter affects the main design, technical and operational parameters. It was recommended to take the indicator of the structural weight of the tractor as a significant.

Key words: tractor, parameters, power, weight, optimization, classification

INTRODUCTION

The agro-industrial complex of modern Ukraine is diverse. More and more farms and small farming households are appearing in the structure of agro-industry. There is a certain specificity of exploitation of technical means in the operation of such farming. Agricultural machines which have proven themselves well during performing work on an area of hundred hectares have a low load in these conditions. Moreover, the use of large-sized equipment leads to an overuse of energy resources. All this has a negative impact on the cost of production and hinders the development of farming.

Given the above, an urgent scientific and practical task is the development and improvement of small-sized equipment, which is able to perform a wide range of tasks in both open and closed ground.

ANALYSIS OF LITERATURE SOURCES AND PROBLEM STATEMENT

The problems of creating small-sized equipment are covered in the works of V.V. Adamchuk, S.P. Pohorilyi [1], Voynash S.A. [2, 3], Sytnykov V.R. [3], Gamaleev P.P., Sytnykov V.R. [4, 5], Guryakov M.V. [6], Kyselov K.V., Kozmyn S.F. [7], Narang S. [9], Sohne W. [10], Rasool S. [11] and many others scientists.

Adamchuk V.V. and Pogorilyi S.P. [1] particularly note that the use of mobile power means is one way to reduce the cost of crop production. The authors analyze the directions of use of car chassis as a small power vehicle. It was offered variants of formation of mobile agricultural units on its basis. It was proved that the use of such units will reduce the cost of technical park of farming and increase the efficiency of machinery.

Voynash S.A. [2] presented the results of research aimed to determine the operational indicators of a small wheeled tractor, which is designed for use in small and private farming. The authors have developed a number of nomograms that afford to link the load parameters of the tractor with traction operating modes. This made it possible to offer an improved dynamic passport.

Dmitrieva M.N. and Lukhminskiy V.A. [8] developed a mathematical model for determining the depth of the track formed by a small skidding tractor.

The authors presented the formula that reveals the relationship between radial deformation of clay by a small forestry tractor and deformation of soil compression. The obtained mathematical model is implemented numerically that due to approximation affords to obtain simplified and convenient for practical application model for estimating the track depth.

The work [7] is devoted to the study of vertical oscillations of a wheeled tractor under the condition of its movement on a forest drag. The proposed equations make it possible to determine the actual loads taking into account the dynamics still at the design stage of the machine.

Dmitrieva M.N. [8] investigated the relationship between physical and mechanical properties of soil with low bearing capacity and substantiated the dependencies for their evaluation. It was developed a

mathematical model of the process of interaction between the wheeled drive of a small forestry machine and soil with low bearing capacity. It was presented the results of the study of the process of development of stresses and strains in the soil under the action of the wheeled drive.

It is clear that the study of the interaction of small-sized machines with the soil relate to machines for the forest industry mainly.

It was little studied the regularities of interaction of small-sized machines with the soil during agricultural work. In addition, there is no research aimed to develop the methods of designing efficient small-sized equipment for work in agriculture, including indoors.

Given the above, the urgent task is the development of small-sized equipment and the scientific basis of its calculation for agriculture.

THE AIM OF THE STUDY

The purpose of the study is to analyze the features of the construction of small-sized machinery for agriculture on the example of tractors. For this purpose it will be analyzed the features of the layout of some models of mini tractors.

RESULTS OF THE STUDY

Such mini tractors as Solis (India), Chery-Zoomlion (China), Dongfeng (China), Yanmar FX-22D (Japan) are the most represented on the Ukrainian market.

In order to identify the design and operational features of mini tractors it was analyzed more than 250 models. The results of the analysis are below.

The tractors are made according to the classic layout that provides a sequential arrangement of transmission elements and transmits the location of the engine. In most models the front wheels are much smaller than the rear (Fig. 1)

a) b)

Fig.1 – Mini tractors: *a* – Solis; *b* – DTZ

At present the schemes of arrangement of mini tractors differ in execution of a frame that allows to make them all-wheel drive and to increase traction and coupling properties. In addition, the improvement of the frame structure, in particular the use of articulated, allowed to develop and establish the manufacture of tractors of small width.

The energy source is internal combustion engines. (Table 1) Most engines are 3-cylinder, 4-cylinder.

Table 1 Technical characteristics of mini tractors

Model	N, hp	Dimensions	Engine	Design Weight, kg	Wheel-drive
Solis 20	20	2660/970/1500	Three-cylinder diesel	950	4×4
Solis 26	24	2715/1065/1550	Three-cylinder diesel	1005	4×4
Solis SF-160	16		Single-cylinder	680	4×2

Lovol 1304	130	5060/2285/2987	Six-cylinder diesel	5250	4×4
Lovol FT-224	24	3300/1350/2350	Three-cylinder	1230	4×4
Lovol FT 354.2	35	3500/1550/2450	Four-cylinder	1420	4×4
Lovol FT 504	50	3980/1650/2450	Four-cylinder	2165	4×4
Chery Zoomlion RD 244	24	3070/1490/1550	Three-cylinder	1250	4WD
Chery Zoomlion RK 504C	50	4120/1720/2550	Four-cylinder	3024	4WD
Bulat	24	2600/1470/1820	Three-cylinder	1300	4×4
Bulat T-245	25	2590/1250/1860	Three-cylinder	900	4×2
Orion Forte RD 244	24	3100/1500/1900	Three-cylinder	1310	4×4
Orion RF 404 Revers	40	3370/1620/2060	Four-cylinder	1490	4×4
MT3-132H	11,8	2500/1000/2000	Single-cylinder	532	4×4
BELARUS-112H-01	11	2500/1000/2000	Single-cylinder	570	4×4

Power ranges from 10 to 130 hp. Execution of engines, at first glance, is complicated. But the presence of 3-4 cylinders at such a relatively low power provides an increase in engine life before overhaul (Fig. 2)

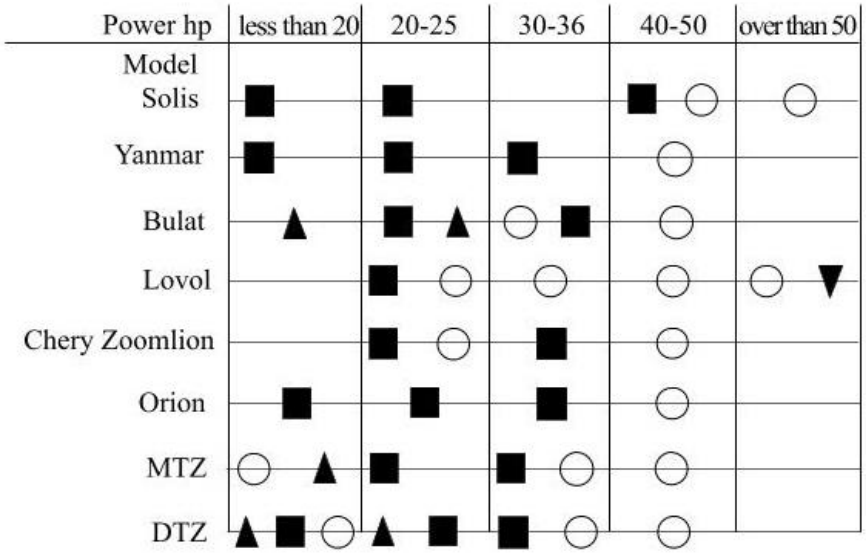

Fig. 2. The number of engine cylinders depending on engine power:

The analysis showed that the engines of mini tractors are mainly diesel with reliable radiator water cooling. This virtually eliminates the risk of motor overheating and engine failure. The vertical arrangement of cylinders, and also a longitudinal arrangement of a cranked shaft allow to carry out connection to transmission through disk clutch. According to Table 1, it is clear that the power of tractor increases with increasing its structural weight. This connection (Fig. 2) can be estimated by:

$$N = 0{,}024m - 1{,}25. \qquad (1)$$

The reliability of the dependence was confirmed by the coefficient of randomization, which is 0.984. In addition, the design weight of mini tractor and its power is characterized by a high correlation (correlation coefficient is 0.992).

All mini tractors can also be combined for their intended purpose. The power indicator is the most appropriate as the basis of such division. It was established the functional purpose of mini tractors based on static analysis.

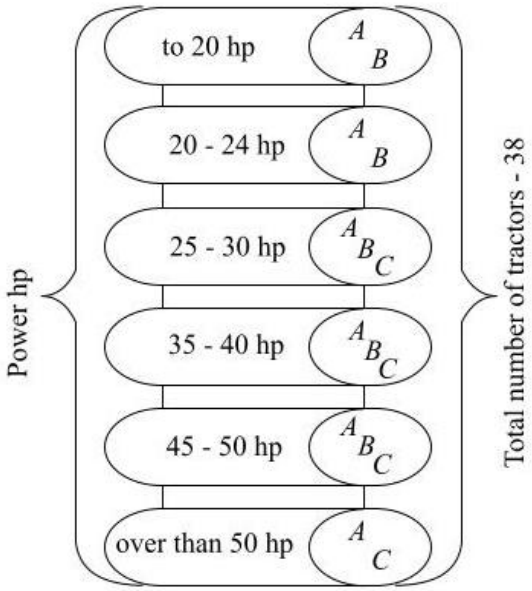

Fig. 3 – Statistical data of the functional use of mini tractors: *A* – for main tillage; *B* – in horticulture; *C* – on the maintenance of farming

The analysis of design and operational parameters of mini tractors of different manufacturers shows certain patterns of their change. Moreover, the design parameters change with the change of power indicator. The functional purpose can also be justified based on the amount of power, which, in turn, has a high correlation with the parameter of the structural weight of the tractor. It can be accepted the concept of accepting the weight of a mini tractor as a criterion for assessing the technical excellence of a mini tractor.

DISCUSSION OF RESULTS

It is necessary to establish areas of rational values of parameters of optimization of mini tractors for further improvement of their design and operational parameters and development of new models of mini-power means.

The study by E. Xora [9] demonstrated that there is no single approach to the choice of optimization parameters during the design (improvement) of machines. The statistical analysis of the relationships between the parameters showed that the power or design weight of a mini tractor can be chosen as a significant. It can be assumed that a significant parameter is a parameter that can be used as a basis for justifying the functionality, as well as determining the size of the tractor. It can be adopted the concept of the feasibility of using the index of structural mass as a significant.

CONCLUSION

Mini tractors are in increasing demand and characterized by a variety of models. Statistical analysis of the models showed that there is no single classification based on design parameters. This makes it difficult to form universal recommendations to farmers on the functional purpose of a model.

Systematization of mutual influences of constructive parameters is a basis of formation of such recommendations. The systematization process requires a large statistical database and the solution of a large number of regression equations. This process can be simplified by selecting a significant parameter that has the greatest impact on design and operational parameters. It is recommended to accept constructive weight of a mini tractor as such parameter.

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Налобіна О.О., Голотюк М.В., Пуць В.С. **Теоретичні передумови систематизації типорозмірів міні-тракторів**

У статті викладено результати аналізу технічних характеристик сучасних міні тракторів. В ході виконаного аналізу встановлено, що конструктивні схеми машин постійно удосконалюються. При цьому змінюються підсистеми машин. Але, як виявив аналіз, існують певні взаємозв'язки між параметрами міні тракторів.

Наявність взаємозв'язків між конструктивними і експлуатаційними параметрами є основою для їхньої систематизації з метою класифікації моделей міні тракторів і типізації з метою встановлення оптимальних параметрів в процесі проектування та виборі функціонального призначення. З метою спрощення процесу систематизації висунуто концепцію щодо можливості вибору одного значущого параметру, який визначає типорозмір і функціональні можливості трактора. Зміна значущого параметру впливає на основні конструктивні та техніко-експлуатаційні параметри. В ході аналізу рекомендовано за значущий приймати показник конструкційної маси трактора.

Ключові слова: трактор, параметри, потужність, маса, оптимізація, класифікація

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DOI 10.36910/automash.v1i16.503