MODULAR SYSTEM IN THE DESIGN OF MOBILE MACHINES FOR MECHANICAL PROCESSING OF LARGE-SIZED WORKPIECES

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Abstract: *This paper presents a modular approach to be implemented to mobile machine tool design. Requirements as well as fundamental principles applicable to the construction of the modules are formulated. A complete structure of the modular system and conceptual design solutions for the functional modules of the mobile metalworking machinery for large-sized workpieces are proposed.*

Key Words: *modular approach, mobile metalworking machinery, large-sized workpieces*

1. INTRODUCTION

Processing and recovery of large-sized workpieces are characterised by high prime cost. This is primarily due to transport expense, especially plant haul, which requires appropriate technological equipment. In some cases transport is even impossible. Mobile metalworking machinery (MMM) could present a solution to the problem. They are mounted on the workpiece close to the machined surface by closing the cutting forces across the workpiece in a short power circuit.

A survey has shown that manufacturers of mobile technological equipment offer different structures of MMM for similar technological problems. Some companies are looking into implementing a modular approach in the design and construction of MMM with different technological purposes. However, a robust modular design system has not yet been developed.

2. MODULAR DESIGN OF MOBILE METALWORKING MACHINERY

Mobile metalworking machines can be considered as multi-functional structures with complex connections among function and size of building elements. Regardless of the technological purpose, they may be constructed from pre-designed, manufactured and tested modules, corresponding to an explicit set of requirements.

Taking into consideration the formulated set of requirements in [1, 2, 4 and 5], the structure of the modules for MMM is subjected to the following extra criteria:

- problem orientation depending on the place of the module in the machine structure;
- functional specialization in accordance with the implemented function of the module in the process of shaping;
- accuracy of adhered and functional surfaces as well as movements performed;
- structural stability based on power parameters, specified for the module;
- minimum mass of modules that facilitates and allows to be easily moved, assembled and dissembled.

The design of each MMM begins with the creation of its structure. When the machine is designed on modular principle, the structural elements are in fact the functional modules. In this paper they are determined by principal type technological schemes [3] for processing large-sized workpieces using mobile machinery. To be developed the following fundamental principles have been considered:

- reduction of existing structural diversity based on common effects and constructive unification of nodes with identical functional purpose;
- grouping modules according to their functional purpose;
- merging adjacent structure modules to achieve a compact and lightweight design;
- compatibility of modules and assembly following principal type schemes for processing large-sized workpieces;
- providing accuracy and inter-module connection’s stability.

3. MODULAR SYSTEM IN THE DESIGN OF MOBILE METALWORKING MACHINERY

A hierarchical modular system for the construction of MMM is developed and its general structure is shown in Fig. 1. As well as being based on existing concepts in MMM design, it also takes into consideration the proposed principal type schemes in [3] and the fundamental principles.

The modular system is made up of four hierarchical levels as the modules of the lower levels are components of the higher levels or participate directly in the structure of the highest hierarchical level – the mobile machine. The proposed modular system has an open structure that allows its expansion and development in levels, including increasing hierarchical levels.

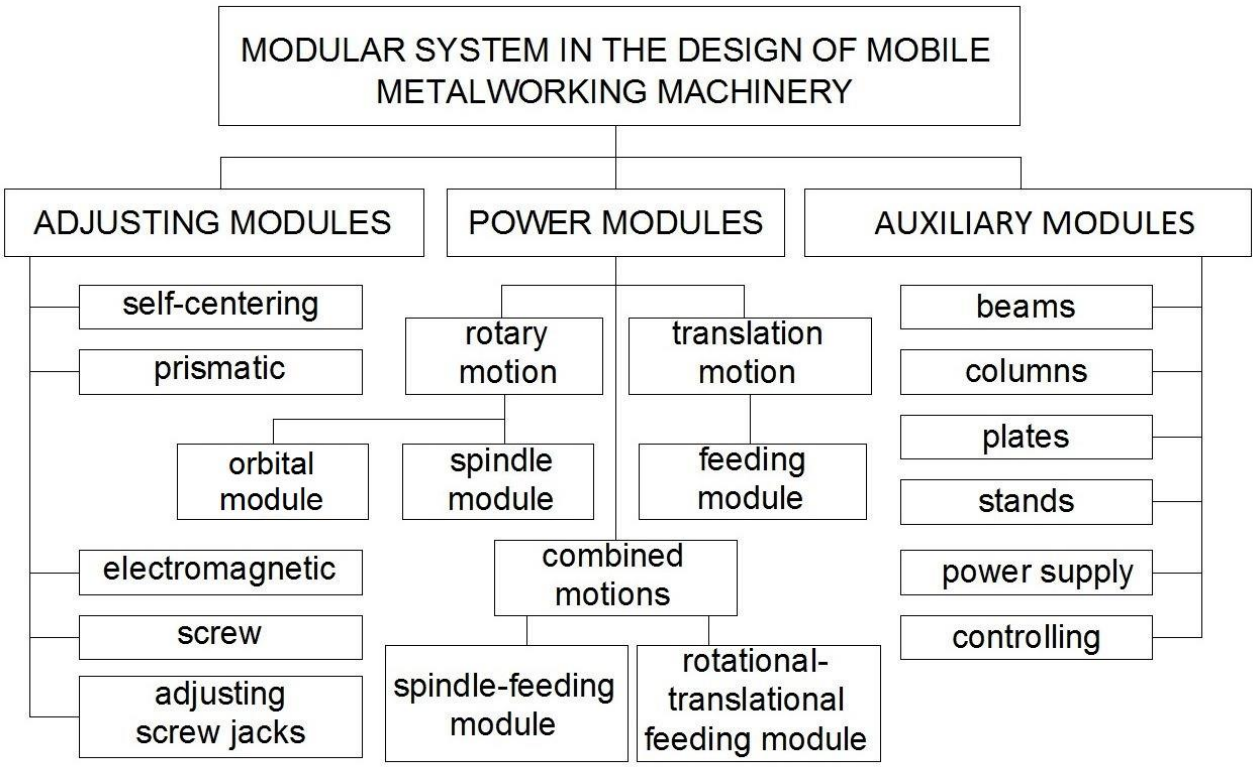

Fig. 1. General structure of modular system in the design of mobile metalworking machinery

Basic modules included in the modular system are grouped by functional roles in three subsystems – power, adjusting and auxiliary modules [1, 2]. Appropriate mix of basic modules of these subsystems allows for MMM design with different structure in accordance with specific technological requirements.

The proposed basic modules are constructively unified and typified. Fig. 2 shows part of the developed conceptual design solutions to basic functional modules.

Power subsystem modules include the following:

- spindle module for transmitting the rotational movement of the tool. Depending on the type of the tool and its mode of attachment, the spindle is designed with different bearings and front end. The drive is also based on a modular principle. Gearmotors with asynchronous, DC, brushless, hydraulic or pneumatic drive are attached at the back end.
- orbital module for transmitting main or feeding circular movements of the nodes of the mobile machine. It consists of two rings – fixed and mobile, mounted securely to each other. The propulsion module is attached to the stationary ring. The drive can be done by different types of gearmotors as well.
- feeding modules to implement the feeding straightforward movements. Depending on the size of the power load and the length of the course, modules with dovetail slides and ball-type or roller guide rails were developed. The drive may be fulfilled with different types of motors and sliding or nut ball screw pairs. A pair model module for movement along two orthogonal axes and the possibility to adjust rotation on one of them is also given.

The modules of the adjusting subsystem show ball screw jacks, capable of determining one or two base surfaces. The design allows adjustment of size on one or two axes and tightening on one of them.

In the auxiliary subsystem the modules include beams, columns, slabs and stands needed to build the MMM supporting structure.

Fig. 3 and Fig. 4 show a constructional variant of the mobile machine for processing flat surfaces by means of turning. MMM is made up of five basic functional modules and additional original nodes, specifically designed for this machine.

MMM is designed for processing foot rests in nuts of large press machine with weight of about 350 tons. Planar surface (pos. 3) can be processed by milling or turning. Analyzing the principal technological schemes [3] and the corresponding component structures, the preference is on processing by turning for it requires less number of base functional modules. The machine setup is done by adjustable ball screw jacks

along two axes toward the screw surface of the pin (pos. 4). The selected adjusting modules (pos. 1) allow for precise levelling in the installation of the machine toward the pin in radial and axial direction. They are mounted on the stationary ring (pos. 2) of the orbital module. The latter implements the main rotary motion, carried out by the rotating ring (pos. 5). It holds the orbital moving feeding modules pos. 7 (along the X-axis), and pos. 6 (along the Z-axis), attached by means of a corner stand (pos. 8).

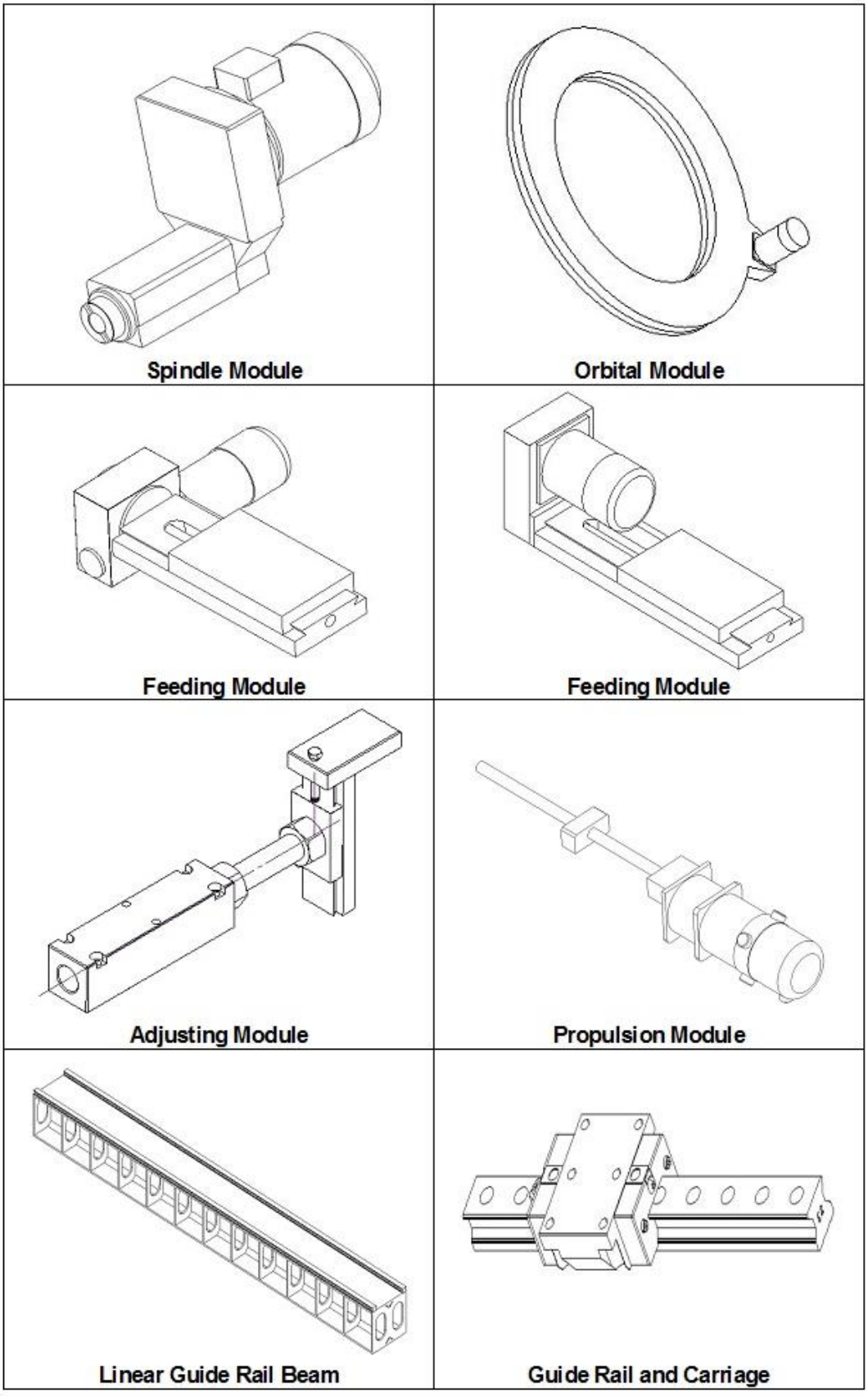

Fig. 2. Basic functional modules for mobile machine tool design

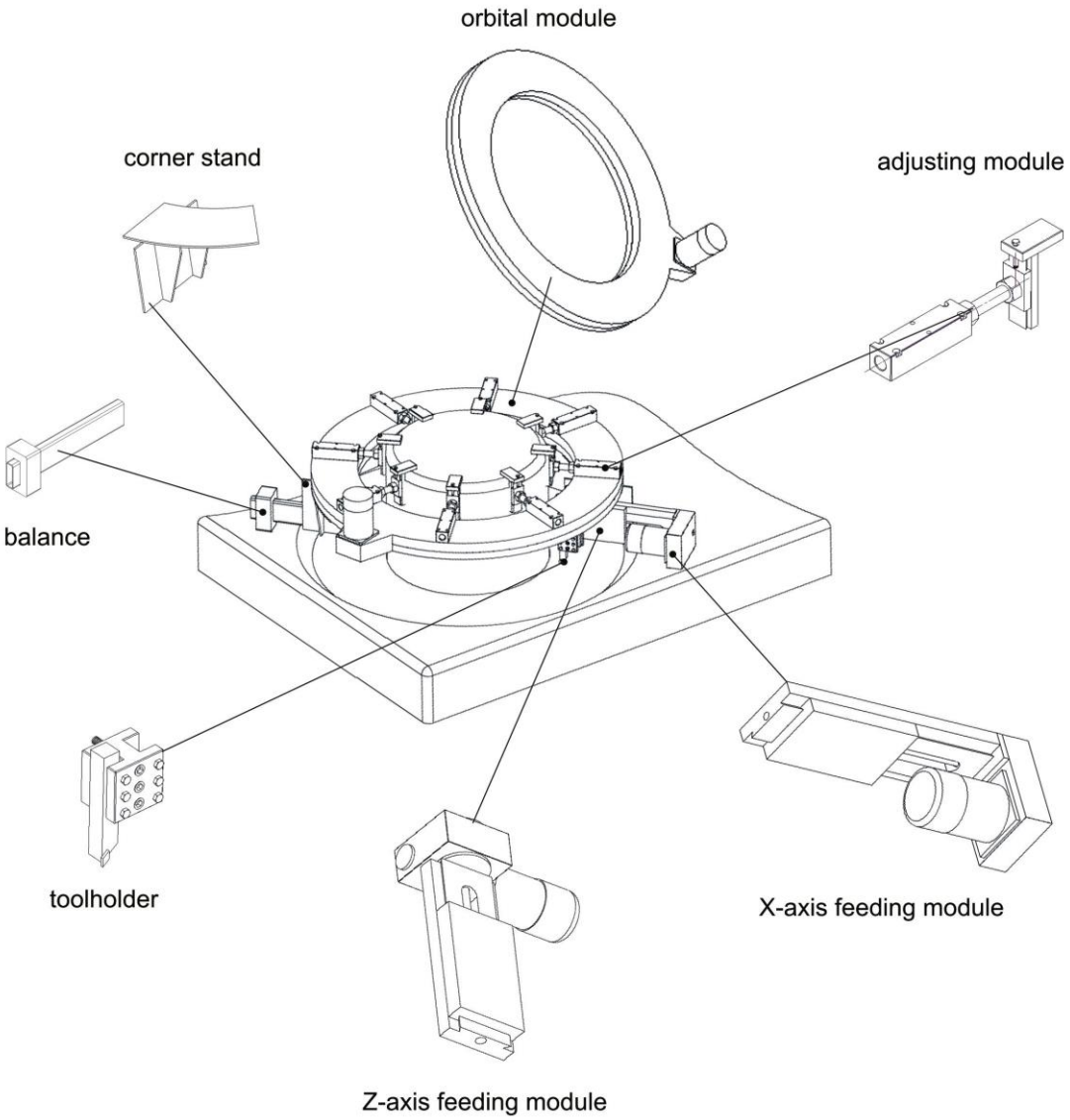

Fig. 3. Structure of a mobile machine for face-turning

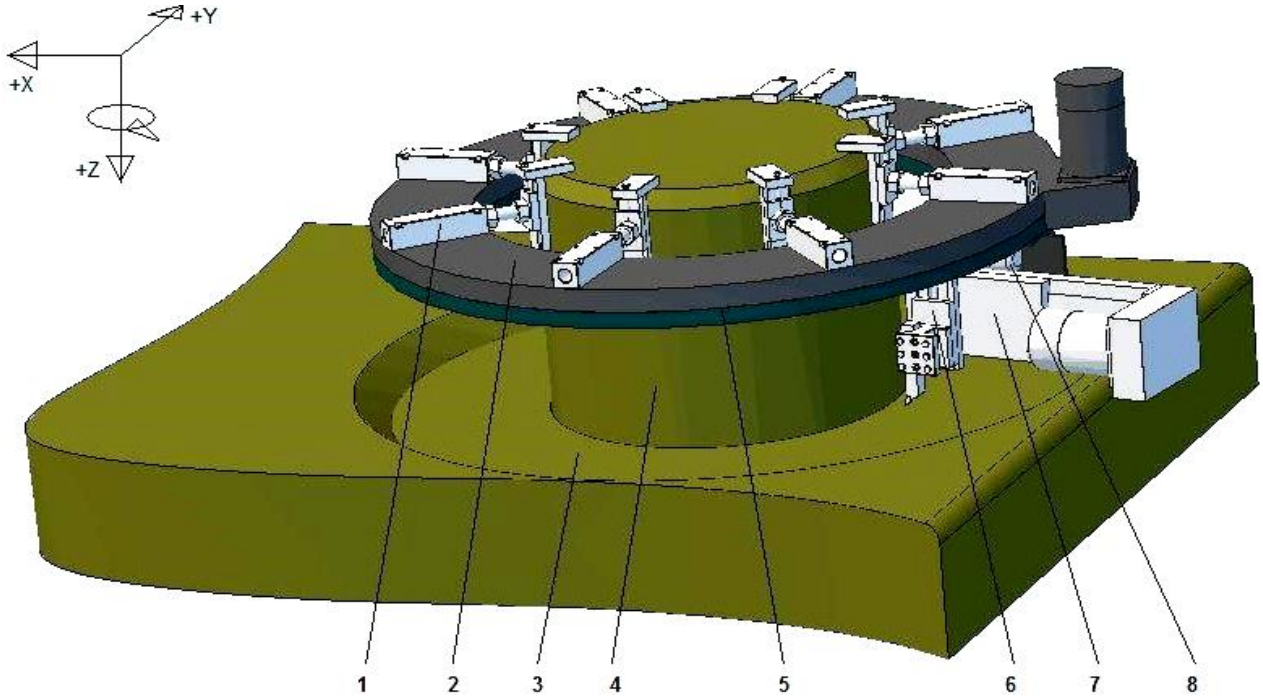

Fig. 4. 3D model of a mobile metalworking machine for face-turning

4. CONCLUSION

The scope of application of mobile metalworking machinery – implementation of various technological operations on large-sized workpieces in single series – justifies the use of modular principle in their construction.

The proposed modular system as well as the developed functional base modules provide conditions for:

- effective construction of specialized MMM to meet specific technological requirements in a range of typed and unified structural units, capable of reconfiguration when changing technological requirements;
- generating variants of structural and constructive solutions to MMM with an arbitrary shaping function and determining the optimum in accordance with the set technological task and imposed restrictive conditions;
- streamlining the design process of MMM, creating librarie of parametric 3D models of basic functional modules and implementation of project procedures in GCAD environment.

ACKNOWLEDGMENTS

The presented paper is funded by the Scientific and Research Centre of Technical University of Sofia, Contract №142PD0007-16/2014.

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