TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics and Mechanics
Vol. 54, Issue I, 2011

STRUCTURAL – FUNCTIONAL ANALYSES OF KINEMATICS OF MACHINE TOOLS AND OF MACHINING CENTERS IN CORELATION WITH TYPE AND MACHINING COMPLEXITY OF THE PIECES

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Abstract*: The paper presents a structural-functional analyses regarding the kinematic structure of different types of machine tools or machining centers. Assignation of degrees of freedom between tool-piece-device-machine, elements component of one technological system MDSP determine a series of kinematical structures of machine tools or machining centers, each of them with its advantages and disadvantages. All elements component from a MDSP system are interacting between them, indirectly or directly, depend on processing existent on pieces with complex surfaces.*
Key words: *machining centers, machine tools with numerical command, kinematic structures.*

1. INTRODUCTION

The main purpose of actual technology is that to realize products as better quality in a very short time and with manufacturing costs lower. Since the complexity of the products is growing and the production cycles are drop, the realization of them imply machine tools or CNC machining centers, the most modern equipments, capable to satisfy these requirements, and which are: flexibility, accuracy and productivity.

1.1 The advantages of use of CNC machine tools and machining centers

Any modern production system, which is having in perspective to fabricate competitive products, must to meet the requirements of increased productivity, flexibility and reliability. This thing can be accomplish by use of systems based on numerical control, and which are quickly adaptable to the requirements of the current production, and will continue to be used an ascendant way disfavor of classical machine tools. Numerical controlled machine tools because of flexibility regarding the processing, responding quickly at the changing of production task.

Following the above mentioned, we can synthesize the most significant of these CNC systems which can be use into of production systems:

- reducing of machining time;
- contouring of parts with complex shapes;
- high accuracy and repeatability;
- reducing the number of the catches of the part;
- simplification of the tools and of fixing devices;
- adaptation possibility of the program at the required concrete conditions through corrections;
- improved machining accuracy;
- increase the quality of machined surfaces;
- increase the tools life.

2. THE STRUCTURE OF MDSP (MACHINE-DEVICE-TOOL-PIECE)

As we see from figure 1, a MDSP system is compound by devices, tools, piece and machine itself; between all components are having place different types of interactions which directly or

indirectly can define the structure of the machine tool.

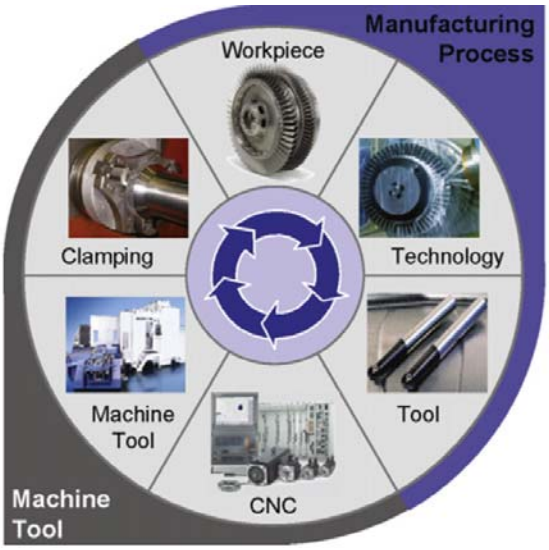

Fig. 1. The structure of MDSP and the interactions with the processing operation

The common point between components is give by the processing operation. This thing is useful, because regarding the execution drawing of any piece can determine the kinematics structure of the machine tool/machining center adequate to process the respectively piece.

3. CONSIDERATIONS REGARDING THE KINEMATICS OF MACHINE TOOLS AND OF MACHINING CENETERS

A major impact in determination and a optimal choice regarding the kinematics of a machine tool and a machining center is give by the workpiece *geometry* (fig. 1), other aspects which must be considered are:

- machine kinematics (velocity, speed, acceleration),
- production batch,
- the degree of automation (ATC, APC),
- use of accessories (devices),
- machine configuration (type C, gantry, with fixed column, mobile column, etc.),
- dimensional accuracy,
- number of operations,
- the accuracy of machined surface and the product quality,
- cost price (depending mostly by the machine dimensions).

Fig. 2. Different types of pieces with complex geometry executed on machine tools and machining centers

Reconfiguring or distribution of degrees of freedom between the components of a machine tool, machining center or MDSP system can be make at level of (fig. 3):

- clamping device of the piece,
- cutting tool,
- technology,
- axis kinematics.

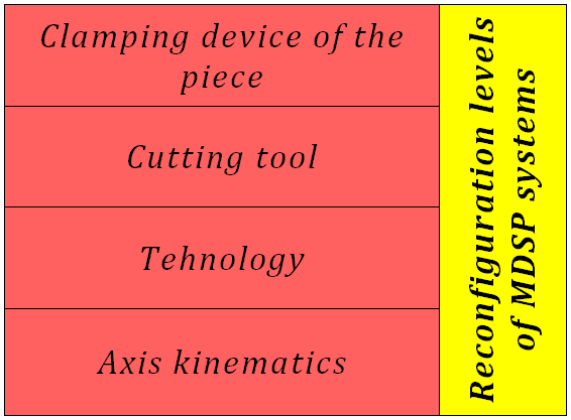

Fig. 3. Configuration levels of MDSP systems (type machine tools or machining centers)

3.1 Types of motions into machine tools and machining centers

The types of processing existent on a part with complex surfaces can be realized in different ways (fig. 4), and these are:

a) movements applied only to the tool;
b) movements applied only to the piece;
c) combined movements applied to both, to the tool and to the piece.

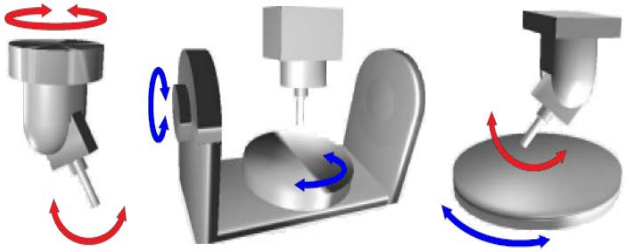

Fig. 4. Three mechanical configurations of machine: a) the tool execute all the movements, b) the piece execute all the movements, c) the tool and the piece execute together all the movements

As it can be observed from figure 4, the additional degrees of freedom can be achieved from combination of movements realized by the tool, piece and the both.

To define the optimal configuration of a machine tool or a machining center must to take account the auxiliary elements which compound in a various percent the structure of a kind type of system (devices – rotary table, tilt table, tools). So, if we have a structure with three linear axis – X, Y and Z, the other two degrees of freedom, rotation can be accomplish by use of different types of devices (rotary table, tilt table) in correlation with the possible movements realized even the tool, even the piece.

Starting from the most general and most complex structure type 3T3R, which theoretically exist, but it is not having practical applicability, because one degree of freedom is suppressed due the interpolation, so that, the structure it will become 3T2R, a structure in 5 axis, wide spread and often used because they offer multitude of advantages: accuracy, flexibility, repeatability.

As a result of all mentioned above, can be make a various number of possible variants of kinematic structures of machine tools or machining centers, resulting by the combination of only the tool, only the piece or both simultaneous. All possible structures are given in table 1.

Table 1.

Possible kinematics structures of machine tools/machining centers

Nr. crt.	PIECE	TOOL
1.	**3T3R**	**0**
	0	**3T3R**
Obs ! The third rotation is lost by interpolation		
2.	**3T2R**	**0**
4.	2T2R	1T
5.	1T2R	2T
6.	2R	3T
7.	1R	3T1R
8.	**0**	**3T2R**
9.	3T1R	1R
10.	3T	2R
11.	2T1R	1T1R
12.	1T1R	1T1R
13.	**2T2R**	**0**
14.	**0**	**2T2R**
15.	1T2R	1T
16.	2R	2T
17.	2T1R	1R
18.	2T	2R
19.	**1T2R**	**0**
20.	**0**	**1T2R**
21.	**1T1R**	**0**
22.	**0**	**1T1R**
23.	1T1R	1R
24.	2T1R	1R
25.	**2T1R**	**0**
26.	**0**	**2T1R**
27.	2R	2T
28.	2T	2R
29.	1T	1T2R
30.	**2T**	**0**
31.	**0**	**2T**
32.	**2R**	**0**
33.	**0**	**2R**
34.	**1T1R**	**0**
35.	**0**	**1T1R**
36.	**1T**	**0**
37.	**0**	**1T**
38.	**1R**	**0**
39.	**0**	**1R**

From the table, it can be observe the fact, that some types of structures are recovered at the motion executed by the tool, or the motion executed by the piece. Also, from the total of these structures combinations not all are have

practical applicability; these can be approach only from theoretically point of view. These types of structures can be like 1R, 2R, 1T, 2T either at the tool, either at the piece.

4. CONCLUSIONS

A structure type 3T3R when the tool is zero, meaning that, the tool is fixed, is not executed any motion is represented by a machine tool type table, where all the motion are executed by the piece. At the opposite pole is representing by a machine tool type gantry, where all the motion are realized by the tool and the piece is fixed.

These two last affirmations constitute the essence from which it was starting this kinematical approach.

Knowing ho execute the motions, the tool, piece or both simultaneous, can know what type of piece can be realized on different structures of machine tools or machining centers.

This analyze is useful and add benefits for all entrepreneur which want to buy a machine tool or machining center which to give the best solution for the types of pieces that are fabricated in their firms.

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Analiza structural – functională a cinematicii maşinilor-unelte şi a centrelor de prelucrare în raport cu tipul şi complexitatea prelucrării pieselor

Lucrarea prezintă o analiză structural-funcțională cu privire la structura cinematică a tipurilor de maşini-unelte sau centre de prelucrare. Repartizarea gradelor de libertate între sculă-piesă-dispozitiv-maşină, elemente componente ale unui sistem tehnologic MDSP determină o serie de structuri cinematice de MUCN-uri sau centre de prelucrare, fiecare cu avantajele şi dezavantajele sale. Toate elementele componente din cadrul unui sistem MDSP interacționează între ele, în mod direct sau indirect, în funcție de prelucrările existente pe piese cu suprafețe complexe.

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