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HANDLING AUTOMATION OF FIXTURE AND FIXTURE ELEMENTS IN FLEXIBLE TECHNOLOGICAL STRUCTURES

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The first part of the paper briefly defines requirements for process automattion handling fixtures and fixture elements within flexible technological structures. The second part includes analysis and systematization of handling processes for fixtures and fixture elements. Based on the previous analysis and systematization, the paper provides description of the solution that meets the requirements for flexible automation.

Keywords: fixture, handling, flexible technological structures

INTRODUCTION

In production processes within flexible technological structures, significant period is necessary for auxiliary times. Auxiliary time shortening means productivity increase and reduction total machining time. Within flexible technological structures, significant auxiliary time shortening can be accomplished with material handling process automation. By material, in manufacturing processes, workpieces, fixture, tools and handling accessories are considered. With flexible technological structure development requirements for material handling automation are more emphasized. In flexible technological structures, significant place belongs to handling automation of fixtures and its elements, /1, 2/.

In handling with fixture and its elements systematization of requirements is associated with the level of complexity for flexible technological structures, and in that frame, it is also connected with workpiece category for fixture are functionally assigned. From view of complexity level, flexible technological structures are multilevel structural forms made from machining – manipulating – transport – storage-measuring – monitoring - control systems which have input for various material handling, /3, 6/.

According to complexity level, flexible technological structures (FTS) can be distinguished as numerical control (NC) machine tool, flexible manufacturing module (FMM), flexible manufacturing cell (FMC) and flexible manufacturing system (FMS), /4, 7/.

Furthermore, flexible technological structures can be classified by material handling tasks and fixture handling tasks that are also in that frame.

TASKS AND FUNCTIONS FOR FIXTURE HANDLING IN FLEXIBLE TECHNOLOGICAL STRUCTURES

Depending on flexible technological structure complexity level, basic tasks are defined for fixture and fixture elements. These tasks are mostly correlated to workpieces reception, locating and clamping and they have to provide, /8/:

- Clamping in measure defined range;
- Automation software (program) adjustment of clamping elements for new measure range;
- Automation software exchange of clamping elements in switch to new machining;

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- Safe and accurate clamping even in case of malfunction.;
- Gap elimination which effects on manufacturing accuracy;
- Automation adjustment of clamping forces so this does not deform workpiece or effects on machining accuracy, etc.

Fixtures function in flexible technological structures is realized with adequate accessories. Flexible technological structure accessories can be divided into two segments:

- functional elements (effectors, sensors, discriminators, converters, amplifiers, etc.)
- fixtures (chucks, collets, mandrels, rests, etc.) (Figure 1.)

Functional elements are array connected and they make control circuit. One control circuit segment consists of effector witch have a subgroup of clamping cylinders. Cylinder structure aided with appropriate connecting elements, such as chucks, collets and mandrels, make automation clamping systems.

Figure 1. Fixtures

Tasks for fixture and fixture elements handling are linked to flexible technological structure complexity level.

Figure 2. shows principle scheme of handling with material (fixture and partially with workpieces) at NC machine tool level. Depending on work-piece mass and its dimensions, work-piece can be placed manually or automatically in chuck. Storage of workpieces is done by storage device. Manipulation process is mostly done manually. Chuck jaw replcement and adjustment is often done manually, and workpiece claming is mostly done automatically, but also it can be done manually. Replacement of centers and holders is often realized manually.

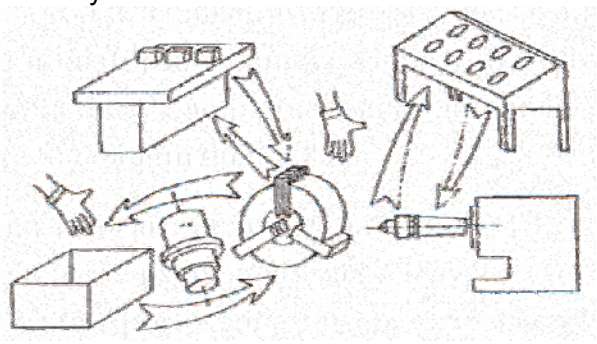

Figure 2. Principle scheme of fixture handling in frame of NC machine tool

Figure 3. shows principle scheme of material handling at level of flexible manufacturing module. Flexible manufacturing module is a structure that joins functional tasks of machining process, machining system, measuring system, monitoring system and automation manipulation system for workpiece, fixture and tool, and in these functional tasks material handling functions is being realized. Flexible manufacturing module owns autonomous manipulating system for manipulation with fixture, tools and workpieces. Fixture manipulation, associated with replacement and adjustment of clamping elements, is often done manually, while workpiece manipulation is automated.

Figure 4. illustrates principal scheme of material handling at flexible manufacturing cell level which joins functional tasks of machining processes (these processes are being worked out on a several NC machine tools or on flexible manufacturing modules) machining systems, measuring systems, monitoring systems, autonomic manipulating systems and transport and storage systems. It is considered, that at flexible manufacturing cell level, integral automation of workpiece machining process exists and because of that, material and fixture handling functions are automated.

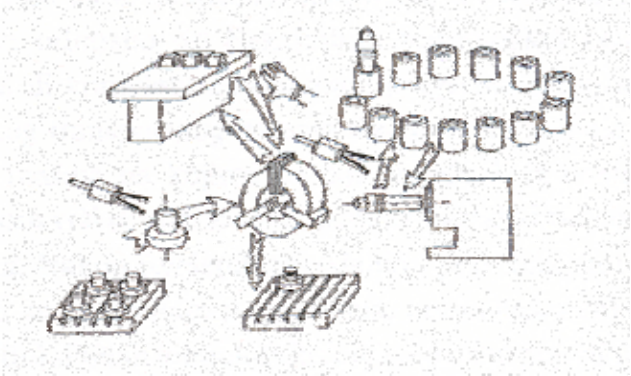

Figure 3. Principle scheme of fixture handling in frame of flexible manufacturing module

In frame of this level of flexible technological structure, manipulation of adjustment and removal of chuck jaw is automatic.

Furthermore, adjustment and replacement of centers is automatic and manipulators do it. Automatic fixture storage supplies these kinds of systems. Replacement and adjustment of clamping elements is automated, individual, or combined.

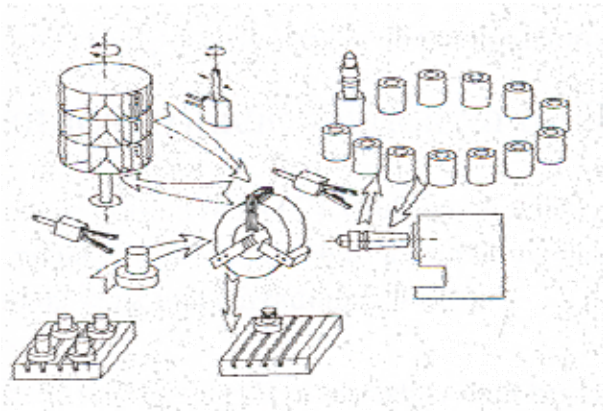

Figure 4. Principle scheme of fixture handling in frame of flexible manufacturing cell

Fixture handling in flexible technological systems, which represents circulated manufacturing of specific workpieces, is done automatically. Fixture handling is often done by central automated storage, individually or all together (Figure 5). At this level of flexible technological structure handling with palettes, grippers and adequate adjustment of clamping and grabbing elements is being done. Level of handling automation in flexible technological structures joins fixture handling requirements for flexible technological structures of lower complexity level with higher automation level.

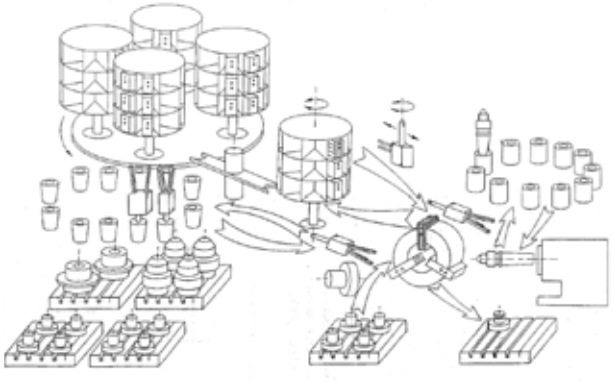

Figure 5. Principle scheme of fixture handling in frame of flexible manufacturing system

For material handling function realization in flexible technological structures, designed fixture solutions must have increased level of flexibility. They perform specific handling functions and themselves are subject for handling in frame of flexible technological systems. Most significant handling functions that are realized by fixtures are functions of grabbing, locating, clamping and relieving. For handling functions realization there are fixture drivers for fixture automation. Ther task is to secure:

- Simple and fast handling functions;
- Reliable and appropriate maintenance of handling functions (ex., adjustment of clamping force for clamping function);
- Undisturbed execution of handling functions (enabling of material flow through its elements, access to specific zones etc.).

Realization of assigned tasks for these elements can be achieved with usage of hydraulic (Figure 6.), pneumatic (Figure 7.), electric or combined drive energy.

Fixture realized functions are often connected to workpieces. Frequently used elements for grabbing, locating, clamping and relieving functions realization are following fixtures: linnets, centres, mandrels, head spinners and chuck jaws.

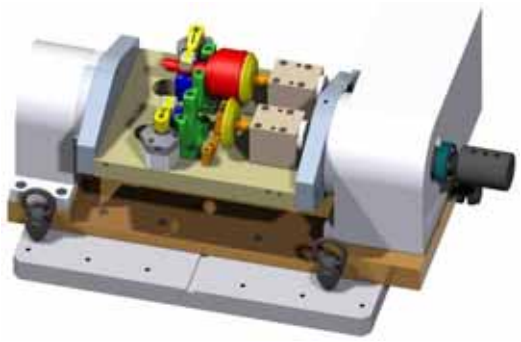

Figure 6. Fixture - hydraulic clamping

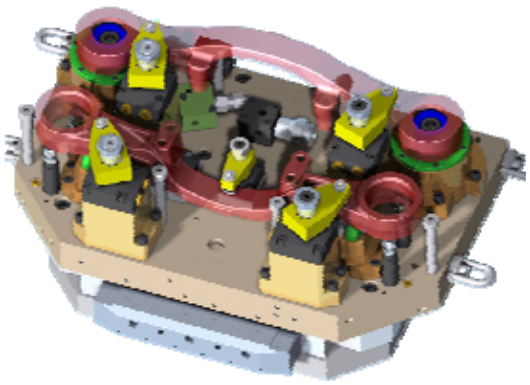

Figure 7. Fixture - pneumatic clamping

AUTOMATED FIXTURE HANDLING IN FLEXIBLE TECHNOLOGICAL STRUCTURES

In flexible technological structures fixtures have wide role can be easily spotted. Besides their usually handling functions fixtures have other such as are: transporting, guiding to machining position, transport away from machining position, transport back to storage etc. Various construction solutions can be used in order to achieve these functions. Fixture handling capability in flexible technological structures depends on fixture construction, its shape, dimensions, gripping surfaces etc. From the other side, fixture manipulating capability is influenced by geometrical and technological characteristics of developed manipulation system concepts. Most significant parameters can be distinguished as kinematics structure, space for manipulation, manipulation accuracy, movement speed, programming possibility, flexibility, capacity, etc.

If fixture structure is such that it provides good and safe grabbing, positioning at machine tool, removing from machine tool for a specific unit (manipulator or robot), then those units are used for fixture manipulation. Figure 5. shows one example solution in frame of flexible techno-logical system. Transporting device transports fixture to manipulator - robot. Robot grabs it and places (or replaces) fixture on a machine.

Figure 8. Segment flexible technological structure where fixture manipulation is done by robot

If the fixture is heavy, inadequate for gripping or it has large dimensions, it is being moved from the storage by adequate transporting device to machine tool and after that fixture is placed on the machine manually or automatically by adequate equipment. Fixtures are previously being placed on palettes and after that they are together transported and placed on a machine tool. Transport can be done on various ways by usage of rail guided vehicles, transporters, motor vehicles etc.

Figure 9. Segment flexible technological structure where fixture manipulation is done by rail guided vehicle

Palettes movement, in frame of individual conception for flexible technological systems, from a constructive point of view, can be translator, circular or circular-translator (Figure 10.).

Figure 10. Segment flexible technological structure where palettes do fixture manipulation

Figure 11. Regal warehouse for fixture store

It is convenient to store palettes with fixtures on previously defined place. Regal warehouse is suitable for that purpose (Figure 11.). In such occasions, transporter disposes, or picks up, palette from a locker that is in certain closet level. Besides closet storages, drum storage solutions can be used.

Handling automation field is imposed as obligatory in higher levels of flexible technological structures. In automation systems, need occurs for automation replacement and adjustment for fixture and its elements, because man is excluded from direct manufacturing.

In complex flexible technological systems, needed fixture is brought from central storage, where all the workpieces, tools and fixtures are stored. In simple flexible technological system, in central storage blanks i finish parts are stored, while tools and fixtures are stored in sub storages.

For appropriate automated fixture handling and functioning, certain flexible technological structure has to have an adequate manipulation system. Furthermore, automated transport and storage systems are necessary, in case of integral automation in flexible technological structures, because any other transport and storage system would be meaningless.

AUTOMATED FIXTURE ELEMENTS HANDLING IN FLEXIBLE TECHNOLOGICAL STRUCTURES

In certain levels of flexible technological structures, besides possibility of whole fixture replacement in automated circle, there is a requirement for automated adjustment and/or replacement of individual fixture elements or its groups. Several developed conceptions are illustrated on following figures. Numerical control commands and certain manipulator does adjustments (replacements).

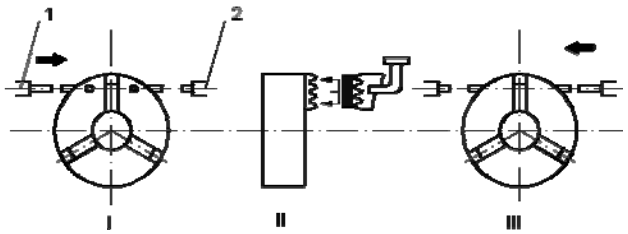

Figure 12. Scheme of chuck jaw automatic adjustment

Figure 12. shows scheme of chuck jaw automatic adjustment. First part (I) of the Figure 12. shows how automated unit (item 1) presses chucks left button and releases chuck jaws. On second part (II), automated gripper unit removes chuck jaws and sets them in to right position. Part three (III) illustrates automated unit (item 2) presses chuck right button and hardens up chuck jaws. After that, chuck is automatically rotated for 120° for adjustment or replacement of next chuck jaws.

Figure 13. shows sequence cycle of chuck jaw set automatic replacement. First part (I) of Figure 10. shows two-position manipulator movement towards chuck and with three pins (scheme shows only two) it presses three chuck buttons what results with chuck jaws loosening. Simultaneously, three manipulator grippers are catching chuck jaws. On second (II) part of Figure 13., manipulator is going away from chuck, rotates for 180°, and then returns back to chuck. Manipulators pivots are pressing chunk buttons and simultaneously new chuck jaws (2) are placed and automatically tightened in chunk. At third part (III), manipulator is pulled out from chunk and chuck jaws are replaced.

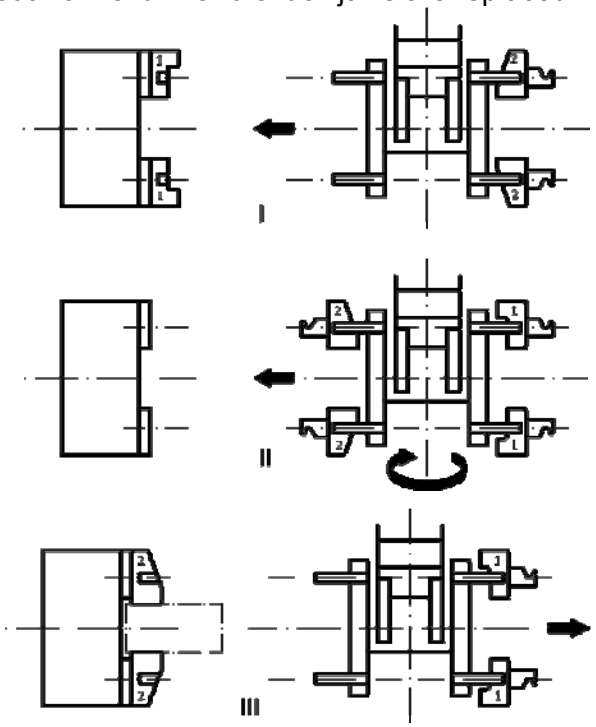

Figure 13. Sequence cycle of chuck jaw set automatic replacement

CONCLUSION

Solving problems in material and fixture handling, in various complexity levels of flexible technological structures, is a significant and complex task. Development of new flexible technological structures solutions demands new fixture development which is used for execution of handling functions with working objects. New flexible technological structures solutions must have defined fixture handling functions for certain complexity levels. Beside its complexity, nowadays there are numerous examples of developed fixture handling manipulation systems that exist in flexible technological structures and they represent the need for existence and further development of these systems.

Constructions and aims of further fixture development are turned towards numerical controlled flexible technological structures. Naturally, this means that new fixtures solutions

must satisfy all required tasks for accuracy, working safety, needed level of specific function automation, defined level of modular structure etc. All of these requirements must be in harmony with needs and requirements of specific flexible technological structure, or with specific flexible technological level. Nowadays fixtures represent significant peace in a puzzle of flexible technological structures because of its material selection, automation of design and construction, automated manipulating at adjustment, replacement, transport and storage.

Based on shown constructions of fixture solutions with higher flexibility level, it can be concluded that present development of modern fixtures is going in three directions. First direction is improvement of fixture flexibility to accept wide range of various workpieces, and enhanced locating and clamping accuracy for workpieces. The second direction in development of modern fixtures, is increased flexibility compared to transport, storage and manipulating systems in flexible technological structures. Third direction of development is described in appliance of automated fixture and/or fixture elements identification. One of technologies is RFID technology that implies base elements existence such as RFID reader, antenna, and RFID tag, /5, 9/. RFID antenna, in identification procedure, has to be placed on location where fixture and/or fixture elements are being recognised. Information sign, RFID tag is on fixture and/or fixture elements. With RFID technology appliance automated fixture and fixture elements handling in flexible technological structures is significantly simplified and auxiliary times are shortened.

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AUTOMATIZACIJA RUKOVANJE PRIBORIMA I ELEMENTIMA PRIBORA U FLEKSIBILNIM TEHNOLOŠKIM STRUKTURAMA

U prvom delu rada ukratko se definišu potrebe za automatizacijom procesa rukovanja priborima i elementima pribora u okviru fleksibilnih tehnoloških struktura. Drugi deo rada obuhvata analizu i sistematizaciju rukovanja priborima i elementima pribora. Na bazi analize i sistematizacije, prikazana su rešenja koje zadovoljavaju zahteve fleksibilne automatizacije.

Ključne reči: pribor, rukovanje, fleksibilne tehnološke strukture

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