

## FLEXIBLE MANUFACTURING SYSTEMS

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### ABSTRACT

*In the mechanical processing industry, small series manufacturing occupies about 75% of the total production volume. Only 5% of the time of stationing a piece in the processing workshop is necessary for the processing: actual cutting (30% of the 5%), preparation, positioning, measurement and idling. The rest of the time is for waiting and transport. Therefore, the flexible manufacturing systems are a necessity for the increasing productivity within production with a wide variety of types of the machined parts. The paper presents the basis of the conception of the structure of flexible manufacturing systems.*

KEYWORDS: manufacturing system, machining center, manufacturing cell, flexibility

### 1. INTRODUCTION

The flexible manufacturing system can be defined as an integrated assembly of machine-tools serviced by an automated system for the transport, handling and storage of semi-finished products, finished parts and tools.

The flexible manufacturing system is equipped with an automated measuring and testing equipment, able to perform, under the command of the computer, the simultaneous or successive manufacturing of the different parts belonging to a certain family of products under minimal operator intervention and with reduced time adjustment.

The flexible manufacturing system was constituted by:

1. the application of the numerical control to the machine-tools generally and to the machining centers particularly;

2. the development of various auxiliary technologies, necessary for automation: an automatic tool transfer system consisting of tool magazines, a mechanical hand, an indexing mechanism, a main shaft, an automatic transport of parts and tools in palletizing system, and automatic warehouses;

3. using the computer to control the system.

The flexible manufacturing system is a complex, qualitative solution for the flexible production automation based on the principles of modernization, typing, hierarchy in the multi-level structure, integration into the

production management system, adaptability and minimization of the flow of operations and circulation of materials.

### 2. FLEXIBILITY CRITERIA FOR THE MANUFACTURING SYSTEM

The flexible manufacturing system differs from traditional manufacturing systems by the following features:

- *flexibility* - the ability of the system to quickly adapt to changes in the geometric dimensions of the piece or to changing it with a similar one within the same product family and to operate over longer periods of time with maximum efficiency and minimal structure changes;

- *the ability to accept semi-finished products in a random order;*

- *the ability to simultaneously or successively process different parts belonging to the same family, using the tools and gripping devices required at a particular machine at the right time and in the desired sequence;*

- *use in the production of unique, small and medium series;*

- *the possibility of gradual integration;*

- *functional autonomy for three shifts without human operator intervention for direct productive functions;*

- *use numerical control machine-tools, industrial robots, automated transport systems, process computers;*

- *perform intensive loading of machine-tools.*

The flexible manufacturing system is an evolutionary process, a way of organizing and controlling the manufacturing process, incorporating

the latest developments in microelectronics, machine tools with CNC equipment, manipulators, industrial robots, etc.

By the degree of flexibility, the manufacturing technology systems are divided into three categories:

1. Flexible transfer line;
2. Flexible manufacturing cell;
3. Flexible manufacturing system.

The flexible transfer line consists of a group of universal or specific machine-tools and has various automatic work units, usually arranged in a serial configuration and interconnected by means of a semi-fabricated transport system, subordinated to the working principle of an automatic line.

On a flexible transfer line, different types of parts can be processed simultaneously or sequentially, adjusting the line automatically when passing from one piece type to another.

Structurally, the flexible manufacturing system is made up of three subsystems:

1. the manufacturing subsystem;
2. the logistical subsystem of materials, tools and devices;
3. the informational subsystem.

### 3.WORKING UNITS

By working unit is meant a system consisting of an assembly of the semi-finished products subsystem, a device subsystem, a machine subsystem and a tool subsystem that compete to achieve the work tasks envisaged in a manufacturing system. Figure 1 [1] shows a machining process on a flexible manufacturing system with two CNC machining centers, where:

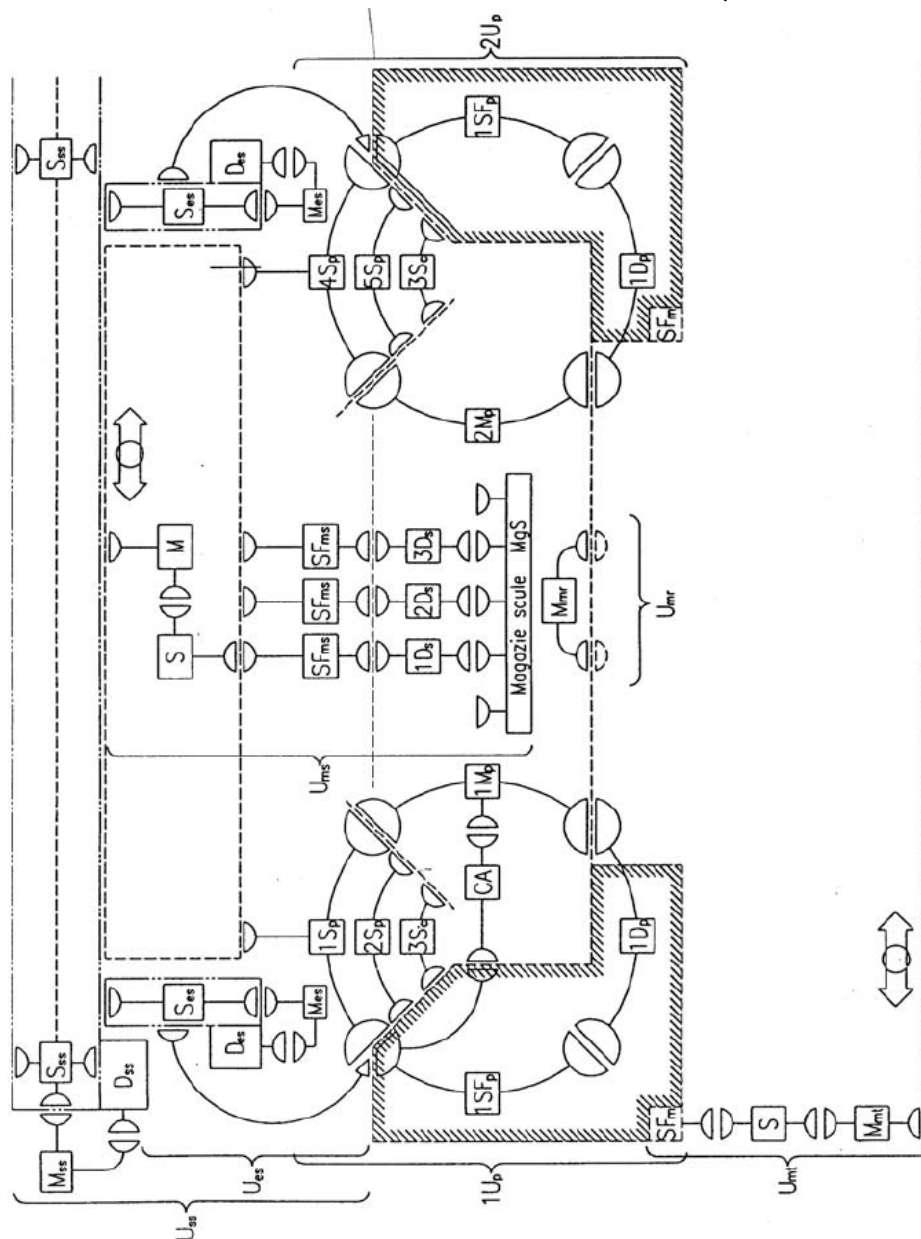


Fig. 1. Work units of the cutting process[1]

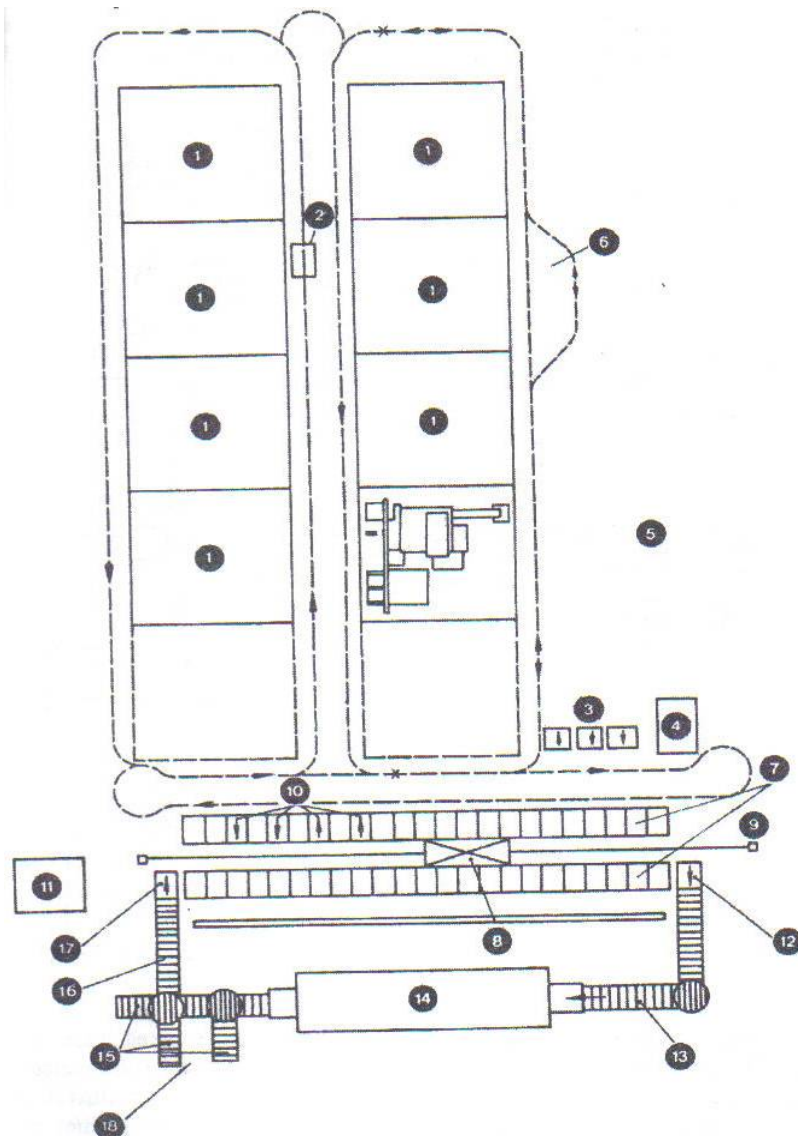


Fig. 2. 400 Fritz-Heckert flexible system of WMW [2]

Up1 is the working unit that processes the 1SFp semi-finished product, mounted in the 1Dp processing device, pallet type.

The 1Sp and 1Dp assembly is the semi-finished products subsystem 1SFm in the handling units that perform the manipulation Umt and rotation Umr.

For the 2Up working unit this assembly becomes a semi-finished subsystem 1SFp and a 1Dp device.

The handling and transport unit Umt will take over the pallet with the 1SFm semi-finished product.

The parts handling mechanisms will transport the pallet with the semi-finished product, either to the Umr handling and rotation unit, which rotates the pallet by 180 ° (most of the time, but can rotate only with 90 °), or to the 2Up working unit. The tool handling unit takes over the pre-tensioning mechanism from the MgStool magazine in which

1Ds, 2Ds, 3Ds devices are positioned and transports them to the toolboxes of the machine tools, in the order given by the DNC computer of the flexible system.

The chip removal units have harpoons or scrapers to transport the chips through the guttering.

#### 4. FLEXIBLE MANUFACTURING SYSTEMS

Figure 2 shows the 400 Fritz-Heckert flexible system of WMW, designed for processing feeding box of the machine-tools [2].

The flexible system consists of two rows of flexible cells -1, of FC 400 K / 2.5 production, between which a trolley runs on the rails -2.

In station 3, the devices, tools, measuring and control heads are maintained. In station 4 the transfer on pallets of the devices, tools, measuring and control

heads is performed. The central magazine of devices, tools, measuring heads and control-5 is located in the vicinity of station 6, where the maintenance and technical service of the transport trolley is performed. The bilateral magazines- 7 is served by a manipulator- 8, which is maintained in station- 9.

The transport of the semi-finished products between the bilateral magazine and the manipulator-8, controlled from the control point – 11, is made in the storage cells - 10. The table- 12 serves for the transfer of the semi-finished products and parts between the magazine- 7 and the roller conveyors-13, autonomously driven. The flexible system also contains a washing station- 14, in which the chips remaining on the parts are eliminated after the cutting process.

The loading of semi-finished products and unloading the processed parts from the pallets is done in stations- 15. The roller conveyor- 16 is manually driven. In the station- 17 the transfer of pallets loaded with semi-finished products is made to the manipulator 8. The central station of loading and unloading- 18 serves the entire flexible system that can machining process 319000 parts annually in 38 types, having maximum dimensions 400x400x160, maximum weight of 40daN.

A typical structure of Flexible Manufacturing Systems- FMS can be the following (Figure 3 [3]):

- two horizontal machining centers;
- a system with 16 pallet storage stations;
- two loading / unloading stations;
- a computer with FMS (Flexible Manufacturing System) program for industrial production.

This program offers the following facilities: it is based on the using of the numerical control equipment installed on one of the machining centers in the system, it can be updated later, it can be extended later in advantageous conditions.

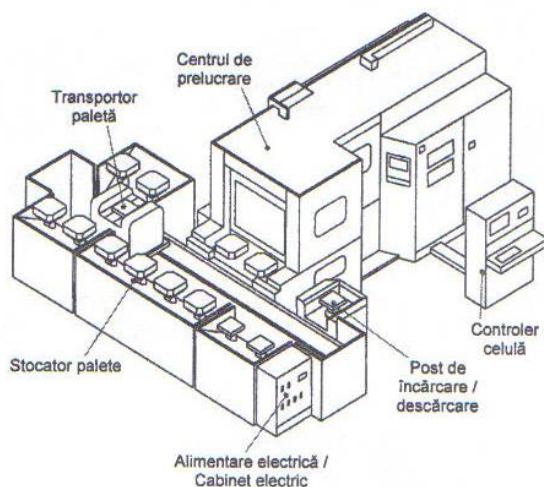


Fig. 3. Flexible cutting system -Mazatrol FMS [3]

The flexible manufacturing cell represents the technologically independent elementary component of the flexible manufacturing systems.

Figure 4 [4] shows a flexible manufacturing cell consisting of the following components:

- a CNC lathe;
- a horizontal processing center;
- a robot for manipulating parts.

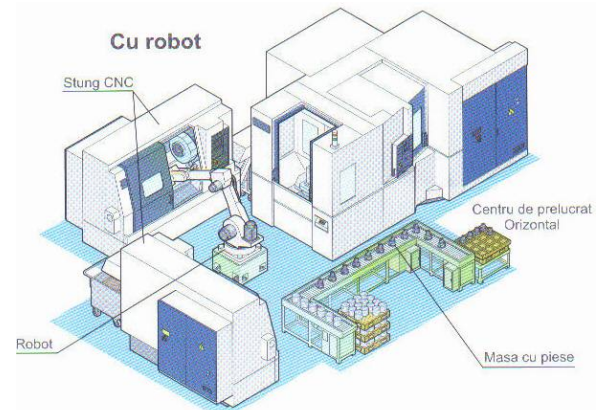


Fig. 4 Flexible Manufacturing cell (Mori Seiki- The Machine Tool Company) [4]

Several flexible manufacturing cells, the same or different, specialized on a certain set of technological operations required to manufacture a particular family of parts, is a flexible manufacturing island.

It is characterized by complete technological autonomy, high functional autonomy (without human operator intervention) and own management of the material flow.

## 5. CONCLUSIONS

The flexibility of the manufacturing systems consists in the automation of the technological processes that have the rapid capacity of adaptation in the modification of the manufacturing technology. The flexible automation of the technological processes of manufacturing has now become a necessity, representing the central pillar for obtaining integrated manufacturing systems at global level. These are characterized by the combination of the complex equipment and machines that are controlled by high performance computer systems, assembling the functions of control, processing, handling, transport, storage in one hierarchical unit.

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