Automated Tool Changing System in the Intelligent Manufacturing and Assembly Cell

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Abstract. This paper is dealing about complex design of sensor equipment, which will be used by automated tool changing system of manufacturing and assembly cell, which is located at the Institute of Manufacturing Systems and Applied Mechanics. This complex sensor equipment design is outgoing from knowledge about intelligent manufacturing systems. As the tool, which is used for the sensor equipment design are used sequential diagrams.

1. Introduction

The industrial manufacture is still forwarding. Today we are not talking only about using of IT, classical automated instruments. But when we are talking about flexible manufacturing systems it is effective to talk also about possible using of new generation manufacturing systems. These new generation manufacturing systems are also called intelligent manufacturing systems. All IMS subsystems are including parts of so called machine intelligence (sensor equipment). Using of given systems with combination of machine intelligence will lead to the complete labor remove from the manufacturing system. Basics which are needed for realization of machine intelligence in manufacturing systems is so called monitoring, which is able to monitor internal stay of the system and also changing conditions coming from environment. Monitoring systems are using sensors which are located at some proper place of the system, usually such place is tool, machine or some manipulating device. Sensors are identifying parameters, which are then used as input data of control system. Following to this data is realized some, technological, manipulating or other helping process.

2. analysis of flexible manufacturing cell

A flexible manufacturing cell can be found at the department of technological devices and systems “Fig.1”. This flexible manufacturing cell is created of some bearing subsystems such as:

- Industrial robot with Cartesian kinematics
- Shelf storage system

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There are five manufacturing phases integrated in the flexible manufacturing cell.
- storage (semi products storage and storage of final product just before its shipping),
- transport and manipulation (transport and manipulation of semi products and products),
- manufacture (manufacturing of single semi product to the final product),
- assembly (assembly of single final product in to the one final product assembly),
- shipping.

2.1. Shelf storage system
One of the main parts of the manufacturing system is shelf storage. This storage has many functions in the manufacturing cell “Fig.4”. Some of them are:
- semi product storage,
- final product storage just before its shipping,
- for manipulation with semi products and also for its transport,
- for manipulation with final parts and its transport back to the storage.

2.2. Industrial robot with Cartesian kinematics
Other one very important part of the manufacturing cell is robot created from three axis, which are represented by three electrical driven actuators “Fig.3”. Whole robot works in the Cartesian workplace. There are many elements, which are located at the working space of the robot.
- Special tool position used for automated tool changing system,
- Rotary unit,
- Pneumatic driven gripper,
- Grippers storage,
- AHC unit “Fig.2”,
- Tools storage.

Following to the conclusions and knowledge, which are coming from intelligent systems studies, were in the flexible manufacturing cell designed special added sensor units for each device.
That means that every device will have its own sensor units, which will be used for processing of primal information. Such information ensures communication between single devices and control system. Before single sensor units specification, there was needed to specify requirements, which will be given to the designed intelligent manufacturing and assembly cell.

Main requirements used for intelligent manufacturing and assembly cell design were following:

Designed intelligent cell have to be able to react on various situations which are coming during the manufacturing process. Such as:

- React to the change of shape of manufactured or assembled part, React to the change of part dimensions,
- React to the usage or not usage of single subsystems by manufactured parts,
- React to the part types change,
- React to the change of technological parameters,
- Assurance of collisions situations in to the cell,
- Low manufacturing costs,

During the design of intelligent manufacturing cell, there was very important to conserve two basic subsystems, such as was during flexible manufacturing cell design. Designed intelligent manufacturing cell also save five manufacturing phase.

3. **Writing Methodology Of Communication Ways Between Single Devices Of IMC**
Before design of sensor equipment of single system subsystems, there was also important to solve writing kind of single stays and movements connected with parts. These stays of parts have to be created during running production process in the intelligent manufacturing cell. Proper writing methodology was created, which would be able to define the communication ways between single devices during running production process. Sensor equipment can be designed following to the writing of communication ways between single devices. At the beginning there were two kinds of writing methodology:

- Methodology of writing which is using evolution diagrams and algorithms.
- Methodology of writing which is using rules of sequential diagrams.

3.1. Sequential diagram

It is a new writing form, which is usually used are writing form for programming in the language UML. These diagrams are used for description of objects stays. Sequential diagrams are used for showing, how are single objects communicating to each other in the time “Fig.5”.

Methodology of sequential diagrams was chosen as a proper methodology for communication writing between single devices operated in the intelligent manufacturing cell.

Only synchronous messages can be found in the designed intelligent manufacturing cell. That means, there will not be any other operation created without backward signal in the control unit.

The beginning of sequential diagram of automated tool changing system is shown at the “Fig.6”.

Figure 5: Objects representation in the sequential diagram
4. Sensoric Equipment Design Following To The Automated Tool Changing System

Before design process of single sensor equipment, there was important to realize communication analysis of devices communication ways in the time. The sequential diagram methodology was used “Fig.6”.

Writing methodology using sequential diagram, is a good way how to analyze communication between single devices, which are placed in the working space of the cell.

These problems were solved during automated tool changing system:

- Placement analysis, or presentence analysis of grippers in the storage body,
- Proper gripper identification following to the shape of the gripper.

For presentence analysis of gripper is the storages are used inductive sensors with type: SIEN – M8NB-PO-K-L.
Inductive sensor is assembled to the gripper body, with help of assembly bracket “Fig.7, 8”. The dimension of storages are small, that why also the sensor dimension are in smaller value. The model of sensor placement on the gripper storage is showed at the “Fig.9”.

5. **Sensors Design Following To The Gripper Shapes Detection**

For identification of single gripper types following to their shapes, was designed identification system, which is using color sensing sensors. This application is using two such sensors with type: SOEC-RT. Used sensor is able to sense three color kinds, which are then placed to the sensor memory. Gripper storages are
equipped by color labels. Two sensors are sensing color label combination and so they are able to separate nine possibilities. Example of such sensing is presented at the “Tab.1”. Sensors placement at the manipulator body is showed at the “Fig.10”.

At the “Fig.11, 12” is whole intelligent manufacturing cell and workplace of intelligent manufacturing cell.

- sensors identification:
- color sensor 1: red, blue, yellow
- color sensor 2: red, blue, yellow

Table 1: sensed colors combinations

<table>
<thead>
<tr>
<th>sensor 1</th>
<th>sensor 2</th>
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<tbody>
<tr>
<td>red</td>
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</tr>
<tr>
<td>red</td>
<td>blue</td>
</tr>
<tr>
<td>red</td>
<td>yellow</td>
</tr>
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<td>red</td>
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Figure 10: Sensors placement at the manipulator body

Figure 11: Workplace of intelligent manufacturing cell
At the beginning of manufacturing process are all gripper collected in the shelf. They are all in the switch on position. In the moment of manipulation the signal is coming to the control unit. This signal is dealing about free position in the shelf.

6. Conclusion

During the design process of intelligent manufacturing cell, and during the design process of automated tool changing system, a sequential diagram methodology was used. This methodology was chosen to describe communication of all devices during the manufacturing and also assembly process. Sensor equipment was selected following information, about the communication and signal transmission. The aim of sequential diagram methodology use was to upgrade flexible manufacturing cell in to the intelligent one, with help of sensor equipment. This cell will be used for laboratory purpose.

Following upgrades and development of flexible manufacturing system are integrated to the manufacturing process also intelligent manufacturing systems. But it is also important to say, that problematic of intelligent manufacturing system is still in the stay research and development.

7. Acknowledgements

This article was realized with help of grand tasks.
VEGA 1/0206/09 Intelligent assembly cell.

8. References