THE ASSEMBLY WORKSPACE OF AN INTELLIGENT ASSEMBLY CELL

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Abstract: *This contribution is focused on automation in the robotics. Automation is in present very important part of the science and life as well. In this short abbreviate is necessary to say, that the main issue of this work was the change of the assembly cell to intelligent assembly cell. The aim of this article is to get a new knowledge about a creating of intelligent assembly cell .There are presented the hardware accessories which are used in the intelligent assembly cell at the Institute of Production Systems and Applied Mechanics in this contribution.*
There are more subsystems in this intelligent assembly cell. We will focus on assembly workspace of this system. In this case it has been a description of the structure of an external robot allocated in assembly workspace, main its gripper. Designed gripper works as part of automated flexible assembly system but due to planned algorithm and sensory devices it is rarefied to the intelligent assembly system. In the other case it has been also the used sensory devices exhausted because they are the no separated parts of the intelligent manner of this intelligent assembly cell. This sensory equipment is necessary to apply to this subsystem, to the workspace, an external robot and the fixture as well.

Key words: *intelligent assembly cell robot, sensory devices, exchange gripper, assemblyy.*

1. INTRODUCTION

The basic requirements for manufacturing are to produce many produce in the shortest time, at the lowest costs but also with the highest quality. In this case we have to get and provide fully functional conditions. These elements consist of sensory equipment and intelligent control elements that are essential for building intelligent manufacturing systems (Holubek, R. & Košťál, P., 2013). The intelligent manufacturing system should be that kind of system, what is responsible to react to changes in the process in interaction with the environment and common devices. This industrial intelligence is forwarding all the time. The automatic systems which are designed to repetitive production, where are demanded big rates of flexibility are called flexible manufacturing systems. This flexible manufacturing system includes one or more technological workstations which are connected with the material handling system to optimize material flow. The material is automatic transferred to this system. Nowadays, the flexible manufacturing systems are getting better and higher and their systems are changing to intelligent manufacturing systems. The intelligent manufacturing systems present the systems which contain the adaptation capability to unexpected changes such as assortment changes, technology changes, market requirements and social needs as well.

The intelligent manufacturing system consists of:

- intelligent design,
- intelligent operation,
- intelligent control,
- intelligent process planning,
- intelligent quality management,
- intelligent scheduling,
- Intelligent maintenance.

This contribution shows the intelligent assembly system in our institute. It shows the description of this system, it´s parts, mainly the assembly workspace and also the devices which detach this intelligent assembly cell from the flexible assembly cell.
This article is divided to few parts which are focused to the most important areas.

2. INTELLIGENT ASSEMBLY CELL

Intelligent assembly cell concept was created for the part or small series production. Mainly it is an assembly system with some degrees, which manipulates with semi-products and parts, which are assembled in the system to the final product (Velíšek K. et al., 2005).
The complexity of the system is usually characterized by structure, connection, characteristic elements and also by environment. For design of a system complexity is important to know: what we produce or in this case assemble and how we produce.

2.1 Cell concept

There is the intelligent assembly cell in the figure 1. How you can see, the structure of this cell consists of few subsystems.
The cell subsystems are following:

- storage system,
- manipulating device,
- rotary table – rotary input and output device,
- assembly workspace,
- control system.

Fig.1. Intelligent assembly cell in the Institute of Production Devices and Systems

2.2 Product design

How it was mentioned before this assembly cell was created for the part or small series production. The basic parts of final products are cylindrical housing, piston, spring and cup as is shown in the figure 2.

Fig.2. Basic components for assembly process

There are three different types of cylindrical housings such as silver, red and black. There are also two types of pistons such as silver and black.
In that case, there are so many variants of final products in this assembly process, how you can see in the figure 3.

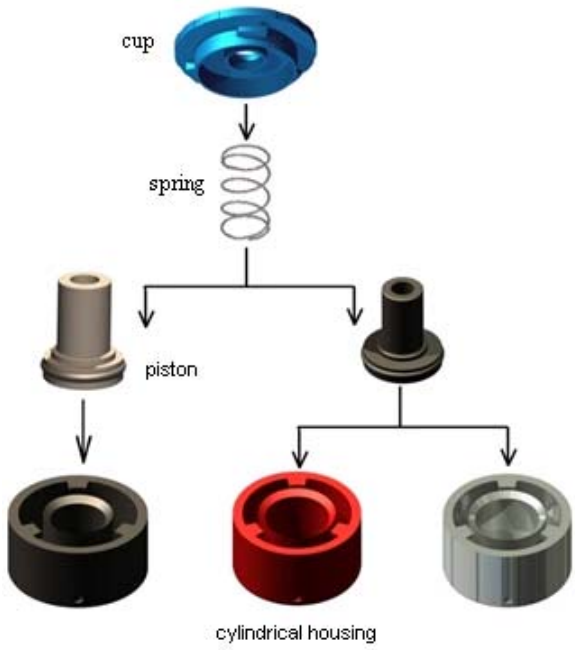

Fig.3. Different kinds of assembly variants

3. ASSEMBLY WORKSPACE

The assembly workspace is assigned for manipulation and assemblage of amounted components. There are two components (cylindrical housing and piston) on pallets which are transported to this workspace. They get here due to the rotary table, which makes the rotary movement between assembly workspace and storage system. These pallets and also components are chosen accordance specified conditions and algorithms (more information about algorithms and modeling of assembly processes are shown in the article of Matúšová, M. & Javorová, A., 2010) from the storage system by manipulator.
This manipulator chooses the pallets from the storage system and also chooses them with the final form products from the rotary table. Next two components such as cups and springs are stored in the buffers in this assembly workspace, as you can see in the figure 4.

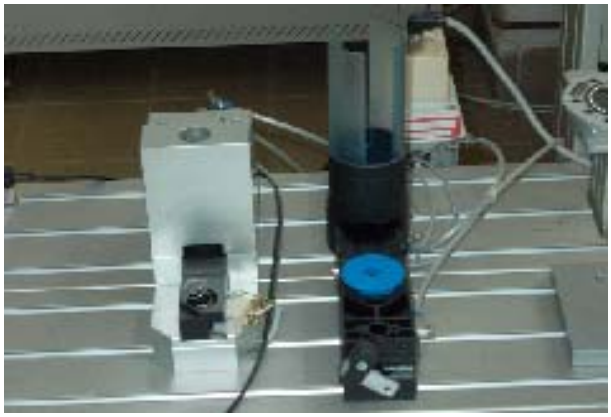

Fig.4. Buffers of the springs and the cups in the assembly workspace

Except buffers, the important part of this space is also the fixture. In this fixture is held the component which is consequently mounted to final entity as you can see in the figure 5.

Fig.5. Fixture in the assembly workspace

Next very important part of assembly workspace is the robot with Cartesian coordinate system as is shown in the figure 6. This robot grips and manipulates with the desired components idle the needs.

As we have many types of components with different diameters, it has to be chosen a good type of tools

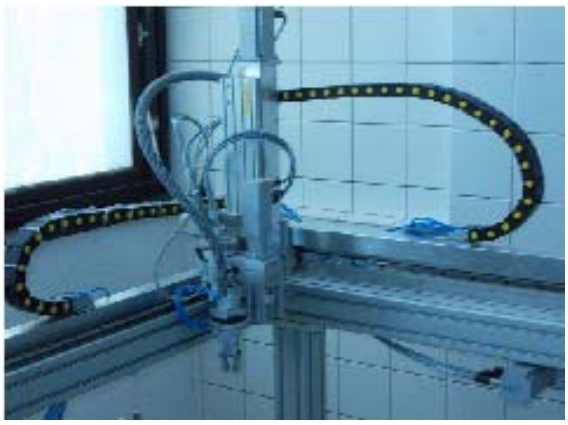

Fig.6. External robot with Cartesian coordinate system in the assembly workspace

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The specific of this robot is that it provides the opportunity to change grippers depending up the required tool for the necessary component. These exchange grippers are stored in the stands which are located in the robot workspace as you can see in the figure 7.

Fig.7. Gripper stands in the assembly workspace

4. GRIPPERS

How it was mentioned before the grippers are changed depending of needed tool and component. If cylindrical housing will be mounted, robot has to use different type of tool than spring will be mounted. In this case the robot consists of exchange grippers and robot arm.

This is one of the good examples of how the automation rises up.

We have a several requirements to this our assembly robots grippers:

- adaptability to manipulated objects,
- high gripping accuracy,
- simply plus rigid design,
- small size,
- high reliability,

- simple maintenance,
- price.

There you can see the universe bind of exchange gripper to robotic arms with effector in the figure 8. In the figure 9, there is the scheme of exchange gripper with the example of the real exchange gripper in our institute.

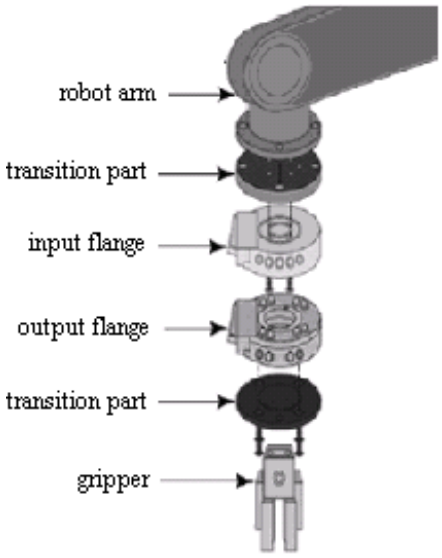

Fig.8. The bind of exchange gripper

Fig.9. The scheme and real example of exchange gripper

5. SENSORY DEVICES

One of the application areas of monitoring systems is the area of robotized assembly. Equipping of assembly systems by sensors is one of the basic levels of increasing of automation and machine intelligence (Holubek, R. & Koštál, P., 2013).

Sensory systems provide monitoring, scanning and sensing of many functions of assembly technologies, processes, properties of mounted object and also environment. The realization of this these functions provides suitable sensory device.

The sensors are the functional elements, forming a block of measuring chain that is in direct contact with the measured environment. The sensors monitor chemical, physical or biological value and transform according defined principle to the measurement value - most of the electrical variable. There are also sensors for non-electric value which is directly converted to a digital signal.

There exist many types of sensory devices and it depends about different parameters such as: energy, distance, input value, contact with scanned/mounted object, output signal, accuracy, generation of sensory devices and type of realization as well.

5.1 Location of sensory devices

The most important question for selection of sensory devices is the location. On the base of the location the appropriate sensory devices will be selected. In this case is necessary to classify following requirements:

- a distance,
- a contact,
- a pressure,
- an allocation of particulars devices,
- a size of build-up area.

Since this should be an intelligent assembly cell the next very important requirements were:

- sensing and monitoring of mounted components,
- sensing and monitoring of environment.

The best location of sensory device application:

- all exchange grippers,
- the fixture.

5.2 The selection of the appropriate sensory devices

On the base of requirements was created a short list of appropriate sensory devices. This short list was designed after detailed selection from a very big group of sensory devices. The sensory device catalogs were scanned and the appropriate parameters were searched. Sensory devices that fulfill the criteria of availability were chosen, again on the base of concrete requirements. Next step in the selection of the most appropriate sensory device was testing. A

lot of sensory devices were eliminated by testing. Only small group of sensory devices that fulfilled required criteria kept.
On the base of these requirements and methodical procedures of selection were chosen following:

- the optical sensory devices,
- the electromagnetic sensory devices.

The optical sensory devices have so many good properties which are suitable for these our assembly grippers. Between the advantages are electrical isolation, wide dynamic range, compact and light and also electromagnetic immunity.
The electromagnetic sensory devices are necessary for monitoring of the statuses of production, assemblage and manipulation. Advantages of this type of electromagnetic sensory devices are small size, safety and also less sensitivity to electromagnetic interference.

6. LOCAL SEARCH OF ASSEMBLY WORKSPACE

How it has been mentioned few times before, this assembly workspace has many species and it rises up this assembly cell to intelligent assembly cell. In this contribution, the sensory devices and their off-set in the exchange grippers and fixture will be solving. The main search was to bring the flexible adaptation to system change reactions and this was fulfilled due to sensory devices. In this part of article are shown the chosen appropriate sensory devices and their allocation.
From the optical sensory devices, the optical sensor with suppressed background was chosen (it is shown in the figure 10) and it was located in the fixture as you can see in the figure 11. We decided to choose this sensory device because of small built-up area. In the cup, there is a small part which serves to final mounting. This sensory device consists of the optical fiber which makes a good orientation of this cup.

Fig.10. Selected optical sensor with suppressed background

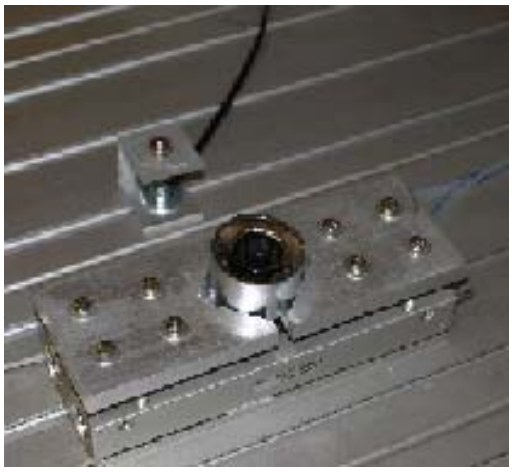

Fig.11. Utilization of optical sensor with suppressed background in the intelligent assembly cell

From the electromagnetic sensory devices, reed sensors were chosen and they were located in the exchange grippers and their stands. The example of this reed sensor is shown in the figure 12 and the utilization of this sensor is shown in the figure 13. All sensory devices were made from company Festo because it is our partner.

Fig.12. Selected reed sensor

Fig.13. Utilization of reed sensor in the intelligent assembly cell

7. CONCLUSION

The main research of this project is to change the flexible assembly cell to intelligent assembly cell. This article was focused to the assembly workplace what is in my opinion the most important part of this cell because of assembly process.

One sign of the ´´intelligence´´ of our intelligent assembly cell is program solution, which was fulfilled but this hasn´t been a purpose of this contribution. From the other hand it is hardware accessory. It is possible to say that this assembly cell got its intelligence due to sensory devices and also exchange grippers.

In the closed future we would like to use more types of sensory devices for many other functions.

The gripper will be fitted by pressure sensory devices which will help to change the power of clamping.

Also we would like to work with component orientation. In this case we will use some optical and inductance sensory devices. They will differentiate the components if will be some changes in component arrangement. The sensory devices will identify what type of component is in the fixture and also what procedure is following.

We will design the sensory device for detection, if the right tool is gripped. It will be dealt about identification of tools due to 2D codes and 2D-codes reader.

8. REFERENCES

► Danišová N., Majerík J. (2011). *Sensoric system for identification of jaws in the jaw buffer and intelligent fixture*, In: Annals of Faculty of Engineering Hunedoara- Journal of Engineering. ISSN1584-2673. – Tom IX Fasc. 3

► Holubek, R., Kerak, P. & KOŠŤÁL, P. (2011). *Possibility of the automatic exchange of grippers*, Machine Design, Vol.3 (2011), No 1, ISSN 1821-1259

► Holubek, R. & Košťál, P. (2013). *The intelligent manufacturing systems*,
registrated: Scopus.
In: Advanced Science Letters. p. 972-975, ISSN 1936-6612. - Vol. 19, No. 3 (2013),

► Matúšová, M. & Javorová, A. (2010). *Material flow analysis of designed flexible manufacturing cell (FMS)*, In: Proceedings in Manufacturing Systems. p. 285-290, ISSN 2067-9238. - Vol. 5, Special Number (2010),

► Meziane F., Vadera S., Kobbacy K. & Proudlove N. (2000). *Intelligent systems in manufacturing: current developments and future prospects, Integrated Manufacturing Systems*, roč. 11

► Ruehl M. & Roth H. (2005). *Robot motion planning by approximation of obstacles in configuration space,* In 16th IFAC World Congress, 2005, Prague

► Schunk, H. & Steinman, R. (2007). *Robot Grippers,* Weinheim, ISBN 978-3-527-40619-7

► Velíšek K. et al. (2005). *Assembly machines and devices*, STU, ISBN: 80-227-2187-5, Bratislava