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PROPOSITION OF DESIGN METHODOLOGY FOR GENERATION OF AUTOMATED ASSEMBLY DEVICES

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Abstract: *The assembly process is characterized as finishing manufacturing process with low degree of automation and it is also needed to implement new innovative trends and technologies. Method of assembly process automation could optimize and improve monitored information such as production costs, assembly time and quality increase of assembled products. The design methodology includes inevitable analytic, proposal and projecting methods and procedures that are special developed and adapted to problematic of automated assembly devices generation. The developed design methodology is also verified by project and realization of automated assembly device for before known assembly product.*
Key words: assembly, automation, design methodology, assembly device.

1. INTRODUCTION

The design methodology is specialized on the area of assembly process automation and design of automated assembly devices and machines. Proposal and creation of automated assembly device is the final result of design methodology. Automated assembly device can assemble final assembly product from the parts [1]. By proposition it is required to detail analyze assembly process, control of assembly process and also assembled product by design of assembly method [2]. Also it is needed to recognize and resolve automation process and the using of automation equipment. Assembly automation suggests the various technical hardware using for automatically realization of assembly process individual sectors or complete on the ground of created control program [3]. Selected and defined automation hardware is integrated to control system with control, coordinate and automate functions. Assembly process control system is known as combined system integration of mechanical, sensor, actuating and control system.

2. INPUT CRITERIA DEFINITION FOR DESIGN METHODOLOGY

Designing of automated assembly device is specifically by reason of complexity and singularity of several assembly device parts and elements. One of the specific characters of assembly device is often modification of assembled product shape and dimension and device have to adjust to it. Other specification of assembly is the increase of assembling parts quantity during assembly process [4]. Tendency of design methodology proposal is to standardize some procedures by design and realization of the automated assembly devices and machines. This standardized proceeding includes four basic levels (Fig. 1). Design methodology proceeds from analytical partition with using of known analytic methods through basic concept planning and concept solutions till to detail designing of assembling workplace and individual devices. Last level of methodology is the design of automated devices considering to before designed solutions of assembly devices in workspace.

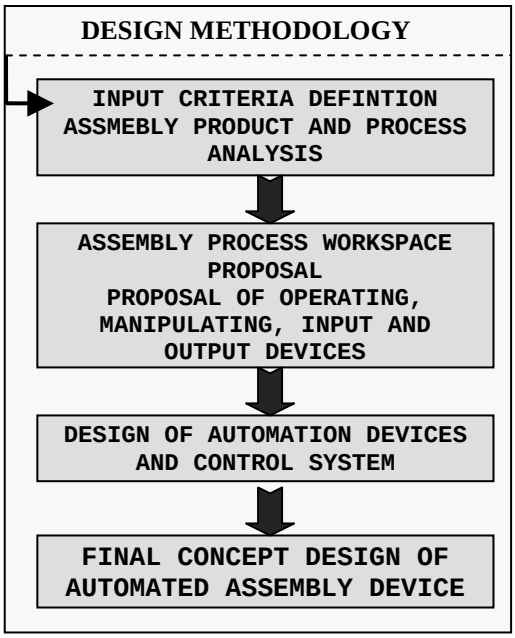

Fig. 1. Basic levels of design methodology

2.1 Input analysis of assembled process and product

Before design of equipment of automated assembly device it is important to detail analyze assembled part in various terms. On the ground of parts basic analyze of assembled product, assembling advance, and choosing of assembly process structure is possible to create the proposition of automated assembly device design by using of design methodology. The first step of analyze includes shape, dimension and number of part analyze of assembled product and its parts. Selection of assembling units and devices and general character of automated assembly system results from detail analyzes. The analyze of assembly group is possible to divide to this categories in a general (Fig. 2.).

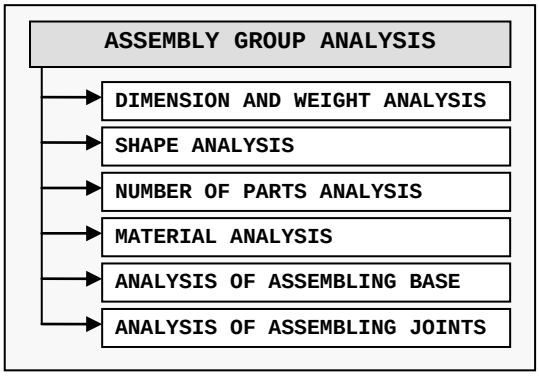

Fig. 2. Partial analysis of assembly group

3. PROPOSITION OF ASSEMBLY UNITS AN DEVICES

Second level of design methodology is a project part includes individual proposals of assembly devices and units that generate automated assembly system and provide for assembly process realization. This level also includes analysis and assembly sequence. On the basic of the first level of methodology, analysis of assembly group, is possible to define some parameters of automated assembly device. In a general is able to determine basic shape, dimension and complexity of final device. On the ground of analyzed parameters summary definition is able to define full parameters that are become a background for design of automated assembly device. Concrete is designated final workspace, carrying construction capacity, energy source size, and information flow quantity. Device workplace generally includes several input devices with assembled parts and one output device after finalization of assembly process. Final assembled product is delivered out of assembly device workplace automatically. Quantity, design, shape and dimension of input and output devices define total shape and dimension of assembly device workspace (Fig. 3.).

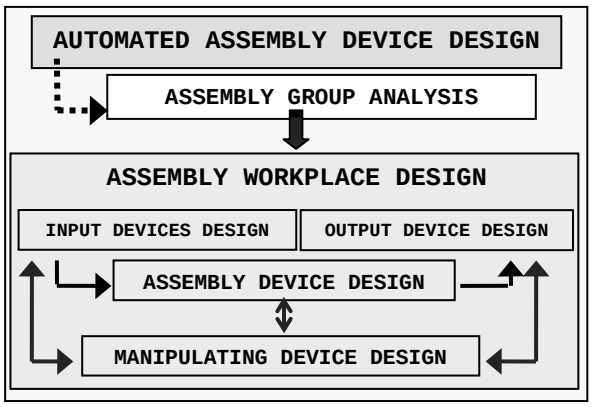

Fig. 3. Design methodology of assembly workplace planning

3.1 Input and output devices designing

Assembly process is characteristic by input devices quantity that provided for interaction connections between assembled

parts. As a result of interconnections of input parts is assembled product. Input devices quantity depends on assembled parts quantity. For every to assembly process imputed part is necessary to propose design of device that included device for part delivery, separating, orientation, clamping and feeding (Fig. 4.).

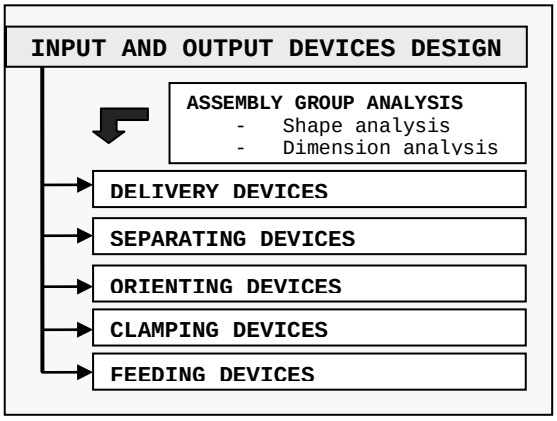

Fig. 4. Methodology of input and output devices design

Assembled product assembly method and technological process has to be designed for simply assembly by help of automation equipment. This is the main condition for designing and generation of automated assembly device and automated assembly process realization. After fist level of method and analysis of assembly joints, assembly operations and creation of assembly sequence is possible to design the character and number of assembling devices.

3.2 Assembly units and devices designing

Assembly operation devices perform joints between parts term assembly. Before assembly operation units design has to be define the character and method of automated assembly process. Process of automation assembly can be various; continuous, linear or discontinuous. According to process type is chosen the type of assembly devices, manipulating devices and totally workplace of automated assembly device. If are the assembling operations dimensional and shaped similar then is able to use universal devices for assembly and manipulation. This type of device can realize all assembly operations. In the second case the assembly operations are standard different and then it is necessary to use individual assembly stations that are realized all assembly. Assembled product is sequentially moved to assembly station to next assembly part. Through integration of all assembly, input and output devices generates workplace for the manipulating device operated in.

3.2 Manipulating devices designing

Automated assembly device is produced by complex of workstations, input and output devices, assembly units worked in various work modes and various level of automation. For provision of automation assembly is required to provide automated interoperable manipulation between operation units in relation to specified assembly and technical sequence. Manipulating device is characteristic as connecting element. On the ground of assembly process analysis and assembly character is able to design the manipulating method. It is important to note to several parameters by choose of manipulating type. First aspect of note is assembly group analysis; concrete the dimension of imputed parts. A second criterion is number of manipulating stand. Manipulating stand is the place of manipulating device position. In this position it is necessary to stop in this position operate manipulating with parts, assembled product or assembling individual parts. This stop positions are exactly input, output, assembly or control units of automated assembly device.

Manipulating device is characteristic as system of technical equipment with individual function and integral unite. Technical equipment of manipulating device is able to class into the individual function groups. There through is possible to design sequentially individual function parts and after that to configurate into one manipulating device by standards of design methodology (Fig. 5.).

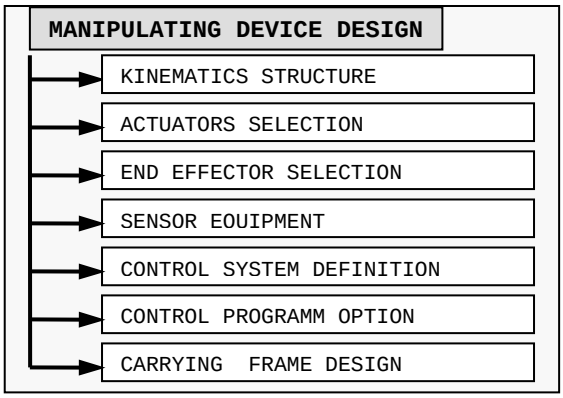

Fig. 5. Methodology of manipulating device design and its function units

3. DESIGN METHODOLOGY FOR AUTOMATION DEVICES AND CONTROL SYSTEM PROPOSITION

Next level of design methodology is the proposal of automation devices and control system (Fig. 6.). These devices and equipment provide for automated assembly process performance. Technical equipment is defined and designed on the basic of before projecting and projecting phase of design methodology and generation of assembly devices proposition. Consistent and depth assembly process and objects analysis provides for rational proposal of automated devices. It is existed a lot of technical devices of automation for automated assembly process realization. On the ground of experience and using of automated devices is chosen the type of automation equipment. In a general has to be design actuating parts, sensory parts, communicating elements and control system by design methodology in sequence. In the second level is able to design the control mechanism for assembly process monitoring and also emergency devices. Mainly is important to choose same energy source for all elements in the automation device. Also are used hybrid automation control systems. In a generally are used pneumatic, hydraulic and electric automation devices. Also are used hybrid automation control systems. On the ground of motion analysis is designed rational advantageous control mode of automation.

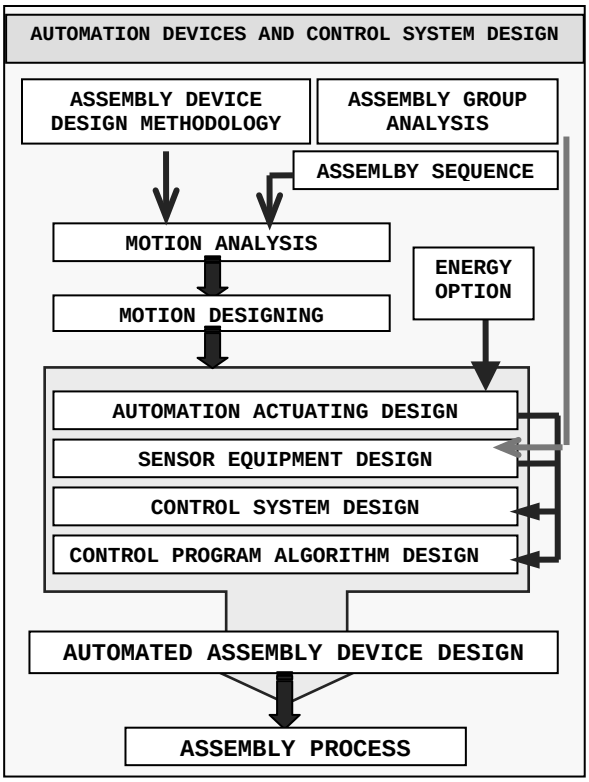

Fig. 6. Schematic chart of automated devices and control system design

Design methodology includes the definition and design of technical automation equipment with regard to assembly sequence and assembly character. On the basic of type of assembly system definition is designed main automation medium and next assistant equipment supporting assembly process. For full automated assembly process it is needed to control automatically assembly, manipulating, conveying, clamping and positioning processes through the use of automatic controlled actuator parts. Controlling is realized by help of chosen control and sensor system by dimension of assembly device and number of inputs and outputs of automation devices. In the frame of this activity has to be defined assembly sequence and designed control algorithm sequence of all automated assembly device by design methodology.

4. DESIGN METHODOLOGY APPLICATION TO VERIFICATION OF AUTOMATED ASSEMBLY DEVICE MODEL GENERATION

Proposition and generation of automated assembly device is a complex problematic that includes and makes provision for problematic of automated device generation and continuous connects with problematic of assembly device design. Design process of automated assembly device requires tool for automation assembly device problematic. Result of design methodology is the verification and proposition of real automated assembly device for known verified model of assembled actuator (Fig. 7.). Pneumatic actuator model consists of four basic parts in three various modifications (shape, dimension, material) and assembly process is realized by various methods. On the basic of design methodology is important to make analysis of assembled product and process and thereafter to realize assembly sequence.

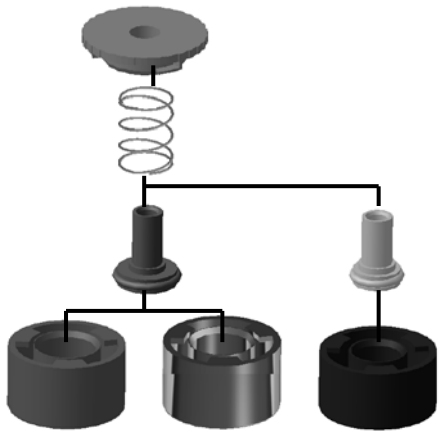

Fig. 7. Sequential scheme of assembled pneumatic actuator assembly sequence

4.1 Assembly workplace and assembly devices proposition

Next level of design methodology is the projecting phase included proposals of devices that are important in automated assembly process. In this solution level are designed devices that generated workplace of automated assembly device [5]. Assembly device constitutes output device for final assembled product delivery, input device for actuator body, spring, piston and cover, and assembly clamping device. Through the use of assembly devices and workplaces integration is generated workplace for the manipulating device in that is operated. Work zone of verified assembly model is generated by designed devices that are important for automated assembly process (Fig. 8.).

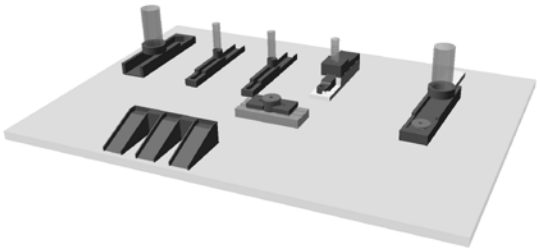

Fig. 8. Expected character of proposal assembly devices workplace

The connecting device between all devices is the automated manipulating device. Basic concept of manipulator is its Cartesian kinematics and manipulating space is cubic. Manipulating device has to operate all devices and workplace positions on the ground of designed assembly devices. It means that manipulator axes have to provide for exact positions in all points. Also is important to design the end effector of manipulator that is universal for all parts grasping.

4.2 Design of automated devices and control system

The proposal comes out from before designed assembly devices that are only technical instruments. Thereafter it is necessary to automate the assembly process by help of next created technical control system. Control system provides for automated assembly process realization. Design of automated devices is generated on ground of all motions analysis by assembly sequence and designed assembly devices. As a work medium for actuators is chosen compressed air. On the basic of motion analysis are

generated pneumatic actuators that provide for automatic motion sequence. The motion is the smallest part of assembly and by connection of all motions by help of control is possible to realize automated assembly process. Important element of device is sensor equipment that is generated on the ground of design methodology in three levels; actuators end positions checking, part in process detection and position and travel of manipulator axes. Control algorithm as last part of system is the base for generation of control system and program. For design of control program are used methods: motions short entry, step diagram, sequence table and Grafcet [6].
Before assembly device introduction in operation has to be provided for more technical realizations. All devices have to be mounted on the basic frame e.g. Final design of automated assembly device is showed on Fig. 9.

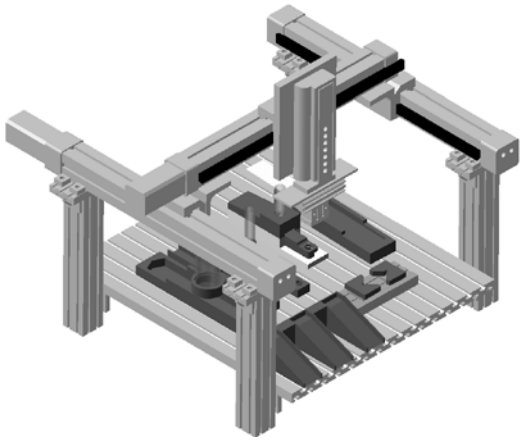

Fig. 9. Proposition of generated automated assembly device for verified model

5. CONCLUSIONS

Main contribution of the methodical compilation is a complex design methodology for generation of automated assembly devices with use of optimal automation technical devices. Methodology includes requisite analytic and proposal methods and procedures that are developed and modified for problematic about automated assembly devices generation for control of assembly processes. Designed and verified design methodology will be used by projecting and realizing of intelligent assembly cell (IAC) and by proposition of automation and sensor equipment and control system equipment.

6. ACKNOWLEDGEMENT

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