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PARTIAL ANALYSIS AND DESIGN SPECIFICATION OF SEGMENTAL ROBOT GRIPPER EFFECTOR BY HIGH-FEED MILLING

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ABSTRACT

Elimination of production times is a broad-spectrum issue that is addressed by every manufacturing company, not excluding the engineering industry. Continuously increasing demands on the safety of manufacturing processes and production accuracy can be achieved only by achieving the complexity of the machine - tool-workpiece - jig system. One of the parameters of the system complexity, which ensures precise and fast machining is the jig which forms an irreplaceable part of the production process. The presented article describes the partial analysis and design specification of segmental robot gripper effector using advanced technologies. Introduction part of this article describes theoretical approaches of issue and state of the art. Material and Methods provides the creation of a design solution with basic parameters specification. The main part of this article presents a description of the analysis and design specification of segmental robot gripper effector, which is produced by high feed milling technology with a final summary of the obtained results. This research was supported by grant KEGA 025TUKE-4/2018.

Keywords: high feed milling, design, robot gripper effector.

INTRODUCTION

The explicit development of current technologies is directly proportional to the continuous improvement and rationalization of the production process. In the development of these technologies, an important aspect is the implementation of science and research into practice. One of the possibilities of such implementation is the creation of design tasks within the interconnection of the engineering industry and robotics through effective design solutions (Murcinkova et al., 2020). One of the possibilities of providing such a form of implementation is the creation of design solutions within the creation of robotic systems, such as segment effectors for the robot gripper. The gripper is the end effector of the industrial robot robotic arm, while it is very similar to robotic arms. It differs in that it can perform many more functions than robotic hands. There are different types of end effectors, each designed for a specific operation (Mohammad et al., 2018). The figure 1 provides a classification of these effectors.

Gripping effectors are also called gripping heads or grippers, which are intended for gripping, fixing and carrying objects. Industrial robots have used in a variety of technological operations. They work with a variety of components that differ in weight, shape, strength and, above all, the surface roughness of the manipulated object. At present, grippers have made of various materials such as ceramics, glass, wood, plastics, metals, etc. Each model of an industrial robot has several variants of grippers, which can be easily replaced if necessary (Michalik et al., 2018).

Gripping effectors - grippers that perform the function of gripping and holding the object of manipulation, ensure its fixation during relocation and at the same time participate with the robot arm in the positioning or orientation of the object of manipulation at the place of delivery.

Technological effectors - working effectors of the "tool" type; they perform the specified technology independently. The movement, position and orientation in space has realized by the parallel movement of the robot arm. Their function is to hold a technological tool for the implementation of the required technology.

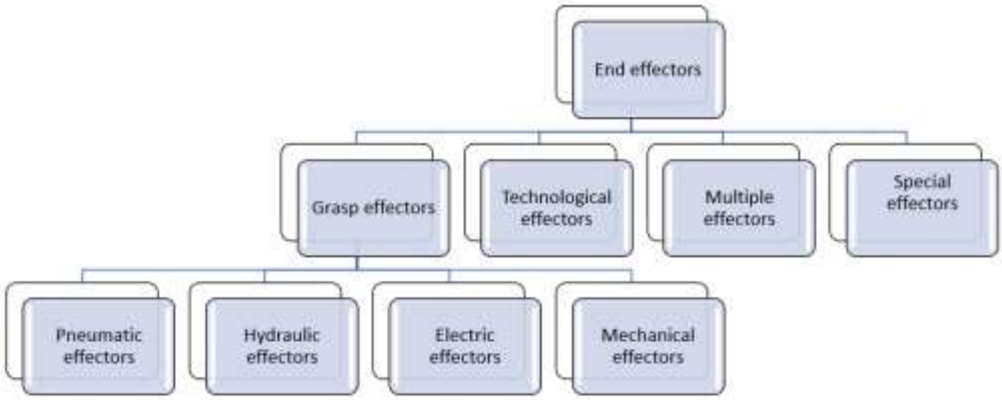

Figure 1. Classification of end effectors

Combined effectors - perform various technological and handling operations. These are multifunctional effectors for selected gripping functions or a combination of different technological and gripping operations using one effector.

Special effectors - are designed for special gripping, technological and other system operations. They perform various types of functions that it is not possible to include in any of the previous categories. These are mainly effectors used in special types, especially service robots.

Due to the diversity of current technologies which is possible to apply in the production process, it is necessary to choose the right technology through which the component production. To ensure a suitable selection, it is necessary to take into account:

- Proper component operation
- Solution of the most suitable shapes
- Selection of suitable materials and shapes of semi-finished products
- Economy of the production process and assembly

One of the advanced technologies, which fully meets the requirements to ensure adequate production of a segment effector for the robot gripper, is the technology of high-feed milling.

High feed milling is a productive method that requires special tools and machinery. Material removal is a small depth of cut (a_p) up to about 2 mm and a high feed per tooth (f_z) up to 3 mm and can remove up to 1400 cm^3 of material per minute. The great advantage of the HFM method is the direction of the resulting force during machining, which leads to a reduction of vibrations, an increase in the stability of the cutting process, an increase in tool life. The biggest advantage is the increase in machining productivity. Compared to conventional machining, up to a 60% reduction in production time is possible to achieve. By increasing productivity, the smaller depth of cut has replaced by the necessary increase in cutting speed (Zauskova et al., 2017). For high-feed milling, cutting materials have produced that have high strength, hardness, toughness, wear resistance, resistance to oxidation and chemical action. The cutting materials have most often made of a high-quality sintered carbide substrate with a coating. PVD or CVD coating improve the cutting properties. The choice of tool for HFM influences by several factors, e.g. high reliability, durability, favourable acquisition costs. The tools speed up the cutting process, but also improve the force loading of the machining unit and reduce vibration. Cutters are usually made by internal cooling because it allows direct cooling of the cutting point. The cutter diameter is selected depending on the size of the machined surface. Cutters with VBD for roughing and/or solid carbide cutters are most often used (Gylienė & Eidukynas, 2016). The technology of high-feed milling has chosen as the most suitable alternative in solving the established problem. The specific specification of the design solution is given in the following part of the article.

MATERIAL AND METHODS

The problem solution was realized based on cooperation from practice. There was required production of chamfer in the middle part of the effector. The mechanical drawing presents the figure below. The high-feed milling technology has been used for production to ensure the elimination of production costs.

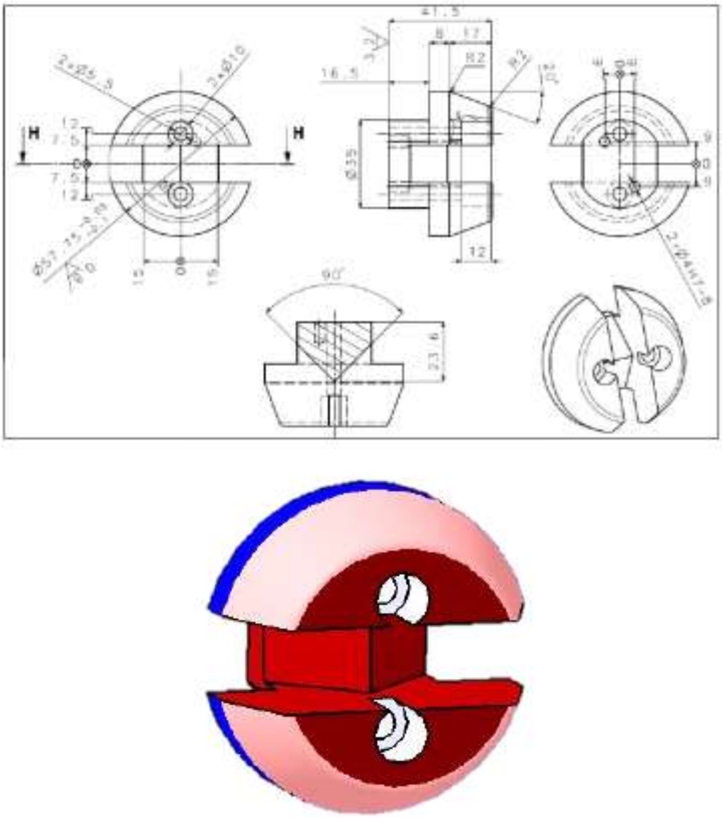

Figure 2. Mechanical drawing (left) and 3D presentation (right) of produced component

The material EN AW-6082 was selected for the production of the defined part, which is an important construction material due to weight. The material E295 was selected for the production of the clamping jig, due to its availability, price and required properties.

Table1. Basic properties of applied materials (Alloy data sheet, 2020; Properties of material, 2020)

Parameter	EN AW-6082	E295
Yield stress [MPa]	260	350-550
Tensile strength [MPa]	310	650-880
Elongation [%]	10	8-25
Thermal Conductivity [W/m.K]	170-220	25
Modulus of elasticity [GPa]	70	200

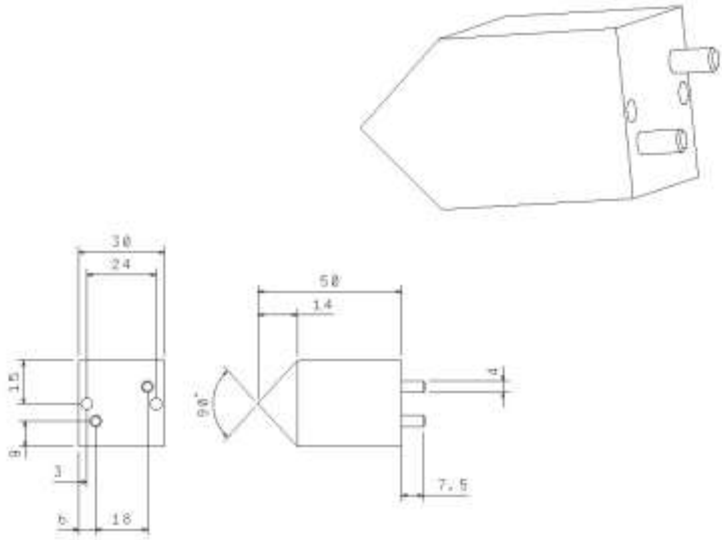

Figure 3. Clamping jig of segmental robot gripper effector

The HAAS VF-4 CNC machine tool was used to carry out the production process. This machine tool is described by high accuracy, temperature stability and has a rich clamping carousel.

Figure 4. HAAS VF 4

DESIGN SOLUTION OF SEGMETAL ROBOT GRIPPER EFFECTOR

As mentioned in the previous chapter, the problem lies in the production of a chamfer. For this reason, the suggested solution was designed by a special fixture that will ensure workpiece stability. The clamping of the jig is secured by screws, to ensure the strength and durability of the joint. During the solution of the established problem, several proposals were created, which were then subjected to a detailed analysis. It was selected the alternative with the implementation of a table jig due to ensure the all required parameters. Into the table jig is clamped component using pins and screw connection. Individual parts of the preparation have modelled using CAD / CAM software Catia.

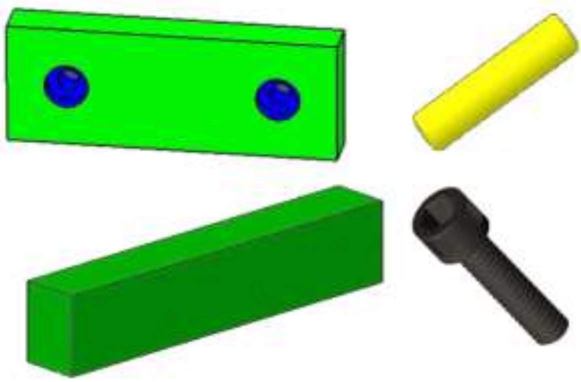

Figure 5 The model solution of segmental robot gripper effector jig

The model solution consists of a stop, a guide pin, a washer and a locking screw. The stop serves as workpiece and during the machining the other side of the part. This component also ensures the stability of the product. A connection between the workpiece and the jig is formed using guide pins. These components serve for easier clamping and ensure higher strength and precision during machining. In the roughing operations, a washer is a very important part of the jig. This component serves as a zero point for the z-axis. The final connection of the jig with the workpiece is ensured by a screw connection.

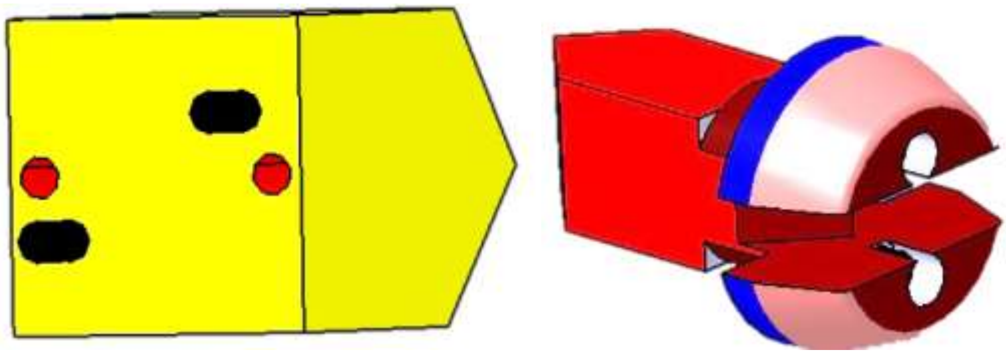

Figure 6. The Model of jig (left) and model of jig and component (right)

Subsequently, the CAD/CAM program has used to create a jig model assembly with a machined part. Based on this model, a clamping jig has produced under operating conditions, which has inserted into the machine vice and secured on one side with a stop, thus achieving better and faster locating.

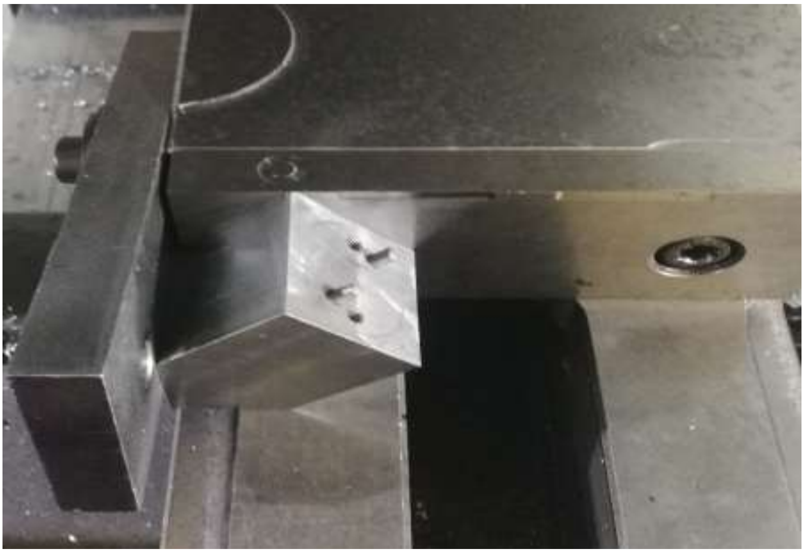

Figure 7. Jig implemented to the production process

CONCLUSIONS

The created jig meets all the required attributes - the quality of the machined surfaces, easy handling, strong fixing of the workpiece. From the reason of a piece production, the primary effort was to design an elementary and economical solution. The above aspects and requirements defined by practice have been taken into account. The requirement for a fixed clamping has ensured by the implementation of a machine vice, pins and a screw connection. Verification in practice confirmed and verified the required parameters, tolerances and functionality of the created preparation.

ACKNOWLEDGEMENTS

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