ESTIMATION OF CONDITIONS IN EXCHANGEABLE JAWS DESIGN OF PNEUMATICS GRIPPER

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Abstract

The paper deals with the design of replaceable jaws on pneumatics gripper of the CNC milling machine EMCO Concept MILL 105, which is part of the iCIM 3000 manufacturing and assembly system. When designing replaceable jaws to allow firm and safe clamping of rotating and non-rotating parts, it was based on limiting factors such as parameters of the pneumatics gripper, dimensions, shape and material of the clamped parts and the like.

Key words

INTRODUCTION

The complete design of the preparation takes into account several requirements such as technological operation, shape and dimensions of the component, material of the components, splinters. There are also clamps with replaceable parts, such as pneumatic gripper, where only replaceable jaws are designed.

The EMCO Concept MILL 105 CNC milling machine, which is part of the iCIM 3000 production and assembly system, is a pneumatic gripper from GRESSEL Ecopos with replaceable jaws. The paper deals with the individual steps of designing the replaceable jaws for a new component base.

CURRENT STATE IN THE MILLING MACHINE

At present, the EMCO Concept MILL 105 CNC milling machine machining of rotating parts with diameter ø 30mm and ø 40mm.
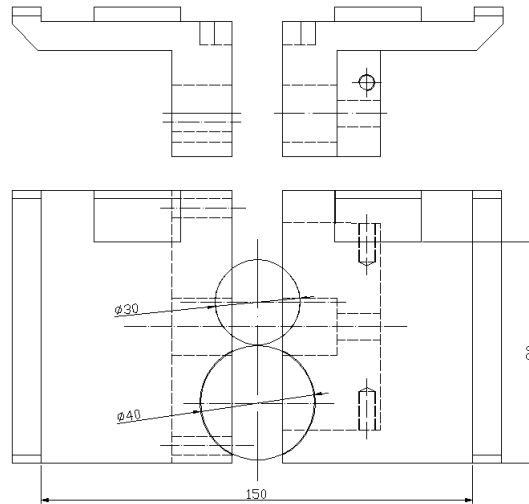
Fig. 1 *Current state of replaceable jaws in pneumatics gripper*

These rotating parts are clamped in clamping jaws, which also serve to clamp a plate-shaped component with dimension 80x150x14.8mm (Fig.1). All machined parts are made of aluminium. Replaceable jaws are clamped on a pneumatic spindle with a maximum clamping length of 70mm and a jaw width of 72 mm. This size is also adjustable for jaws.

NEW COMPONENT BASE AND DESIGN OF REPLACEABLE JAWS IN THE PNEUMATICS GRIPPER

The milling machine is designed to produce rotating components with a diameter of 32mm and a non-rotating components with dimensions 60x140x14.8 mm (Fig.2). New rotary parts and plates are also made of aluminium.
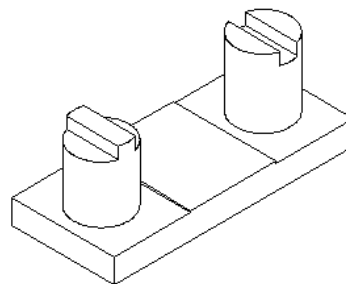

Fig. 2 *New component base*

For the new component base, replaceable jaws are designed to allow firm and secure clamping of rotating and non-rotating components. At the same time, the jaws of the pneumatic gripper cannot clamp the new parts because their dimensions and shapes are different. The clamping of the rotating parts will be up to 8mm in height, which ensures a firm and reliable clamping at a total height of 35mm. The insufficient maximum clamping length of the pneumatic gripper affects the shape of the replaceable jaws.

Dimensions design of fixture parts of replaceable jaws to the gripper

The clamping parts of the replaceable jaws consist of the design of two groups of dimensions. These are the diameters of the jaws for clamping the jaws with screws and the

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spacing between holes for clamping the jaws through the screws (Fig. 3). These dimensions are influenced by the pneumatic sprocket.
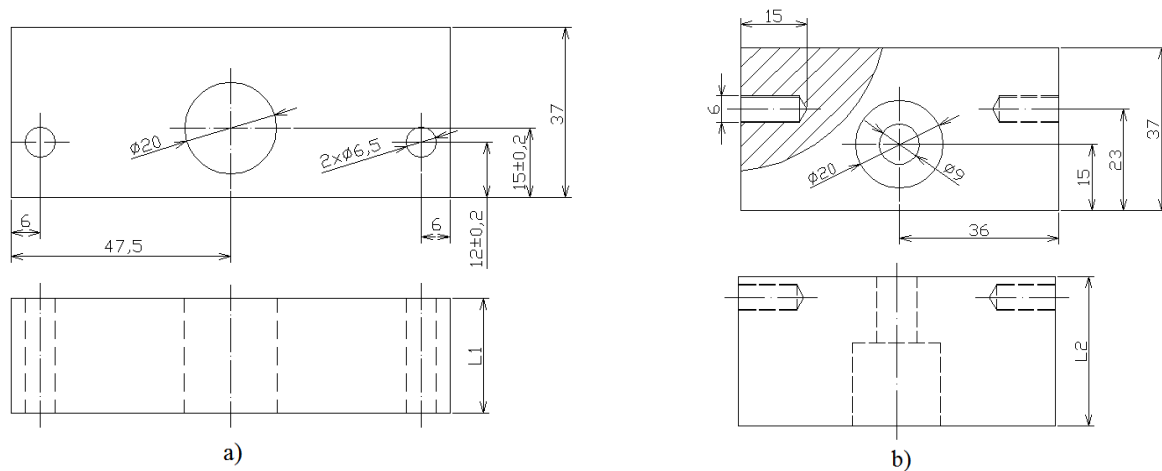

***Fig. 3** Fixture part of jaws to the pneumatics gripper*
a) left jaw, b) right jaw

The most important parameter that affects the dimensions L1 and L2 is the maximum clamping length of the pneumatic gripper, which is 70 mm and the clamping stroke of the pneumatic gripper, the value of which can be selected in the range of 1 to 5 mm.

The clamping stroke determines the distance that the jaws move when they are snapped and tipped. In this case, the distance of 7mm jaws (Fig. 4) and 11mm jaws was determined. Thus, the clamping stroke is 4mm. Dimensions L1 and L2 can be determined on the basis of the opening and clamping stroke of the pneumatic gripper. The total width of the left and right jaw represents 59mm. Based on the design, the width of the left jaw was L1 = 25mm and the width of the right jaw L2 = 34mm.
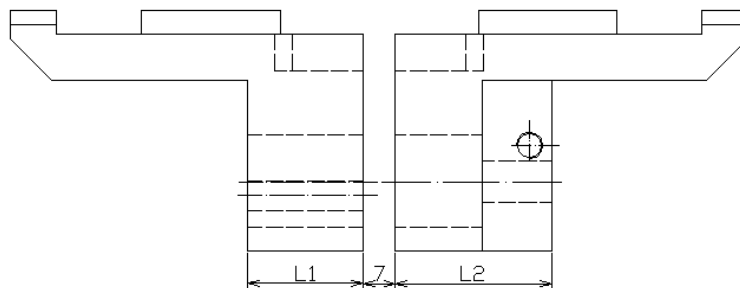

***Fig. 4** Mutual dimension of replaceable closed jaws which are fixture in pneumatics gripper*

Design dimensions of fixture part of replaceable jaws for base plates

Clamping of plates 60x140x14.8 mm is high up to 5mm. The dimensions l_1 and l_2 are given by the length of the plate from which the distance between the closed jaws is deducted. The sum of the lengths of the clamping parts of the left and right jaws for clamping plates is 133 mm. On the basis of the design, the length of the clamping portion of the left jaw was l_1 = 66.5mm and the length of the right jaw clamping length l_2 = 66.5mm (Fig. 5).

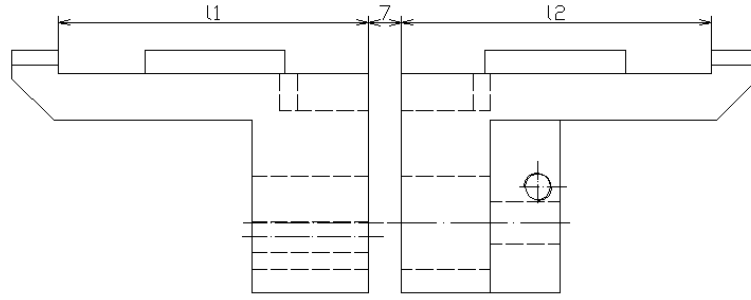The width of the left and right jaw clamps was determined to be 77mm (Fig. 6) based on the base plate width of 60 mm.

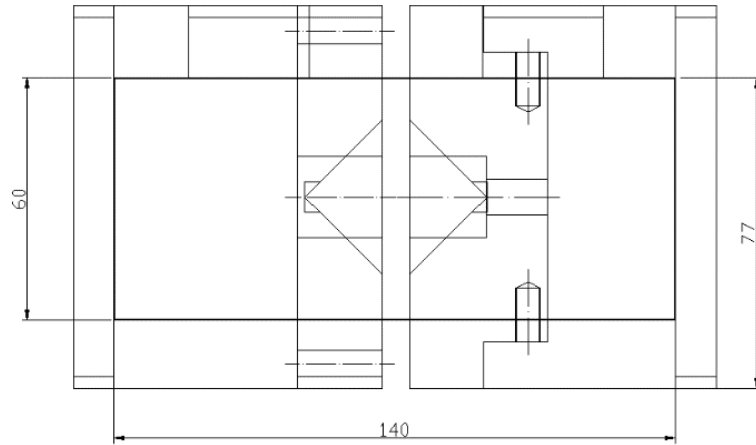*Fig. 5 Lengths of fixture parts of replaceable jaws*

Fig. 6 Fixture of base plate in the replaceable jaws

Dimensions design of prisms of replaceable jaws

Prismatic jaws are designed to clamp the rotary workpieces. In this case, the prism angle α=90° was also selected.

The prism design (Fig. 7) was based on the diameter of the clamped work piece D and the distance h, which represents the length of the prism, in this case determines the dimension of the clamping part for clamping the plate, i.e. h = l_1. The distance h is an important value for determining the H value, which represents the distance of the edge of the clamping portion of the base plate from the component axis. The H value is defined by:

$$H = h + 0{,}707 \times D - 0{,}5 \times C \quad \text{[mm]}, \qquad [1]$$

where:
h – flexible part dimension for fixture of base plate [mm],
D – workpiece diameter [mm],
C – width of prism [mm].

If the value C is not known, it can be based on the $L_{zč}$ value, which represents the distance between the clamped jaws and its value is 7mm. In this case, the relation for H is determined as:

$$H = h + \frac{L_{zč}}{2} \quad \text{[mm]}, \qquad [2]$$

where:
$L_{zč}$ – dimension between closed jaws [mm].

Based on the previous relationship (1) it is possible to derive the relationship for determining the prism width C in the form:

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$$C = 2 \times (h - H + 0{,}707 \times D) \quad [\text{mm}] \tag{3}$$

Dimensions SA and SB (Fig. 7) are defined by relationships:

$$SB = \frac{D}{2} \quad [\text{mm}] \tag{4}$$

$$SA = \frac{SB}{\sin\frac{\alpha}{2}} \quad [\text{mm}], \tag{5}$$

where:
α – angle of prism [°].

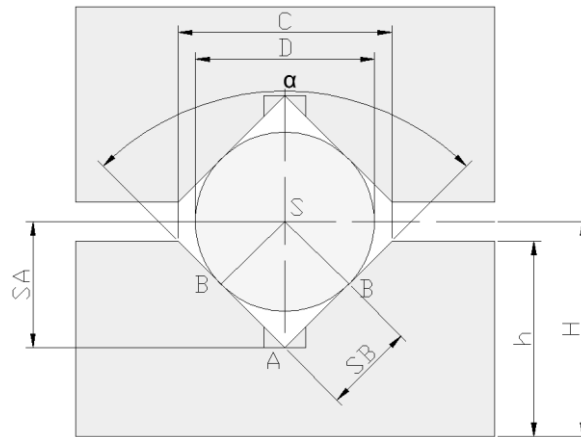*Fig. 7 Base dimensions of prism*

According to previous relations, the basic prism dimensions for the rotary components with diameter ø32mm (Tab. 1) were calculated. The designed replaceable prisms are shown in Fig. 8.

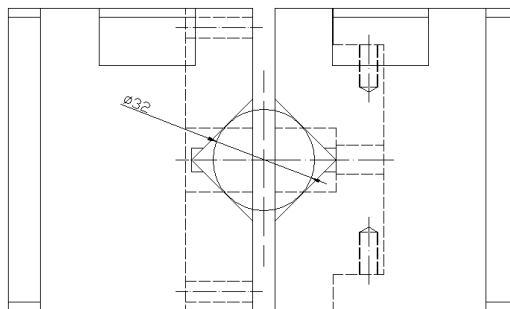| Table 1: Base dimensions of prism						
Diameter of fixtured workpieces D [mm]	α [°]	h [mm]	H [mm]	C [mm]	SB [mm]	SA [mm]
ø 32	90	66.5	70	38.3	16	22.6

Fig. 8 Replaceable jaws for workpieces ø 32mm

Selection of suitable material for removable jaws

Steel with a minimum tensile strength about 450MPa, is one of the most commonly used materials for the jaws' jaws. The chosen material was therefore the E360 (11 700) structural steel, suitable for machine parts that have higher resistance to wear and tear.

Determining the size of the clamping force

The size of the clamping force is an important parameter for machining. The clamping force must be greater than the cutting force so that the workpiece is not displaced or vibrated. The pneumatic sprocket used has a maximum clamping force of 3000N, which means that the cutting force must be smaller.

Determination of the size of the cutting force consists of the following steps:
• Selection of a suitable cutting tool
• Determination of cutting conditions
• Calculation of the cross section of the fragments taken
• Determination of cutting resistance
• Calculation of the cutting force size
• Determination of the safety factor
• Determination of the size of the clamping force

The size of the clamping Fu force can be determined by:

$$Fu \geq \frac{K \times Fc}{f} \text{ [N]}. \hspace{2cm} [6]$$

The coefficient of friction *f* between the workpiece and the clamping surfaces of the preparation. Its value depends on the surface of the preparation and the machining of the workpiece.

The clamping forces required to clamp the rotating components and plates have been calculated. All values were below max. The clamping force which the pneumatic claw is able to clamp.

CONCLUSION

The aim was to design replaceable jaws on the GRESSEL Ecopos pneumatic gripper clamped on the EMCO Concept MILL 105 CNC milling table. The new jaws were designed to ensure firm clamping and setting up of newly-formed rotating components with ø 32mm diameter and a 60x140x14.8mm (WxLxH) baseplate.

The design of jaws was based on limiting factors, such as the parameters of a pneumatic gripper as a maximum and minimum cutting, maximum clamping force, maximum clamping stroke, clamping screw spacing and others. Another important design factor was also the size, shape and material of the parts. For the versatile use of the pneumatic gripper, the shape of the designed jaws has been adapted to the gripper parameter. When designing replaceable jaws, their dimensions were proposed, which were divided into three groups. These groups consist of the dimensions of the clamping parts of the replaceable jaws, the clamping part of the replaceable jaws for the base plates and the dimensions of the jaws of the replaceable jaws.

The chosen material was E360 structural steel (11 700). To design the components and base plates, it was necessary to determine the size of the clamping force. The required size of the clamping force must be less than the maximal clamping force of the gripper. After calculating the clamping forces, it was found that all the components and base plates could be securely clamped on the pneumatic gripper.

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