About Designing of a Gripper with Two Adjustable Jaws

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Abstract: *The paper presents aspects related to the design of a gripper with two jaws, adaptable for different shapes and sizes of the handled objects. The aim of the design was to obtain solutions that were as simple and easy to process as possible, to meet a wide range of uses. The finite element analysis established the deformations, stress and displacements of the fixing elements, in three options of loading. Then some considerations were presented on the technological process of manufacturing the gripping device and conclusions were drawn regarding the suitability of using it.*

Keywords: *Constructive design, gripping system, manufacturing process*

1 INTRODUCTION

The gripper is the interface between the robotic system and the handled objects [3]. It must be adapted for efficient and safe gripping of a wide range of parts with different shapes, masses and volumes. In this respect, the aim is to obtain simple and adjustable gripping elements, easy to process, safe and economical.

2 DEVICE DESCRIPTION

The gripping device is an assembly consisting of two bent components, to which 3 pairs of jaws are attached, adapted for gripping objects of cylindrical or parallelepipedal shape [4]. This assembly can be attached to the connection areas 1 and 2 of the electric parallel gripper SCHUNK EGP 40-N-N-B [5]. (Fig.1)

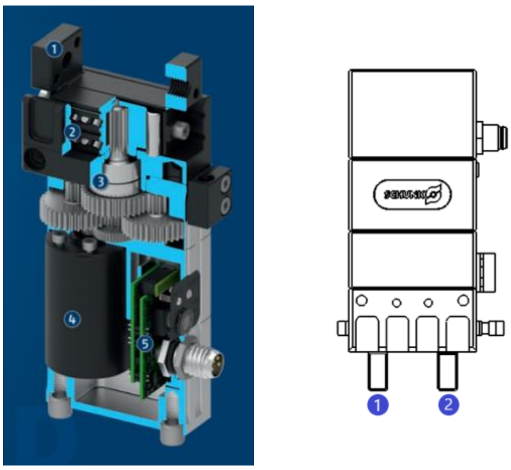

Fig.1 SCHUNK-0310940 EGP 40NNB gripper [5]
1- technological base of placement/fixing; 2- transversal guide system with rolls; 3- rack and pinion gear; 4- servomotor; 5- controller

3 DESIGNING THE COMPONENTS

CATIA Generative Sheetmetal Design [2] was used to design the bent component, obtaining a piece of bent sheet-metal having the shape and dimensions shown in Fig. 2 and lengths, before and after parameterization, respectively, are shown in Fig.3.

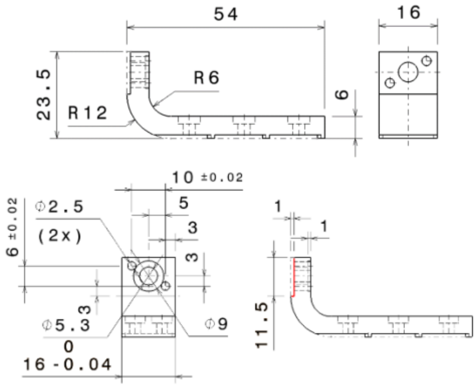

Fig.2 Dimensional characteristics of the supporting component

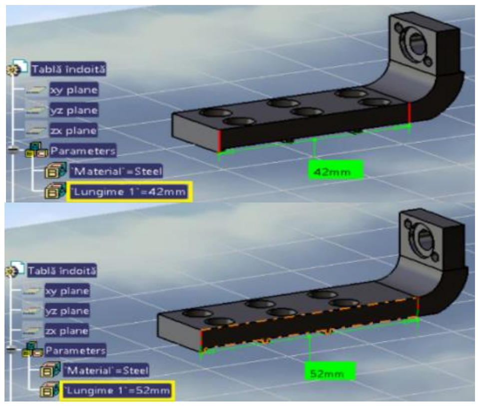

Fig.3 Designing the bent steel strip component

The bent component has an area that allows fixing it to the gripper body, with the help of screws, and three other areas, to which the gripping jaws are attached (Fig.4).

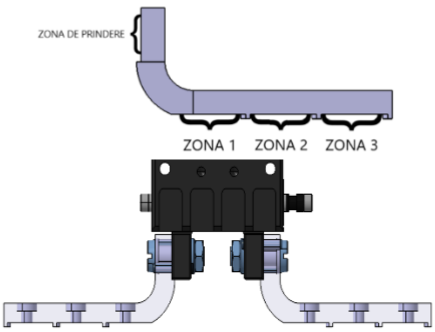

Fig.4 Mounting the components on the gripper

4 DESIGNING THE JAWS

The presented device being designed as a reconfigurable device, it involves the design of three pairs of jaws, each one having certain geometric features (Fig.5). The jaws are designed to grip light but bulky objects, cylindrical or parallelepipedal. As in the case of the bent steel strip, the jaws were designed parametrically, so that their shapes and dimensions could be easily modified in order to optimize them.

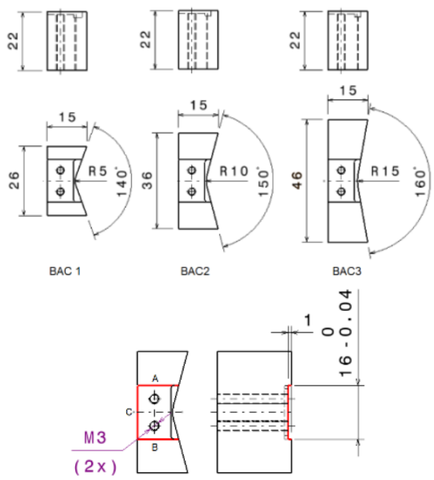

Fig.5 The three types of jaws

In all three situations, the contact is made in a favorable manner, therefore the handling of this type of parts with the help of the designed device can be done successfully, as long as the whole assembly, together with the handled part, does not exceed the maximum mass the gripper can handle.

The placement of the pairs of jaws for setting the contact with the surfaces of the handled parts is shown in Fig.6.

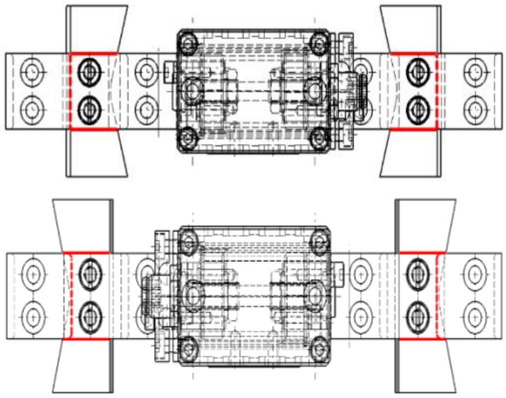

Fig.6 Contact surfaces between the jaws and the two supporting elements

For a proper centering of the parts of the subassembly, finishing milling was provided on the contact surfaces, on both the jaws and the bent component.

The pairs of jaws are attached, in turn, in the three fixing areas, depending on the dimensions and the shape (Fig.7) of the handled objects.

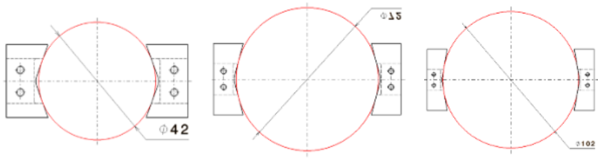

Fig.7 The jaws shaped to grip cylindrical objects, diameters Φ42mm, Φ72mm and Φ102mm

The openings, maximum and minimum, of the jaws, for the stress in area 3 (the largest) are illustrated in Fig.8.

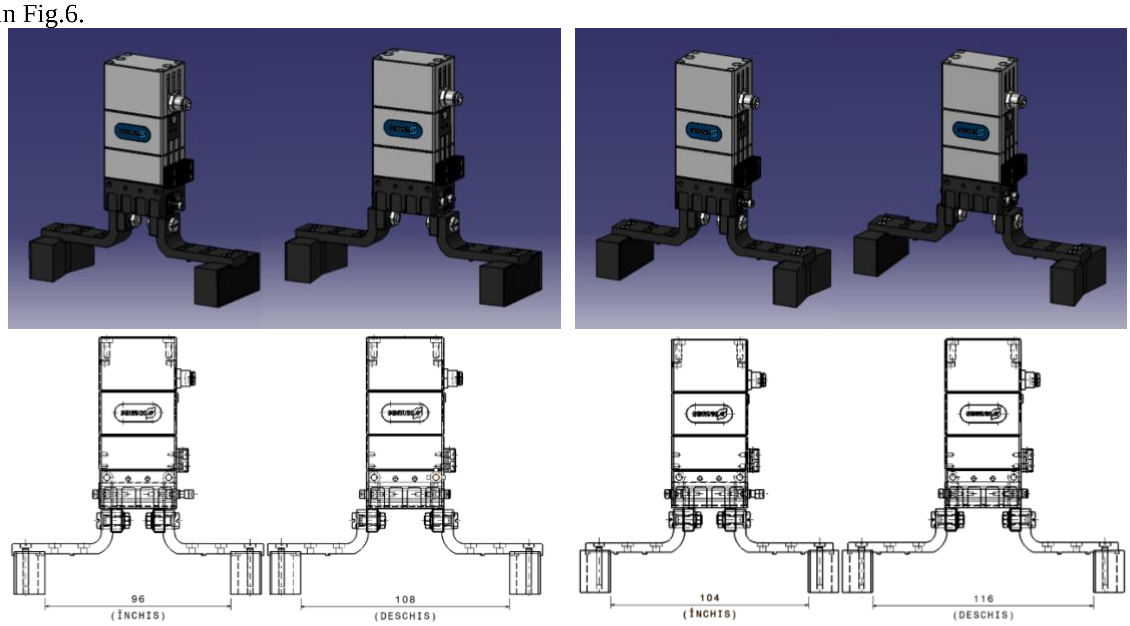

Fig.8 Positioning and openings of the jaws, for gripping area 3 (the largest), for cylindrical and parallelepipedal objects

5 FINITE ELEMENT ANALYSIS OF THE ELEMENTS SUPPORTING THE JAWS

A finite element analysis was performed, in which the appropriate constraints and the stress distributed on the concerned surfaces of the bent steel strips were established. In the present paper, assessing the masses of the component parts and mounting accessories of the device is important because it allows the assessment of the applied forces.

In order to determine the forces applied to the device, the masses of the components and the maximum loading mass M = 0,7 kg were considered. Thus it was determined that the maximum force stressing the bent component is 4.5N.

The physical characteristics of the device components, in the case of the smallest jaws, are presented in Fig. 9.

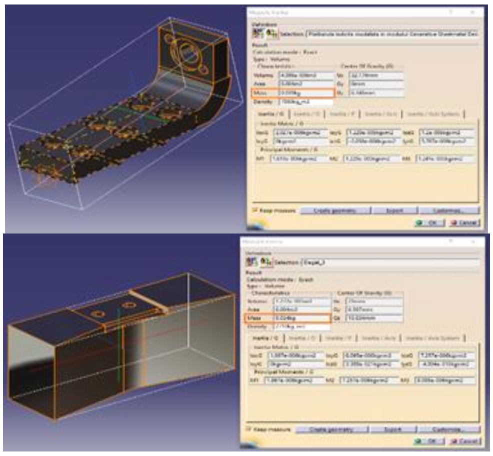

Fig.9 The physical characteristics of the bent steel strip and the smallest jaw

For zone 3, the most stressed, the constraints are established and the distributed forces that strain the bent components to bending are applied (Fig.10). The same procedure is followed for the other two loading areas.

It is observed that at the distal extremity of the bent component, in case of maximum load (zone 3), the maximum stress reached 7.58MPa and the maximum displacements reach the value of 7.35µm. Analyzing the mechanical properties of OLC45 steel, it is noticed that the maximum limit of elasticity is much higher, so there are no residual deformations that affect the operation of the gripper.

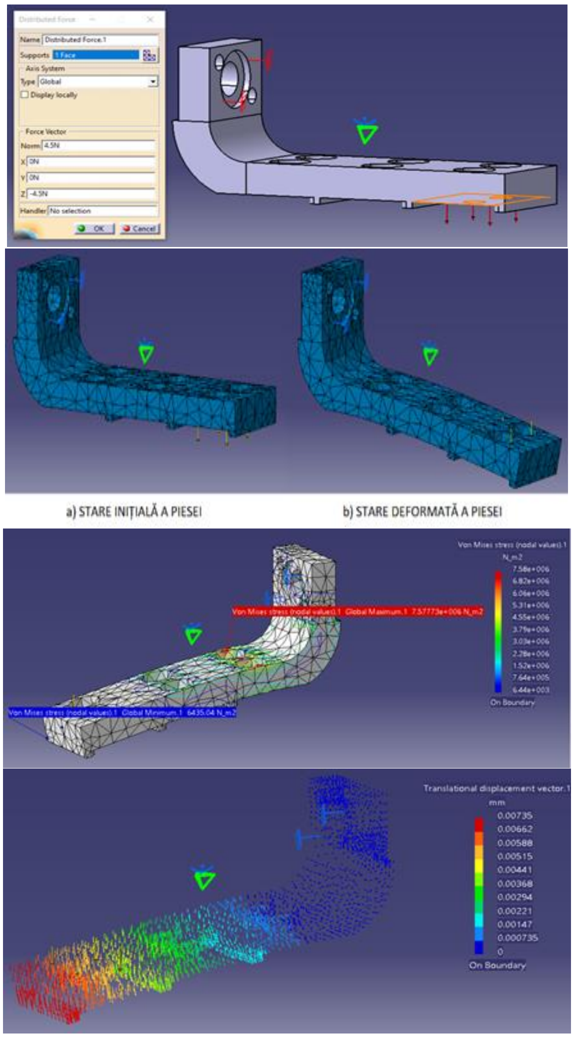

Fig.10 Deformations, stress and displacements corresponding to zone 3

A comparative analysis of the results obtained by applying FEA [1] was performed in two cases: with linear and parabolic elements, respectively, as can be seen in Table 1. It is obvious that the values of maximum stress and deformations are higher in the second case.

Table 1. Results of Finite Element Analysis

	Analiza cu elemente liniare			Analiza cu elemente parabolice		
Zone/criterii de comparatie	1	2	3	1	2	3
Solicitarea maxima [N/m^2]	$6{,}37 \cdot 10^5$	$1{,}53 \cdot 10^6$	$3{,}07 \cdot 10^6$	$1{,}56 \cdot 10^6$	$3{,}97 \cdot 10^6$	$7{,}58 \cdot 10^6$
Deformatia maxima [mm]	0.000584	0,00221	0,0043	0,000948	0,00371	0,00735

6 DATA ABOUT THE MANUFACTURING PROCESS

The bent component is the most important part of the device. For this, the main technological operations and cutting regimes were established, using the NX CAM software, for the CM-1 HASS machine, in 3 axes, suitable for processing small parts.

Fig.11 illustrates the technological flow and the parameters of the cutting regime for frontal-cylindrical milling, centering, drilling, boring, counterboring, in the fixing areas of the jaws and bent component respectively, to the gripper body.

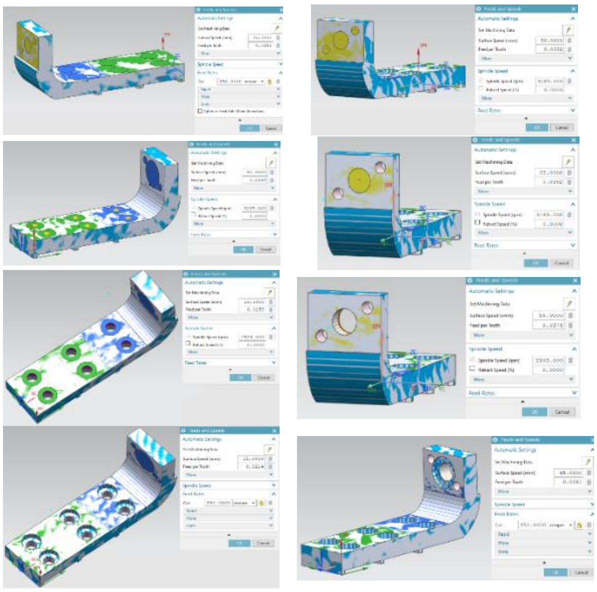

Fig.11 Cutting in the area where the jaws and the strip steel are fixed

After simulating all these operations, the processing time for each operation and the total manufacturing time of the part are determined.

It results that the total time for processing the part is 7 minutes and 22 seconds, representing the actual cutting time. In addition to this, more time is needed to make the part: time to carry out preparatory activities (studying the documentation, taking over the semi-finished products), time to start and adjust the MU, to fix and detach the part, to automatically change the cutting tools, to perform the control measurements, etc.

7 CONCLUSIONS

Since the notion of gripping strategy is usually associated with the identification of ways to ease and optimize gripping processes, it can be considered that the device presented in this paper pursues such a potential strategy. The design of the device based on the use of three pairs of jaws has led to an increased efficiency, resulting in the possibility of handling parts of various sizes. The shape of the jaws and the possibility of mounting them in different positions was intended to obtain a structure that is easily adaptable, in order to handle parts of different shapes.

The maximum strain resulting from the application of finite element analysis is well below the limit of elasticity of the material chosen to manufacture the parts. The deformations recorded when applying the analysis are insignificant, as they do not have a residual character and do not influence the positioning accuracy of the gripper. Both the two bent steel strips and their related jaws require simple processing, so the technologicity components of the device are good, involving relatively low costs.

The two bent steel strips are relatively long compared to the overall dimensions of the gripper body, but this is the feature that gives the device good adaptability and flexibility. However, when using this device, the main drawback is the working space it requires, that must be large enough to avoid collisions with other elements in the operation area of the robot. This can be optimized in the future, through a more efficient adaptation of the shape of the steel strips or the use of interchangeable components.

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