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Examination the Influence of the Type of the Contact Surfaces on the Stresses Receiving in the Manipulated Details by Using Parallel Grippers

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Abstract: *The In the article, by using the SolidWorks Simulation CAE system, the resultant stresses in the manipulated details by using parallel grippers with different types of fingers contact surfaces are studied.*

Keywords: *Parallel grippers, industrial robots, CAE systems, resultant stresses*

1. Introduction

The grippers are a type of end-effectors that allows the industrial robots to capture and manipulate different objects. They use different physical impacts to ensure a firm grip between them and the manipulated object.

The basic requirements that apply to grippers are: to be compact; be suitable for attachment, drive and control; not to damage the objects for manipulation; to act quickly; be universal and have the possibility of resetting [1].

The parallel grippers are a type of grippers that can grasp different objects, which is why they are widespread in the industry. The shape and structure of the contact surfaces of the fingers of the grippers have a significant impact on the security of the grip [2].

The various gripper`s manufacturers offer grippers whose fingers have different types of contact surfaces, (Fig.1) [4].

The aim of the present study is to investigate the influence, which the shape of the contact surfaces of the fingers of the parallel grippers has on the stresses obtained in the manipulated parts.

__Fig. 1.__ Different types of contact surfaces

2. Task Staging

The study was conducted using the SolidWorks Simulation CAE system [3] for five different types of contact surfaces of the fingers shown in (Fig.2): (I) - Smooth; (II) - With transverse grooves without rounded edges; (III) - With transverse grooves with rounded edges; (IV) - With rounded transverse grooves; (V) - With crossed grooves.

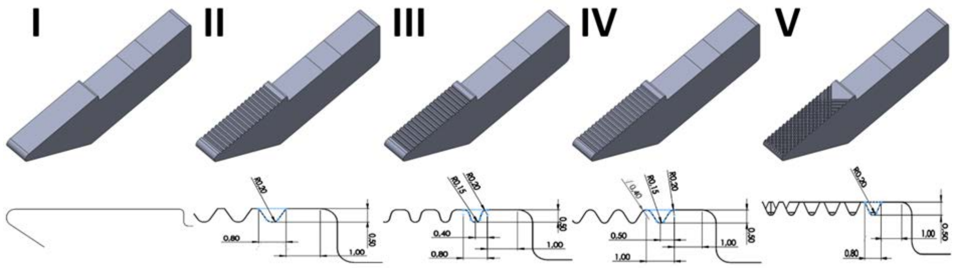

__Fig. 2.__ Types of contact surfaces of the fingers of the gripper

The manipulated parts used in the study are shown in (Fig.3)

They are with planar - (P) or cylindrical surfaces - (C).

The dimension (A) of (Fig.3) determines the position of the manipulated part with respect to the gripper`s fingers.

The study was conducted at three values of dimension (A) shown in (Fig.4).

The selected values correspond to the design dimensions of the different types of contact surfaces (Fig.2) and allow simulation of handling accuracy of manipulated parts within the limits of ± 0,5 mm.

These values define the contact areas that are different when handling parts whit cylindrical surfaces (C) as shown in (Fig.4).

When manipulated parts are with planar surfaces (P), the contact areas are not affected by dimension (A).

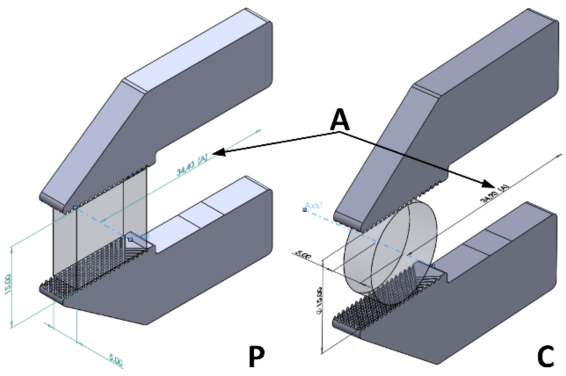

Fig. 3. *Manipulated parts*

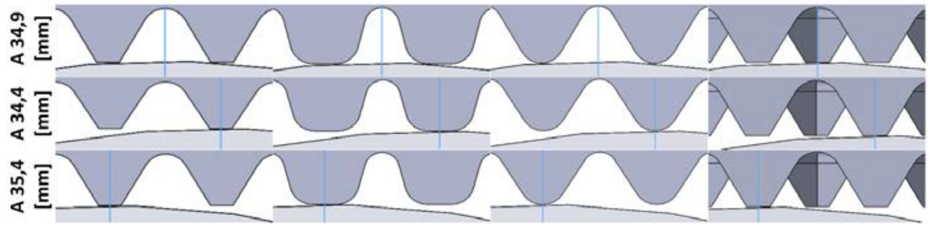

Fig. 4. *Contact areas of the parts with cylindrical surface*

3. Computational model

The computational models used in the study are shown in (Fig.5). The fingers of gripper are fixed (1).

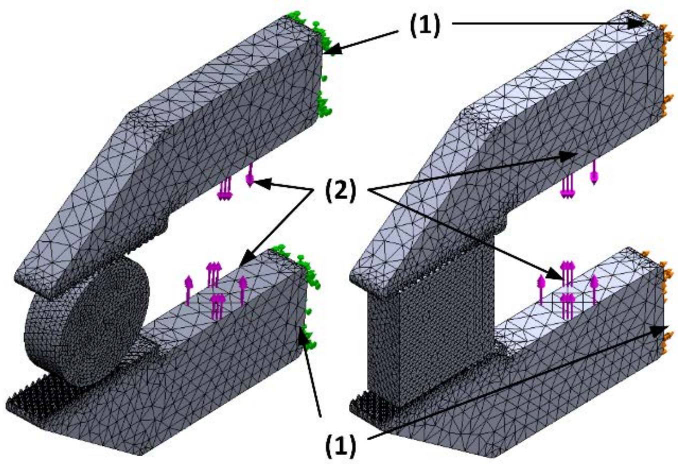

Fig. 5. *Computational models*

The gripping force (2) used in study is 200 N.

The material for the fingers of gripper and the manipulated parts is steel.

The coefficient of friction between contact surfaces is 0,15.

Research has been conducted with constant parameters of finite elements mesh.

4. Results

The resultant stresses in the manipulated details at dimension value (A) of 34,9 mm for the different types of contact surfaces of the gripper`s fingers are shown in (Fig.6).

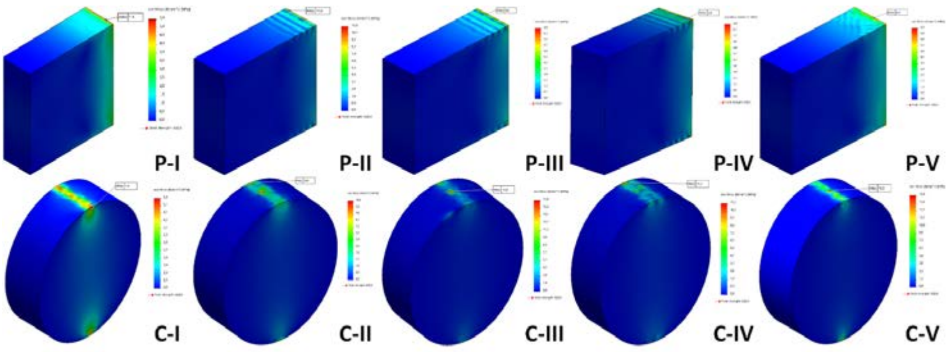

Fig. 6. *Resultant stresses in the manipulated parts*

For the other two values of the dimension (A) the distribution of the stresses obtained in the manipulated parts is similar.

As can be seen, at the planar contact surfaces of the part (P), the resultant maximum stresses are in inside side of the part (which is closer to the applied load).

In the manipulated parts with the cylindrical contact surfaces (C), the maximum stresses are in the contact area between the part and the fingers of the gripper.

A comparison of the maximum values of the resultant stresses obtained in the parts with plane contact surfaces (P) is shown in (Fig.7).

With smooth surfaces of the contact surfaces of the gripper`s fingers (I), the change in the position of the part relative to the gripper practically does not affect the maximum of the resultant stresses obtained in the parts.

In the case of (II) to (IV) at a value of (A) 34,9 mm, the maximum of the resultant stresses in the parts are about 2 times larger than the other cases. This is the result of the contact of the inner edge of the part with the fingers of the gripper (Fig.8).

In case (V), the maximum stresses in the part differ slightly. This is the result of the varying contact area between the part and the fingers of the gripper due to the different number of contact areas at the various positions of the part.

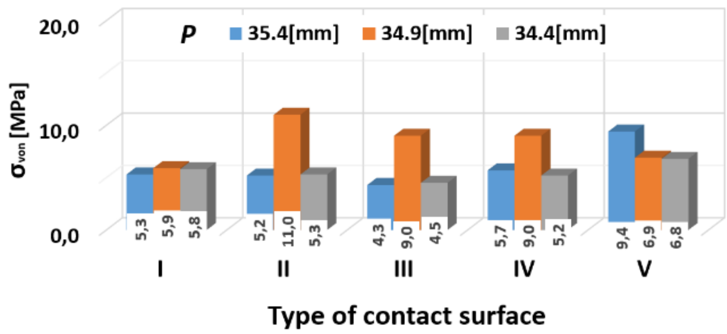

Fig. 7. *Maximum values of resultant stresses in the parts with plain contact surfaces (P)*

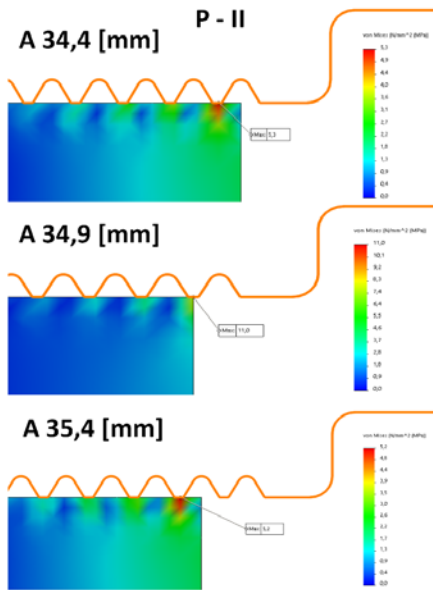

Fig. 8. *Resultant stresses at different values of (A)*

A comparison of the maximum values of the resultant stresses obtained in the parts with cylindrical contact surfaces (C) is shown in (Fig.9).

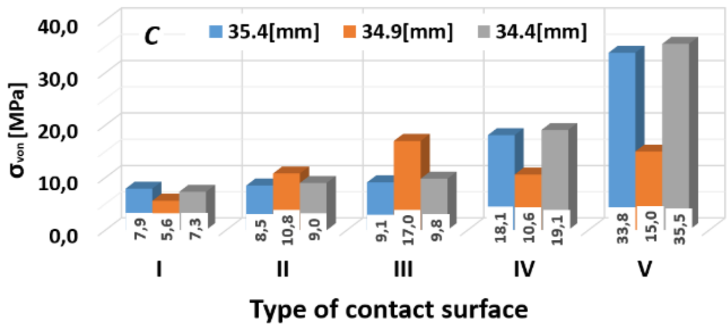

Fig. 9. *Maximum values of resultant stresses in the parts with cylindrical contact surfaces*

With smooth surfaces of the contact surfaces of the gripper`s fingers (I), the change in the position of the part relative to the gripper practically does not affect the maximum resultant stresses obtained in the parts.

In the cases of (II) to (IV), the maximum resultant stresses obtained in the parts vary within the range of 100% resulting from the different contact areas. At values of (A) 34,4 and 35,4 mm, these zones are two (one on finger) at 34,9 mm, the zones are four (two on finger) (Fig.10).

In case (V), the resultant maximum stresses in the parts differ over 2 times. This is due to of the different number of contact areas at the various positions of the part.

At (A) 34.9 mm, the number of contact areas is about twice as large as the other two cases.

In (Fig.11) is shown a comparison of the maximum stresses obtained in the parts, when they are manipulate with the gripper`s fingers with smooth contact surfaces (I), with transverse grooves (II-IV) and with crossed grooves (V).

The data in (Fig.11), for the parts with cylindrical contact surface (C) are for a value of (A) 34,9 mm.

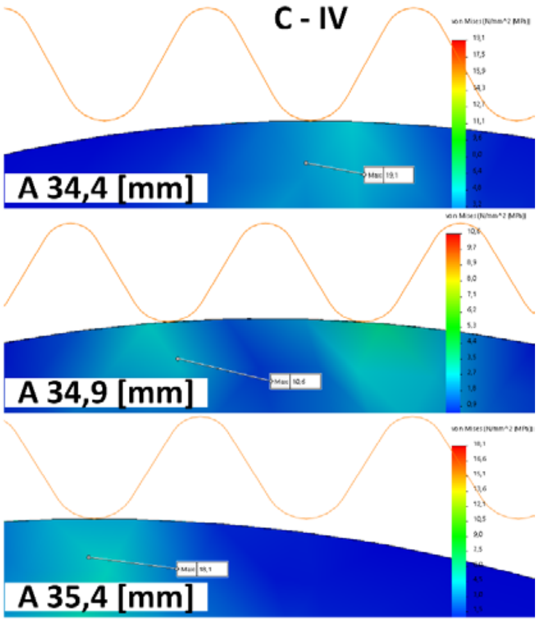

Fig. 10. *Contact areas at different values of (A)*

From a practical point of view, for parts with the contact surface of the type (C) and gripper`s fingers with transverse grooves (type II and III), the cases of (A) 34,4 and 35,4 mm are unlikely and for type (IV) become impossible.

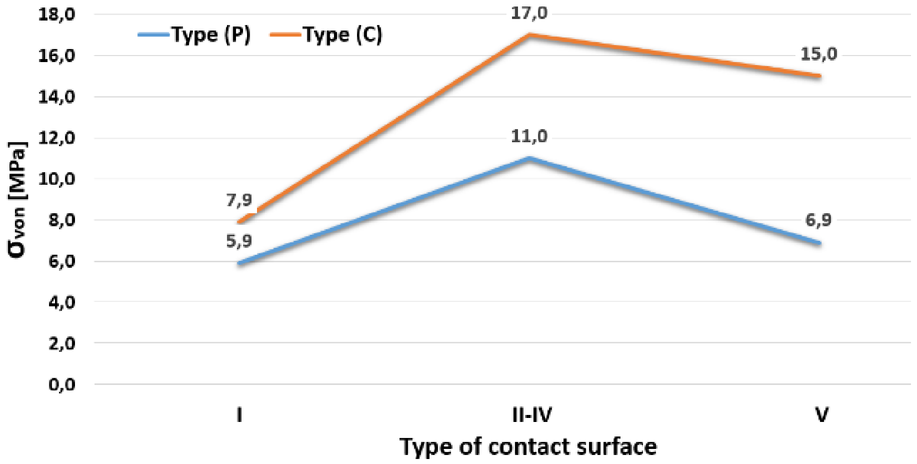

Fig. 11. *Maximum resultant stresses in the parts with different contact surfaces*

This is due to unsustainable contact between the parts and the gripper`s fingers, as a practice always is being worked, under the conditions shown in (Fig.10) for a value of (A) 34,9 mm with two contact areas for each finger of gripper.

Conclusions

At the smooth contact surfaces of the gripper`s fingers, irrespective of the shape of the contact surface of the part, the plane (P) or the cylindrical (C), the stresses obtained therein are not affected by the mutual arrangement of the part and the gripper.

At contact surface of the gripper`s fingers with transverse grooves and plane contact surface (P) of the parts, the resultant stresses in them can increase about two times, depending on the arrangement of the part and the gripper. At cylindrical contact surface (C) of the parts, the differences in the obtained stresses are smaller.

At contact surface of the gripper`s fingers with crossed grooves, taking into account what has been said for the parts with cylindrical (C) contact surfaces, as a practice the arrangement between the part and the gripper does not affect the resultant stresses in the part.

In order to minimize the values of the stresses obtained in the manipulated parts, the fingers with a smooth contact surface are preferable to those with crossed grooves, which in turn are preferable to those with transverse grooves.

When using fingers with transverse grooves, in order to minimize the values of the stresses obtained in the manipulated parts the shape and parameters of the grooves must be comply with the gripper construction and the accuracy of positioning of gripper during gripping of the part.

The proper shape and size of the transverse grooves can substantially reduce the resultant stresses in the manipulated parts.

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Исследование влияния типа контактной поверхности на напряжениях, получаемых в манипулированных деталях с использованием параллельных захватных устройств

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Резюме: *В этой работе с использованием CAE системы SolidWorks Simulation были исследованные напряжения получаемых в деталях, манипулированных с помощью параллельных захватов, с различными типами контактных поверхностей пальцев.*

Ключевые слова: *параллельных захватных устройств, промышленные роботы, CAE системы.*