PROPOSITION FOR THE DEPLOYMENT OF VACUUM EFFECTORS

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Abstract

The article deals with the selection of appropriate vacuum holding components and their localization in the handling system that is to hold and move rectangular plates .In this article the method of designing and creating the calculation and the program that will enable the automatic selection of the suction elements, as well as their optimal localization in relation with the permitted deflection of the handled object. The calculation is verified by FEM modeling.

Key words

effector, gripper, suction gripper, suction cups, construction of gripping effectors, object handling

Method proposition for the selection and deployment of vacuum components of the holding systems

The proposed solutions and the calculation were done for items intended for the manipulation of the vacuum effectors according to the following conditions: manipulated object is flat - sheet metal or metal plate, or a part of it, with a maximum dimension of 2000 x 1200, material - steel plate thickness of 0.2 to 7 mm.

The selection of the required size (diameter) and the number of effectors is such to ensure the safe manipulation with the object and the optimal deployment is doen according to the permitted deflection of the manipulated object ,where this value is entered into the program by the user [1,2]. In the case of solving one vacuum effector, we can simplify the manipulated object to a circular plate held at the center D_p .

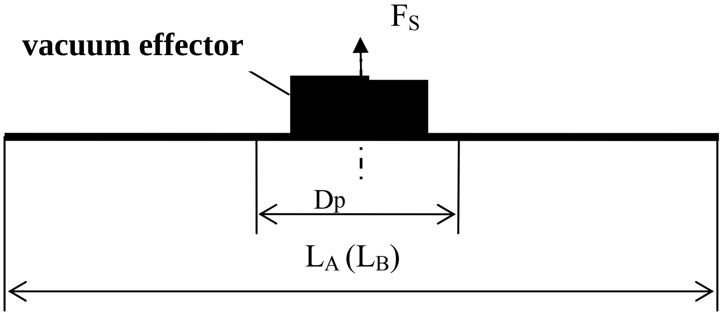

Fig. 1. *Using one effector*

For the deflection of the plate is true that [4]:

$$Y = \frac{-0,53 + 1,53\left(\frac{2D}{D_p}\right)^2 - \frac{0,94}{\left(\frac{2D}{D_p}\right)^2} - 3,21.\ln\left(\frac{2D}{D_p}\right) - 3,55\left(\ln\left(\frac{2D}{D_p}\right)\right)^2 - \frac{0,89}{2}\ln\left(\frac{2D}{D_p}\right)}{1,3\left(\frac{2D}{D_p}\right)^2 + 0,7} \frac{p.(D/2)^4}{E.h^3} \tag{1}$$

The case of holding with several effectors, where the object handled is of circular shape of radious R we suggest the deployment of the effectors on a circle of diameter R_u.

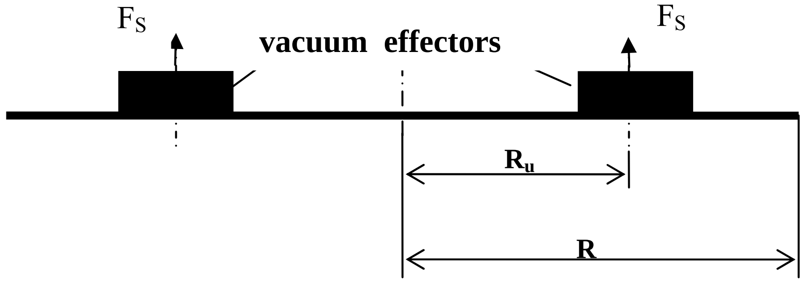

Fig. 2. *Using several effectors*

And solving the following equations we get the equation of deflection on the perimeter [4]:

$$Y_Y = \frac{239}{208}\frac{R^4.\rho.g}{B.h^2} - \frac{141}{104}\frac{R^2.R_u^2.\rho.g}{B.h^2} + \frac{43}{208}\frac{R_u^4.\rho.g}{B.h^2} + 3\frac{R_u^2.R^2.\rho.g}{B.h^2}\ln\frac{R_u}{R} \tag{2}$$

And the deflection of the plate in the center is:

$$Y_S = \frac{143}{208}\frac{R_u^4.\rho.g}{B.h^2} + \frac{R^2.R_u^2.\rho.g}{B.h^2}\left(\frac{57}{104} - \frac{3}{2}\ln\frac{R}{R_u}\right) \tag{3}$$

The total deflection of the circular plate is then expressed as the sum of those two deflections:

$$Y = Y_Y + Y_S .$$

The problem of rectangular plates can be solved with suffiecient accuracy, by representing the rectangle as two circular plates with diameters responding to the lengths of the sides of the rectangle. (Fig. 3) [3].

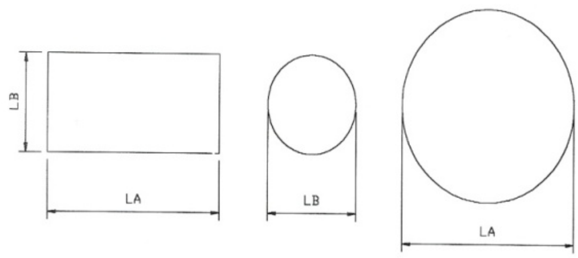

Fig. 3. *Substitution of rectangular plates byt circular ones*

Proposal for automated selection and distribution of vacuum components in the holding systems

In the study, the software used was 2009 version of SolidWorks software with an integrated program SolidWorks Sumulation used for solving model situations. This sub-program operates on the principle of finite element method FEM. Following the establishment of a network of elements, it calculates the parameters in nodes by applying specified material properties. The accuracy of the calculation is then given the delicacy of the network. Therefore, for these relatively simple cases the criteria selected are very strict, inaddition to the controlled formation of a curvilinear grid. The force action is represented by the acceleration of gravity.

Material that was used: metal 11 343.0 heat rolled.
modul of elasticity E = 2 .10^5 MPa
poisson's constant= 0,28
modul of shear stress G = 8 .10^4 MPa
density ρ = 7,87 g/mm^3
Tensile strength Rm = 325 MPa
Yeild strength Re = 180 MPa

Fig. 4. *Volume network of the plate*

Analysis of deflection using a one vacuum effector

This simple situation gives us an initial idea of the deformations and tensions in the material. The used structure resulted in 82,576 computing nodes and 45,879 elements. The resulting effect is accentuated by the deformation ratio of 4:1 (Fig. 5). In this case, we can control the deflection only by changing the effector diameter.

Input Data:
- Diameter of the effector D_U = 40 mm
- Central deployment
- Semi-product 350 x 600 x 0,5 mm.

Output Data:
- The deflection of the free end(corners)Y = 15 mm
- Maximum stress in the areas marked red is = 59.8 MPa.

DEFLECTION VALUES OF SEMI-PRODUCT 350X600 Table 1

Dimensions: 350 mm x 600 mm						
thickness [mm]	0,5	1	1,5	2	5	7
deflection[mm]	15,08	3,78	1,70	0,87	0,12	0,053

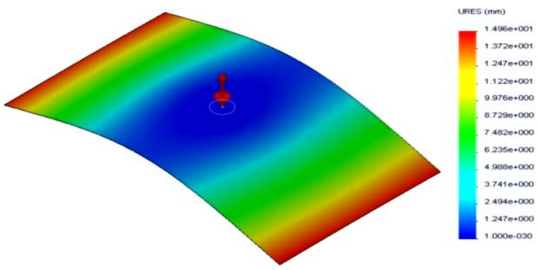

Fig. 5. *The course of deformation show in scale 4:1*

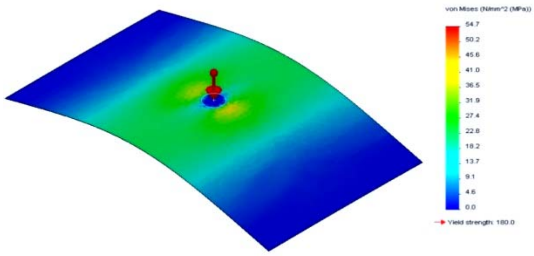

Fig. 6. *The course of stress*

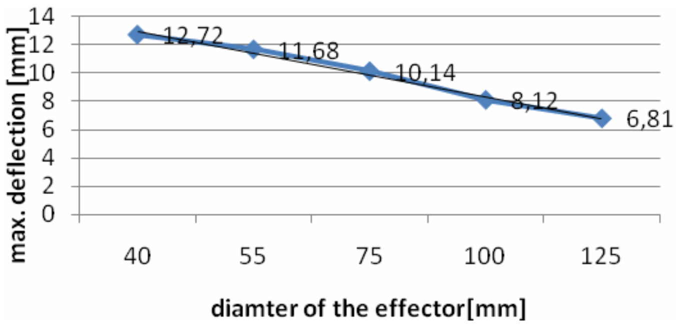

Fig. 7. *The relation between deflection Yandthe diameter of the effector D_p*

Deflection analysis in the case of using two or more vacuum effectors

In the case of using two effectors deployed along the length of the axis ,the regulation of the deflection of the free ends was done by changing the distance seperating the effectors fro each other. The contour of the effectors are represented in the images below as circles.

Input Data:
- Diameter of effector D_p = 40 mm
- Number of effectors n = 2
- Diameter of the pitch circle Du = 90,125 mm
- Semi-product650 x 1000 x 0,5 mm
- Permitted deflection 100 mm.

Output Data:
- deflection Y = 109 mm > Y_{DOV} = 100 => doesn’t meet required conditions.

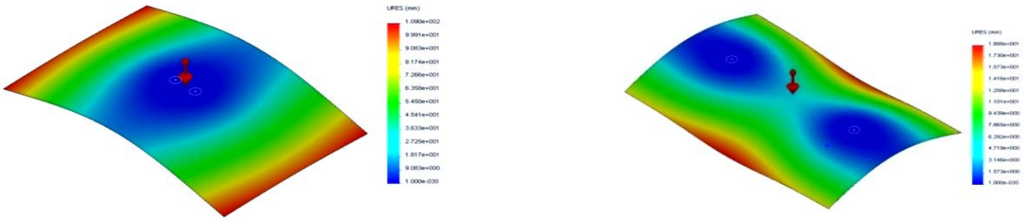

Fig. 8. *Using two effectors*

To highlight the benefits of using multiple mounting in cases with high strain, a dependence was obtained between the deflection of the free end and distances seperating the holding elements. The calculation was performed for semi-product of dimensions 1200 x 750 x 1.5 mm. When using an element with a diameter of 125 mm, we calculated 26 mm of deflection and tension in the critical areas reached values upto 100 MPa. As the chart shows the change in distance, results in an exponential decrease of the value of the deflection.

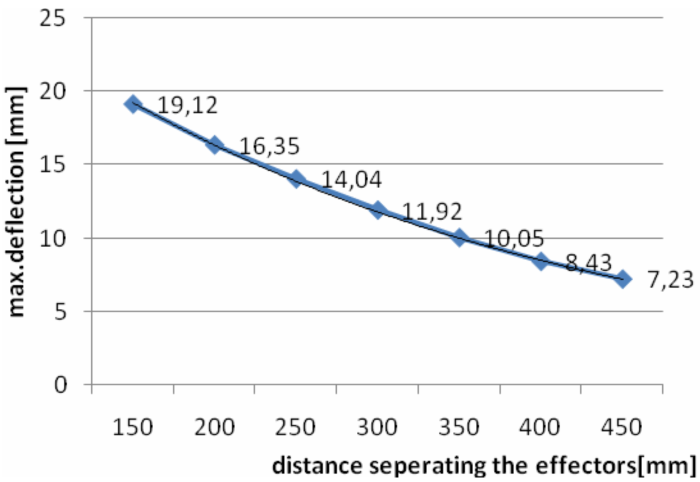

Fig. 9. *The relation of the deflection Y and the distance between the effectors*

When using several vacuum effectors, whether because of force-stress on the elements or due to the reduction of the deflection, after consideration the solution should be chosen in, so that it best meets the requirements of no additional costs, and chosen a solution that will best meet the requirements of no additional costs to deal with. This confirms the dependence shown in Fig. 10. The result confirms that the arrangement of elements in the form of a ring, affects the deflection only by the use of 4 effectors.

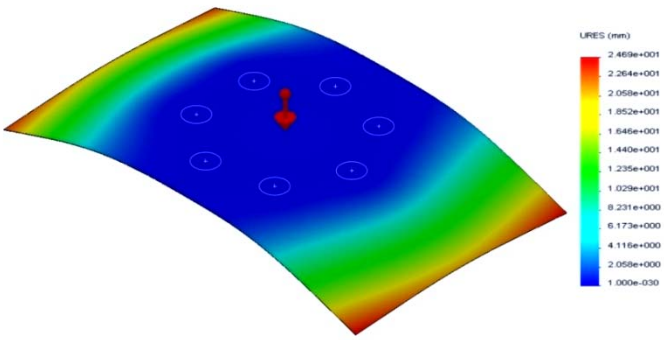

Fig. 10. *Holding using more several effectors*

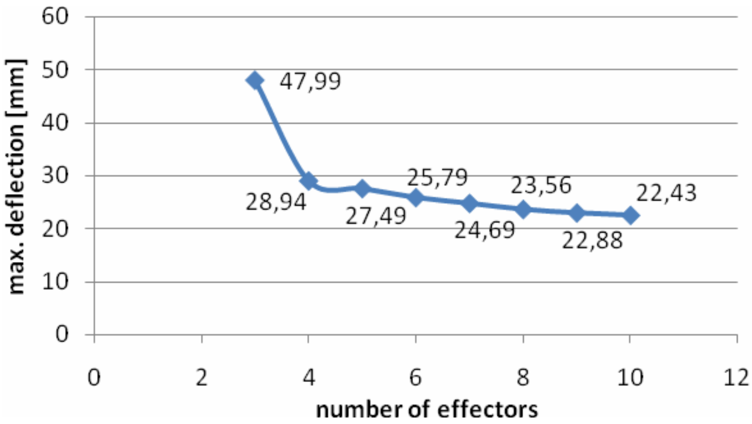

Fig. 11. *The relation between the deflection Y and the number of effectors n arranged in a circle n*

Effect the arrangement of elements on the deformation

This example illustrates the different deformation patterns at different ends of the plate and the way it is deformed in relation to different arrangements of the effectors. Choice between these arrangements depends on the requirements, like which side should enter the forming machine.. Choosing the right arrangement is evident from Fig. 12 and Fig. 13.

Input data:
- diamter of the effector D_P = 125mm
- number of effectors n = 3
- diameter of pitch circle D_U = 516,0775 mm
- semi-product 1200 x 2000 x 1,5 mm.

Output Data:
- difference of deformation of opposite corners Δ = 47,2 mm
- difference of deformation of opposite corners Δ = 54 mm.

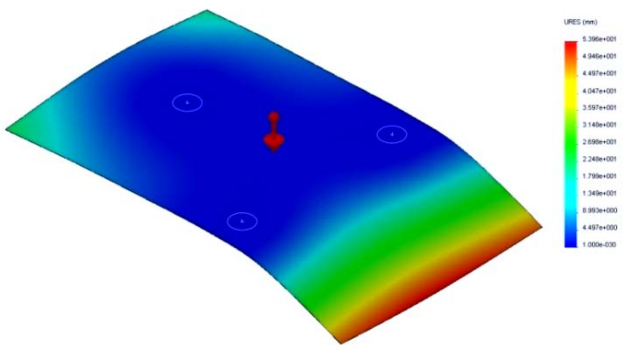

Fig. 12. *Deformation with a symetrical longitudonal arrangemet*

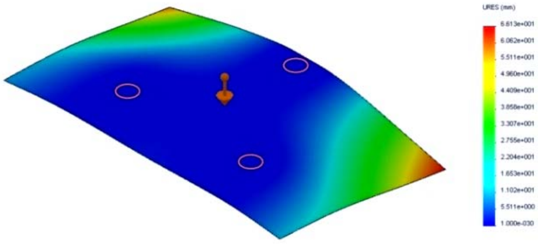

Fig. 13. *Deformation with diagonal symetrical arrangemens*

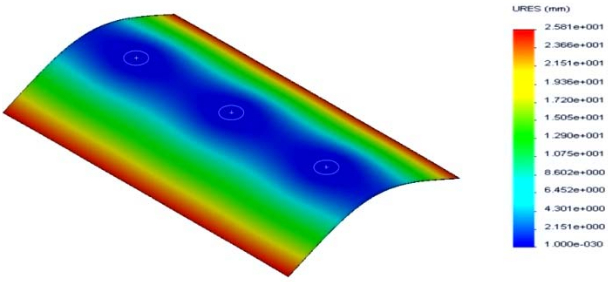

Fig. 14. *Deformation with linear arrangement along the larger dimension*

Conclusion

The research presented in this paper was to obtain visual images, and numerical values while examining the handling process when manipulating a metal sheet plate in the form of a rectangle. The results obtained are in the form an image, which shows the plate as well as the place its holded from and colors showing the intensity of the deflection and stress all over the plate. Numerical values represented the extreme stresses and deformations of the material.

In the second part of the presented research results in the case of one gripping element, the impact of variations of the diameter of the vacuum effectors on the resulting delfection. In all the cases studied, the deformations occuring where only elastic deformations. The case of using two vacuum effectors was analyzed, were the dimensions f the vacuum components where chosen in such a way to satisfy the force requirements for ensuring a safe grip on the manipulated object. In the last part our attention goes to the the issue of using more effectors arranged in a defined circle. Based on the values obtained, it can be argued that it is economically advantageous to use the maximum number of four elements. Further an increasethe value of the deflection significantly doesn't appear. Additionally, the effect of rotating the trio of elements with an angle of 45^o and the linear arrangement on the value of the deflection.

The presented approach helps to simplify the work of a designer in the design of the vacuum grips. It helps the user to select the correct size and number of effectors in handling a steel sheet as well as choosing the best location. In the calculations, the dymanic page of the problem in hand has not been solved or calculated. The safe grip of the object was ensured and secured by a safety factor.

Practical Application of the new methodology of appropriate deployment of the holding elements is used to manipulated and handle materials with large diameters and perimeters and of small thickness. In these cases it is possible to replace the intuitive deployment calculation method described in this paper. The result is a rational determination of the size and number of the vacuum effectors.

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