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OPTIMIZATION OF SUCTION GRIPPERS PLACEMENT FOR MANIPULATION WITH THIN SQUARE SHEET METAL

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Abstract: *The article deals with finding optimal placement of the suction grippers on the area of square sheet metal. The objective is to find a position of the suction grippers which ensures minimal deflection of the sheet metal. To find suitable position of the suction grippers was used worldwide known code CATIA V5. Through structural analysis and optimization methods of this robust software solution was found optimal location of the suction grippers. In this case will be deflection of sheet metal minimal. Simulated annealing algoritmus was used for solve given problem.*
Key words: *FEM, optimization, CATIA, simulation model*

1. INTRODUCTION

Numerical methods represent many years leading computational utility. Initially uninteresting finite element method (FEM) has today become one of the main computing resources not only in the engineering industry. Main advantage FEM is graphic interpretation often very abstract phenomena in which classical technique solutions introduces considerable simplification at the expense of accuracy.

Problems of the optimal design dealt already Galileo (1638) who derived the shape fixed beam with constant normal stress. Although Galileo did not define an optimization problem his results was confirmed with modern approaches. Development of optimization is mainly conditioned by the limited energy and material resources, strong competition and recently the problems of environmental protection.

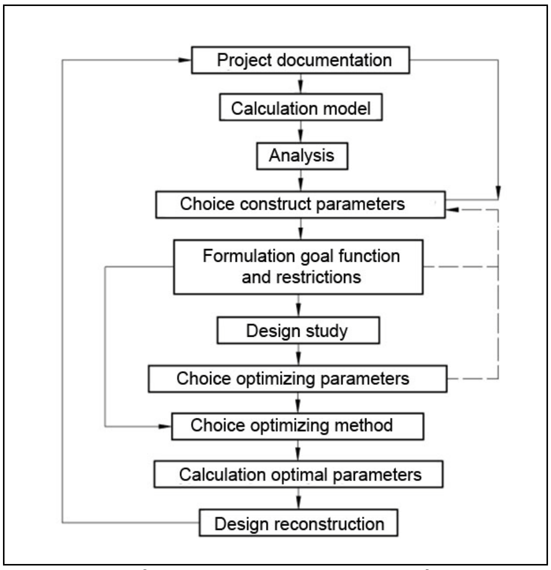

Fig. 1. Procedure for design optimization (Sedlár, 2007)

2. THEORETICAL BASE

Optimization can be defined as the procedure for obtaining the design, which is best of all possible proposals with regard to the prescribed objective and a given set of geometric boundaries of the system behavior. This objective is of great technical significance (Žmindák et al., 2000).

Optimization is a type of design problem where a set of design parameters is divided into two groups. The first group consists of predefined parameters. The second group consists of parameters called design variables. Optimization then we understand finding the optimal values of design variables to maximize the objective or criterial function whereby must meet requirements (called boundaries) on the geometry and state structures. CATIA V5 software contains several algorithms for optimization. One of them is the simulated annealing algorithm. This method can be viewed as an extension of gradient method, which prevents sticking to solve.

Simulated annealing is a computational stochastic technique for obtaining near global optimum solutions to combinatorial and function optimization problems. The key principle of the method is to allow occasional worsening moves so that these can eventually help locate the neighborhood to the true (global) minimum (Suman, 2004).

3. SIMULATION MODEL

The simulation model was created in code CATIA V5. Sheet metal with dimensions 0.5 x 600 x 600 mm was idealized through shell type elements named QD8 (parabolic) with representation of sheet metal thickness 0.5 mm. We have considered four suction grippers with diameter 40 mm. Generated mesh was from the most part consists of square mapped elements . Number of elements was in average 5500 during the execution of optimization procedures.

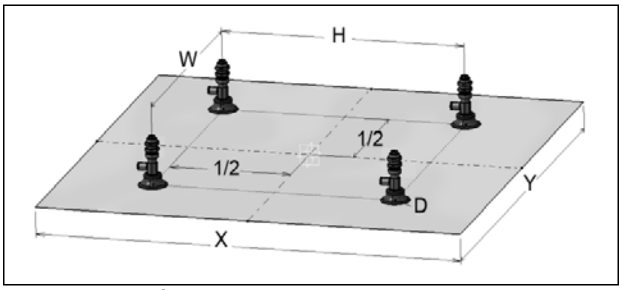

Fig. 2. Design of the assembly

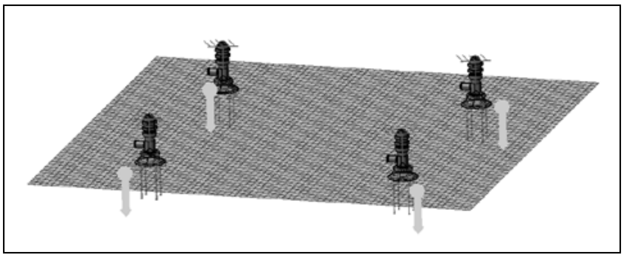

Fig. 3. Generated mesh with boundary conditions and external loads

Generated finite element mesh together with boundary conditions you can see on the Fig. 3. Mathematical formulation of the sheet metal clamping with suction grippers was simulated with the boundary condition which allowed deformation in the sheet metal in location of the clamping. In the simulation model was considered 70% vacuum which also affects the deformation of thin sheet metal therefore was include into the CAE model through external load in form overpressure with the value 0.07 MPa. The breakaway force equals 69.6 N for suction grippers of the type ESG with diameter of 40 mm at 70% vacuum (FESTO, 2011). Sheet metal is bending mainly by gravitational acceleration whose value is 9.81 $m.s^{-2}$. Sheet metal part is made from low carbon steel STN 411373 (DIN 1.0036). Elasticity modulus of the steel is 210 GPa and Poisson's ratio is 0.3. Density of the steel is 7800 kg.m-3. The resulting mass of the sheet metal is 1,404 kg.

The goal of the optimization was searching of the minimum value of maximum sheet metal deflection. Variable design parameters were transverse (H- height) and longitudinal (W- width) distance between suction grippers (see Fig. 2). Choosed range of the variable parameters is presented in Tab. 1.

Dimensions	Initial (mm)	Min (mm)	Max (mm)
W	300	50	540
H	300	50	540

Tab. 1. Variable parameters with their initial value and range

Simulated annealing optimization algorithm was set to unlimited time period. For searching optimal values of the variable parameters was algorithm limited only by the count of possible updates that could be made. Count of the updates was set on 100.

4. OBTAINED RESULTS

By finding the extreme objective function were obtained displacement values of the elements nodes for 100 different locations of the grippers. Process of the optimization can you see on Fig. 4. Minimal deflection was found in step 47 with a maximum value of local deformation plate 1.8 mm. Values transverse and longitudinal distance of grippers are for found optimum following W = 341.63 mm and H = 340.56 mm.

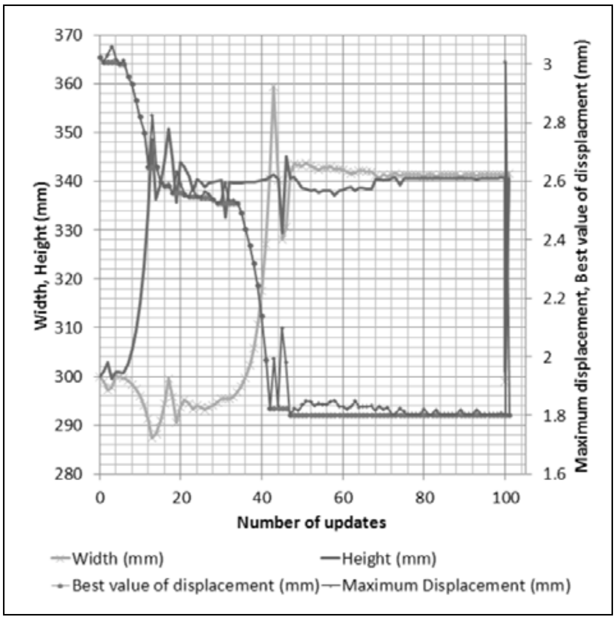

Fig. 4. Process optimization (simulated annealing algorithm)

On the Fig. 5 you can see the best solution from optimization. The values of principal stress obtained from Gauss point of element were $\sigma_{11} \in \langle -117, 21.2\rangle$ MPa and $\sigma_{22} \in \langle -120, 4.14\rangle$ MPa.

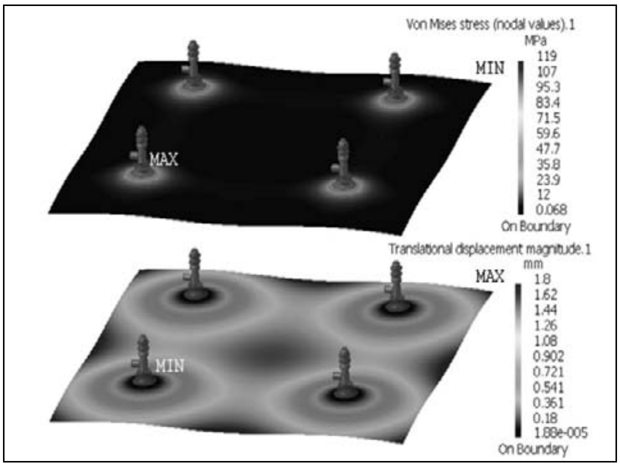

Fig. 5. Equivalent (von Mises) stresses (up) and displacements (down) with particular legends

From the results of difficult optimization procedures revealed that the deflection of a square sheet metal with dimensions 0.5 x 600 x 600 mm will be the smallest, if will situate the grippers for arbitrarily large square sheet metal in a ratio H / X = 0.57 and W / Y = 0.57.

5. DISCUSSION

Through minimalization deflection of the sheet metal will be prevent a possible pull-off of the suction gripper from the sheet metal surface. This condition may occur even if the load does not exceed breakaway force of the suction gripper, but the curvature of the sheet metal will be too high.

In the future I would like deal with finding the optimal deployment of suction grippers on the sheet metals rectangular, circular and irregular shape.

6. CONCLUSION

From the results it is obvious that the suction grippers are localized very close to the diagonals of the square because the longitudinal and transverse distance of the suction gripper is approximately the same. By repeating of the optimization routines for square shaped sheet metals with modified dimensions (0.5 x 700 x 700 and 0.5 x 500 x 500) it was concluded that the placement of suction grippers meet the minimum deflection sheet metal if suction grippers will be placed in positions H = 0.57X and W = 0.57Y.

7. ACKNOWLEDGEMENTS

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