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Computer simulation of the impact of the crumple zone in a passenger car on passenger safety

Authors: Wojciech Mikołejko, Amadeusz Dziwis, Agata Śliwa, Marek Sroka, Kajetan Kojm , Dawid Lazaj , Łukasz Lomania , Agnieszka Sasiela , Cezary Zach

Abstract: The article presents the results of a computer simulation obtained in Solidworks. The subject of the study was a crumple zone, usually placed in the front of a vehicle with the intention of minimizing the effects of road accidents. The purpose of this article was to analyse the stresses and strains on the crumple zone structure under the action of a force of different cross-sections, using different materials.

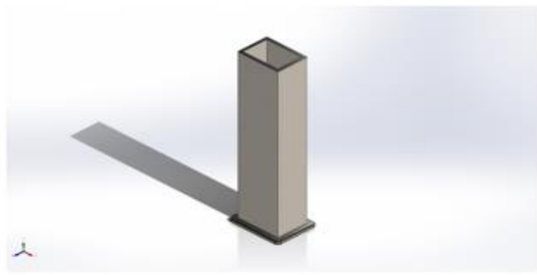
The first stage of the work was to model the crumple zone in Solidworks. In order to study the effect of material type on strength, three different materials were used for the crumple zone - AISI 304 steel, 1.6569 steel and 1.0718 steel. The properties of the selected materials are summarized in Tables 1, 2 and 3. The final stage of work to prepare the models for simulation was to apply a finite element mesh, as shown in Figure 4. The following boundary conditions were used to simulate the failure of the bowl as a result of a frontal collision:- fixed stationary at the connection point between the element and the body,- a force of -100,000[N] was applied.

The results of the computer simulation made it possible to observe the effect of the type of material used in the crush zone on the distribution of stresses, displacements and deformations under force. The results were grouped according to the type of material used in the simulation - AISI 304 steel, 1.6569 steel and 1.0718 steel. Figure 6 shows the results of the crush zone made of AISI 304 steel, the next figures 7 and 8 show the results for the zones made of 1.6569 and 1.0718 steel, respectively. The distribution of stresses (graphs denoted by (a)) are found over the entire surface of the zones, with the greatest accumulation occurring in the nearest vicinity of the force application. Figures (b), in turn, show the distribution of displacements, which are located in the front part of the crush zone - on the side of the force application. The last graphs (c) show the distribution of deformations, these are distributed approximately along the entire length of the crush zone profile. The table summarizes the results of computer simulation of stresses, displacements and deformations for each material.

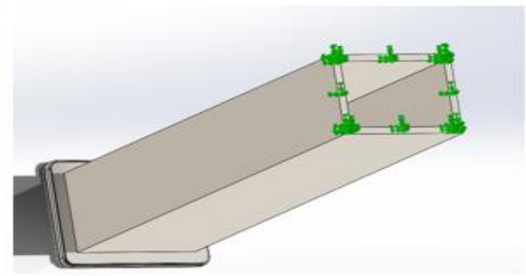
Tab. 4. Maksymalne wyniki symulacji dla badanych stali.
Tab. 4S Results of maximum stresses, displacements and deformations recorded for for the steels tested.

Result / Material	Stress [MPa]	Displacements [mm]
steel AISI 304	105,096	0,132
steel 1.6569	104,673	0,119
steel 1.0718	104,673	0,119

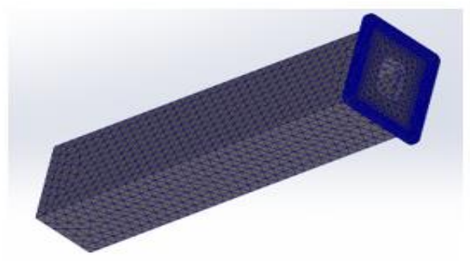
The simulations carried out allowed mapping the behavior of the crumple zone under the influence of an applied force on it with a constant value in time. Comparing the stress values, it can be seen that AISI 304 steel achieved the highest stress (105.096 MPa), while steel 1.6569 and steel 1.0718 had the same stress values (104.673 MPa). Analyzing the displacements, all three materials showed similar displacement values of about 0.119-0.132 mm. For the force-crush zone studied, differences in material type had a negligible effect on the distribution of stresses and displacements. The choice of material for the crush zone will depend on its strength and price, as we will choose the material that provides the greatest safety and is cheap.



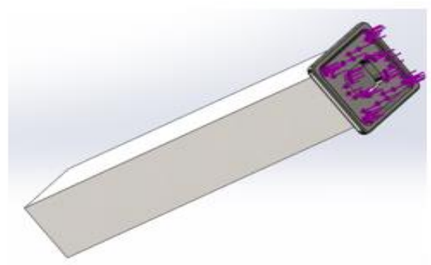
Rys. 2. Zaprojektowany model strefy zgniotu.
Fig. 2. The designed first model of the crumple zone.



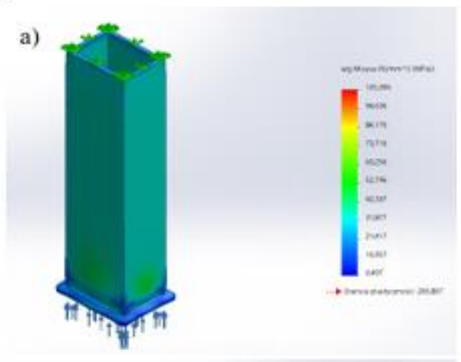
Rys. 3. Umocowanie nieruchome.
Fig. 3. Stationary fixation.



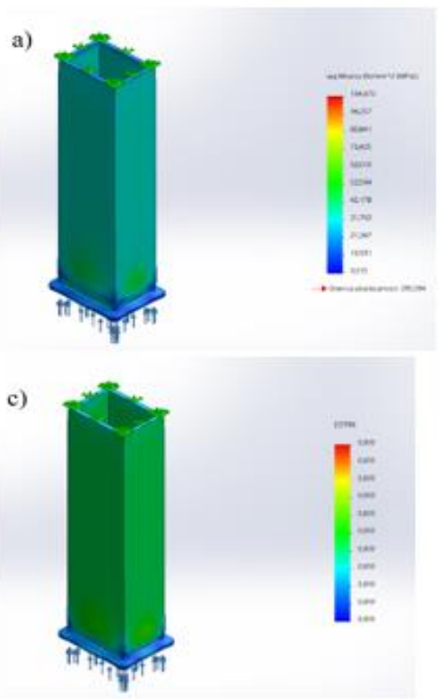
Rys. 4. Nałożona siatka na model.
Fig. 4. Superimposed mesh on model.



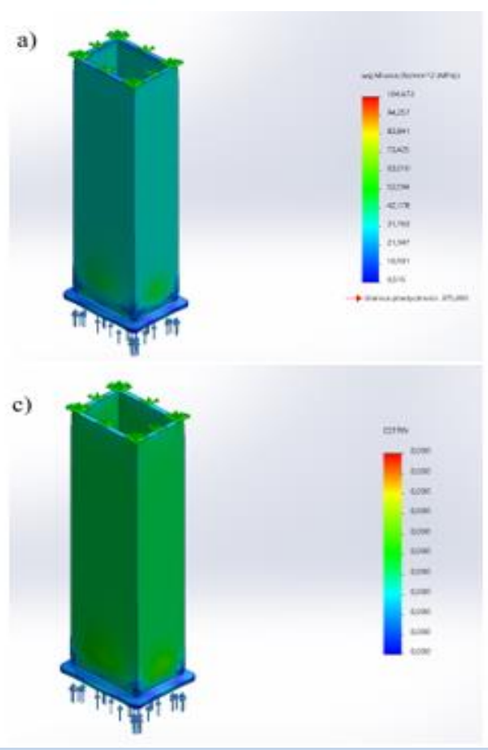
Rys. 5. Miejsce przyłożenia siły.
Fig. 5. Place of force application.



Rys. 6. stal AISI 304
Fig. 6. steel AISI 304 without reinforcements:
a) Rozkład naprężenia. The result of the stress.
b) Rozkład przemieszczenia. The result of the displacement.
c) Rozkład odkształcenia. The result of the deformation.



Rys. 7. stal 1.6569
Fig. 7. steel 1.6569 without reinforcements:
d) Rozkład naprężenia. The result of the stress.
e) Rozkład przemieszczenia. The result of the displacement.
f) Rozkład odkształcenia. The result of the deformation.



Rys. 8. stal 1.0718
Fig. 8. steel 1.0718 without reinforcements:
g) Rozkład naprężenia. The result of the stress.
h) Rozkład przemieszczenia. The result of the displacement.
i) Rozkład odkształcenia. The result of the deformation.