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Influence of the Rib Radius on the Maximum Stress and Deformations of a Corner Bracket

The influence of the radius of circular ribs on the maximum stresses and deformations of a corner bracket was analyzed. The results were obtained using simulations based on finite element method. Two geometries were studied: with one and two ribs. For each of these two geometries the radius of the ribs was ranged between 3 mm and 9 mm. The parts were subjected to bending. The simulations show that the increase of the ribs radius generates a substantial decrease of the maximum stresses and the maximum deformations.

Keywords: *rib radius, stresses, deformations, finite element method, corner bracket*

1. Introduction

The ribs disposed on the sheet metal parts increase the strength and decrease the deformations. The shape and the dimensions of these ribs vary over a wide range of solutions. The optimization of the rib dimensions and positions generates increases in the lifetime of components and material savings [1, 2]. The goal of this research was to study the influence of the radius of circular ribs on the maximum values of the stresses and deformations. The study was made on a corner bracket with the ribs disposed perpendicular to the bended edge.

The analysis was performed by finite element method using *Simulation* module from *SolidWorks* [3, 4]. Two geometries of corner brackets were modeled. The first geometry had one circular rib and the second geometry two circular ribs with the same dimensions. The model, the fixtures and the forces were adopted correlated to the research goal (eg. the mounting holes were not included in the study). The main dimensions of these two geometries are presented in figure 1. The models used where *solids* obtained by a loft of the bracket cross section. For both models the radius of the circular rib was set to four distinct values: 3 mm, 5 mm, 7 mm and 9 mm. For the same type of geometry the area of the cross-section of the corner bracket ranged due to the changing of the rib radius (at constant width).

2. FEM Simulation

The corner brackets were subjected to bending. A static analysis was performed. The material associated to the model was the unalloyed steel C45, (1.0503 EN 10277 - 2: 2008). The fixtures (*fixed geometry*) and the loads (unidirectional force of 50 N) were applied on the end cross-sections of the part (figure 2). There were two reasons for adopting these positions of fixtures and forces: the first reason was to correlate the variation of the cross-section to the variation of the maximum stresses and deformations. The second reason was to reduce the influence of the force and the fixture to the area of the corner radius R30.

The mesh was generated using tetrahedral elements (4 Jacobian Points). A maximum element size of 2 mm (equal to the part thickness) was imposed. The total number of elements ranged due to the variation of the cross-section. For the corner brackets with the radius of the rib equal to 9 mm the mesh is shown in figure 2 and the parameters of the mesh are indicated in table 1.

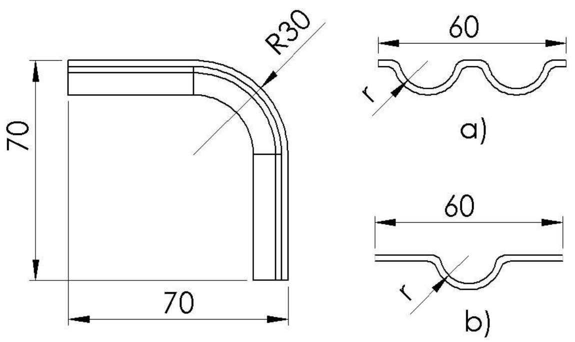

Figure 1. The two geometries analyzed (a – cross section for the bracket with two ribs and b – cross section for the bracket with one rib)

Table 1. Mesh parameters for the geometries with 9 mm rib radius

No. of ribs	Mesh type	Maximum element size	Total Nodes	Total Elements
1	Curvature based solid mesh, 4 Jacobian points	2 mm	38006	20740
2	Curvature based solid mesh, 4 Jacobian points	2 mm	45474	25245

For the analysis were compared the values of von Mises stresses and the values of resultant displacement. The charts of variation of the stresses for the geometries with the radius of the rib equal with 9 mm are shown in figure 3. Figure 4 shows the variation of the resultant displacement for the same geometries.

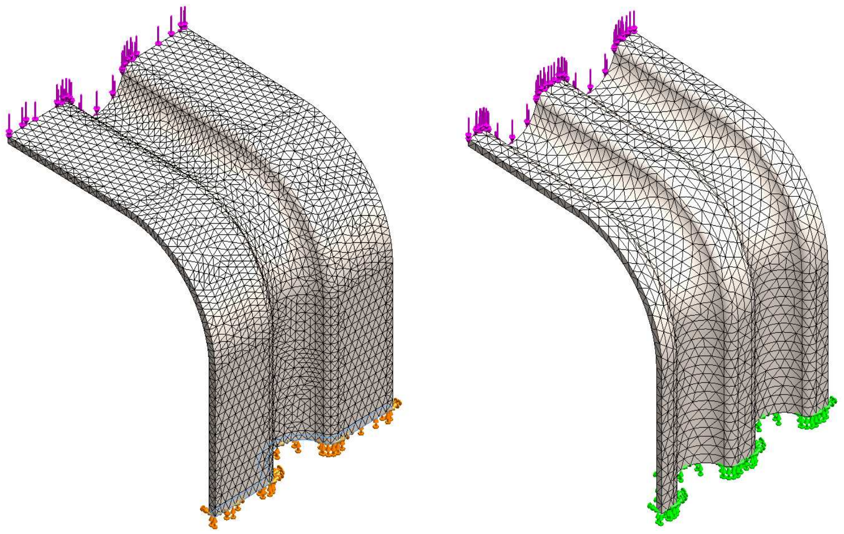

Figure 2. The fixture, loads and the mesh applied on the two geometries at 9 mm rib radius (left – corner bracket with one rib; right – corner bracket with two ribs)

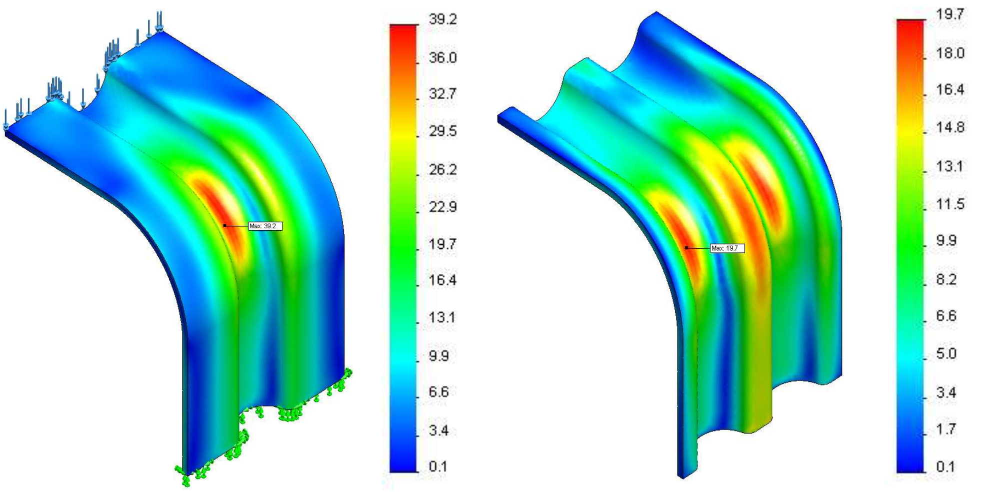

Figure 3. Von Mises stresses [MPa] on the geometries with 9 mm rib radius (left – corner bracket with one rib; right – corner bracket with two ribs)

In the table 2 and 3 are presented the maximum values of the stresses $\sigma_{Von-Mises}$ [MPa] and deformations *f* [mm] obtained for the two geometries at the rib radius of 3 mm, 5mm, 7 mm and 9 mm. Also the area of the cross section of the corner bracket is indicated. The variation of these parameters [%] was calculated relative to the values obtained for the geometries with a rib of 3 mm radius. For a proper evaluation of the increase of the strength has been introduced the coefficient *k* defined as the stresses variation relative to area variation:

$$k = \frac{\sigma_{\text{vonMises (i)}} - \sigma_{\text{vonMises (i-1)}}}{A_i - A_{i-1}} \quad (1)$$

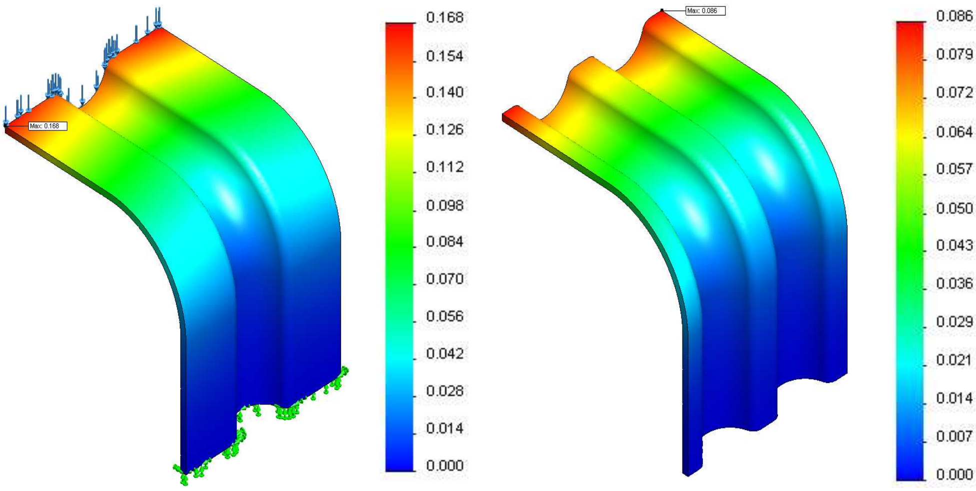

Figure 4. Resultant displacement f [mm] on the geometries with 9 mm rib radius (left – corner bracket with one rib; right – corner bracket with two ribs)

Table 2. Variation of area, stresses and displacement (geometry 1 – one rib)

No.	r	A	ΔA	$\sigma_{VonMises}$	$\Delta\sigma_{Von}$	f	Δf	k
	mm	mm^2	%	MPa	%	mm	%	-
1	3	124.99	0.00	118.30	0.00	0.920	0.00	0
2	5	129.32	+3.46	76.60	-35.25	0.417	-54.67	-10.18
3	7	133.80	+7.05	53.00	-55.20	0.242	-73.70	-7.82
4	9	138.34	+10.68	39.20	-66.86	0.168	-81.74	-6.26

Table 3. Variation of area, stresses and displacement (geometry 2 – two ribs)

No.	r	A	ΔA	$\sigma_{VonMises}$	$\Delta\sigma_{Von}$	f	Δf	k
	mm	mm^2	%	MPa	%	mm	%	-
1	3	129.97	0.00	74.10	0.00	0.616	0.00	0
2	5	138.63	6.66	39.20	-47.10	0.243	-60.55	-7.06
3	7	147.60	13.56	26.80	-63.83	0.131	-78.73	-4.70
4	9	156.68	20.55	19.70	-73.41	0.086	-86.04	-3.57

Figures 5, 6 and 7 show the graphical variation of the maximum Von Mises stresses, maximum displacement and coefficient of stress decreasing, relative to the rib radius. It may be noted that the decrease of the maximum stresses is bigger for the changing of the radius from 3 mm to 5 mm. This aspect is more visible on the geometry with two ribs, but is also found at the geometry with one rib. For the geometry with two ribs the maximum stresses for the radius of 5 mm is about 47% lower relative to the maximum stresses for the radius of 3 mm. For the same geometry the resultant deformation decreases with about 60% for the radius of 5 mm relative to the radius of 3 mm.

The variation of area of the cross section is nearly linear. The area increases with about 3.5 % at the addition of 2 mm on the radius of one rib. It can be concluded that the increase of the area is not the main factor that cause the increase of the corner bracket strength. This conclusion result also from the chart of variation of the k coefficient (figure 7).

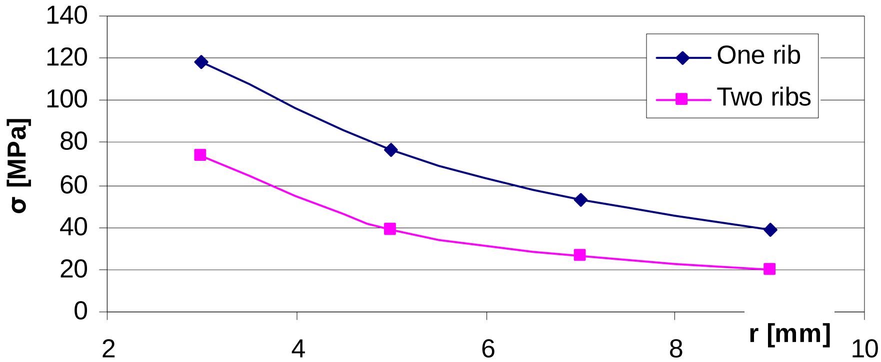

Figure 5. Variation of the maximum stresses relative to the rib radius

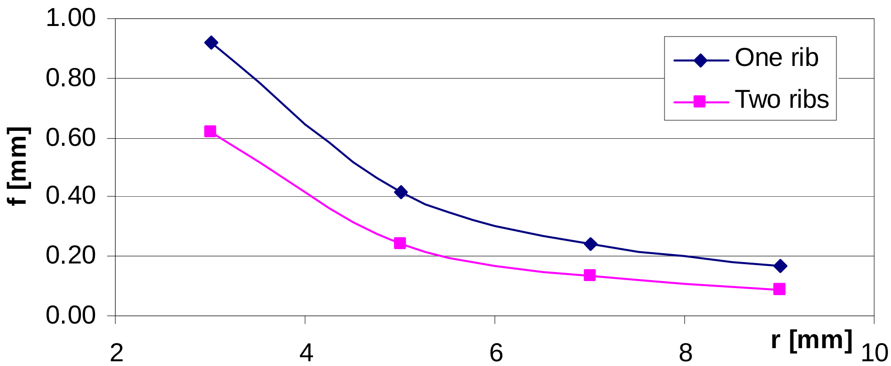

Figure 6. Variation of the resultant displacement relative to the rib radius

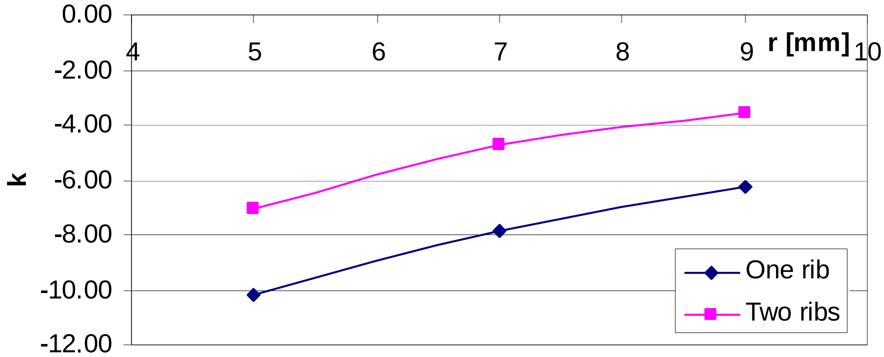

Figure 7. Variation of the coefficient of stress reduction relative to the rib radius

3. Conclusion

After the FEM simulations of the bending of two geometries of corner brackets with ribs at four different radiuses, the next conclusions may be pointed out:

- The geometry with two ribs has values of the stress smaller with about 50% relative to the geometry with one rib;
- The increase of the radius of the rib induces an increase of the part strength and a decrease of the deformations. The strength increase is bigger for the change of the radius from 3 mm to 5 mm.

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