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About the Hangers Design

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Abstract

In this paper is presented an analytical design method of hangers) and a numerical analysis using FEM of stresses for different sizes of these elements. The analysis is performed with and without taking into consideration of crane hook.

Key words: *hanger, numerical analysis, FEM*

Introduction

Much of the large equipment as mud conditioner, fluid storage tanks, containers etc. (fig. 1), are provided with hangers for their manipulation by fixed or mobile cranes. In most cases, the hangers have the form shown in Figure 2.

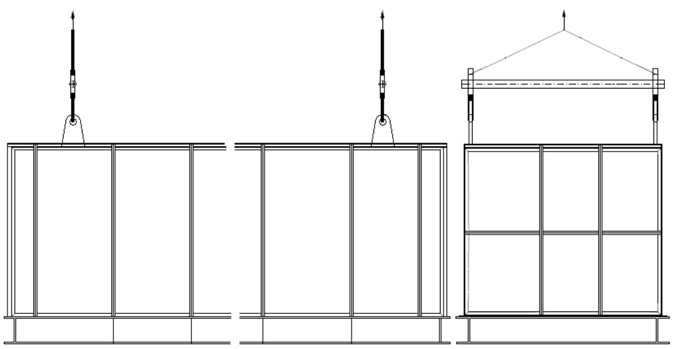

Fig.1. Mud conditioner

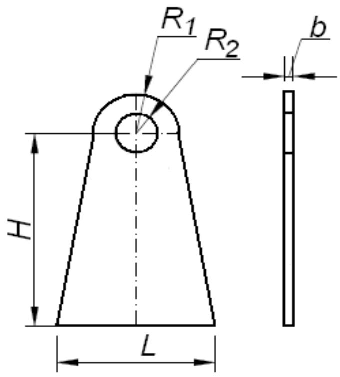

Fig. 2. Hanger

Further, an analytical design will be presented. Using FEM, the stresses in the hanger will be determined and those results will be compared with the analytical ones. The hanger design can be done in several ways: analytical or can check the stresses trough numerical method – Finite Element Methods (FEM).

Analytical Design

Starting from form of hanger, design is considered to be the upper ring of the hanger is constraint in the lower part of it. The strength calculus will be made as to large bending beam with rectangular cross section (fig. 3). It is found that the system is statically indeterminate what involve the statically indeterminate elastic theory. Applying the method of efforts shows that the system is statically indeterminate three times. Using the symmetry it once static remains undetermined (fig. 4).

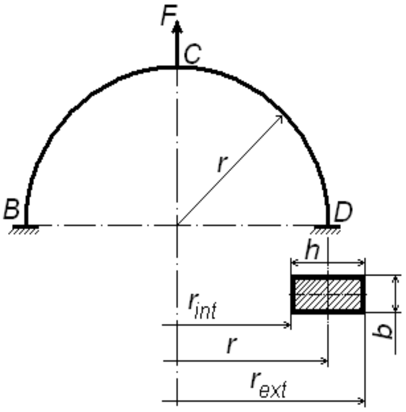

Fig. 3. The analytical model used

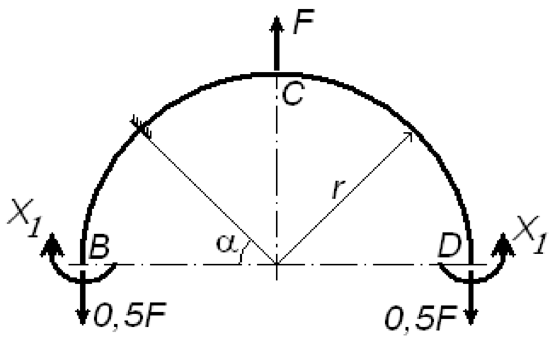

Fig. 4. The basic form of the system statically indeterminate

Equation of condition is:

$$\Delta_{10} + X_1 \delta_{11} = 0 \tag{1}$$

where:

$$\Delta_{10} = 2\left[\int_B^C \frac{m_1 N^0 \mathrm{d}s}{EAr} + \int_B^C \frac{m_1 M^0 \mathrm{d}s}{EI'}\right] \tag{2}$$

represents rotation, in sections B and C, produced on the basic shape of the by force F (fig. 4);

$$\delta_{11} = 2\int_B^C \frac{m_1^2 \mathrm{d}s}{EI'} \tag{3}$$

is rotating, in sections B and C, produced on the basis of the form by $X_1 = 1$ (fig. 4).

In (2) and (3):

$$\begin{aligned} N^0 &= 0,5F\cos\alpha; \\ M^0 &= 0,5Fr(1-\cos\alpha); \\ m_1 &= -1. \end{aligned} \tag{4}$$

is axial effort (N_0) and the bending moment (M_0) in a section of the beam (located at the angle α) produced by the force F on the basic form, i.e. bending moment (m_1) product on the basic form by $X_1 = 1$.

With values of (4), (2) and (3), it is obtained:

$$\Delta_{10} = -\frac{F}{EA} - \frac{Fr^2}{2EI'}(\pi - 2) \tag{5}$$

$$\delta_{11} = \frac{\pi r}{EI'} \tag{6}$$

Other notations have the following meanings: r – radius beam, A – plan area of beam, E – longitudinal elasticity module and I' is calculated with the relation:

$$I' = k_0 A r^2 \tag{7}$$

where:

$$k_0 = \frac{e}{r}; \quad e = r - r_n; \quad r_n = \frac{h}{\ln\left(\frac{r_{ext}}{r_{int}}\right)}. \tag{8}$$

Using (1), (5) and (6) arise:

$$X_1 = F\left[\frac{I'}{\pi A r} + r\left(\frac{1}{2} - \frac{1}{\pi}\right)\right]. \tag{9}$$

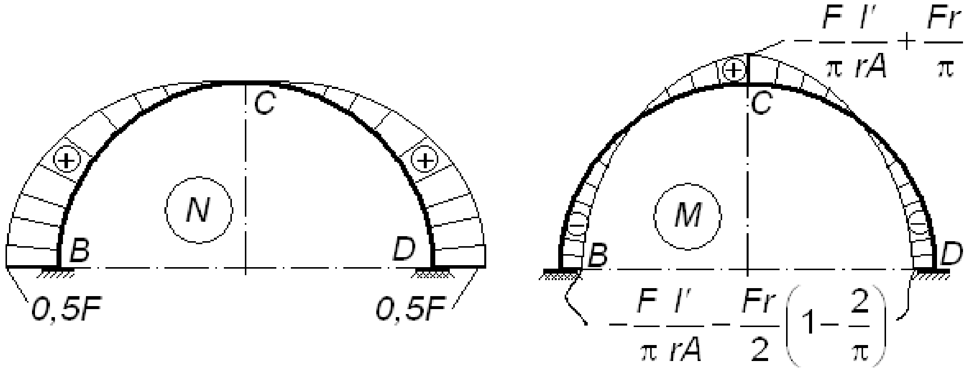

Fig. 5. Sectional effort diagrams

At intrados and extrados of beam the stresses is calculated with the relations:

$$\sigma_{int} = \frac{N}{A} - \frac{M}{Ae}\frac{|y_{1,int}|}{r_n - |y_{1,int}|};$$
$$\sigma_{ext} = \frac{N}{A} + \frac{M}{Ae}\frac{|y_{1,ext}|}{r_n + |y_{1,ext}|}; \tag{10}$$

where:

$$|y_{1,int}| = \frac{h}{2} - e; \qquad |y_{1,ext}| = \frac{h}{2} + e. \tag{11}$$

Using the method described earlier, in table 1 are shown the stresses calculated with (10) in sections B and C for different values of R_1 and R_2 and different thickness b (fig. 2). It was considered, generically a force F = 40 KN.

According to data of table 1 maximum stresses, in absolute value, develops in the section C, at intrados of beam (fig. 5).

Numerical Analysis

For numerical analysis it has been used FEM. To this end he developed a parametric model based on the design in Figure 2 that has been rolled in the ANSYS program. It was considered that the stress that develops in hanger is a plate stresses. In this model has been used 2D finite element PLANE183. Physical model has been subjected to a pressure equivalent to a force F = 40 KN applied on a surface corresponding to an angle of $\alpha = 20^o$, center symmetrically in relation to the axis of symmetry of the hanger (fig. 6).

After run of program have highlighted equivalent stresses Tresca criterion (fig. 7), the maximum values are presented in Table 1.

Table.1. Maximum stresses.

R_1 mm	R_2 mm	Analytic				FEM	Analytic	FEM
		Section *B*		Secion *C*		Section *C*	Section *C*	
		σ_{int} MPa	σ_{ext} MPa	σ_{int} MPa	σ_{ext} MPa	σ_{max} MPa	$c = \frac{R_m^{min}}{\lvert\sigma_{max}\rvert}$	
b = 20 mm								
80	40	137.32	–45.70	**–177.38**	111.65	**166.34**	**2.03**	**2.16**
100	50	109.85	–36.56	**–141.90**	89.32	**134.95**	**2.54**	**2.67**
120	60	91.54	–30.46	**–118.25**	74.43	**111.87**	**3.04**	**3.22**
160	80	68.66	–22.48	**–88.69**	55.83	**84.75**	**4.06**	**4.25**
b = 25 mm								
80	40	109.85	–36.56	**–141.90**	89.32	**133.07**	**2.54**	**2.71**
100	50	87.88	–29.25	**–113.52**	71.46	**107.95**	**3.17**	**3.33**
120	60	73.23	–24.37	**–94.60**	59.55	**89.49**	**3.81**	**4.02**
160	80	54.93	–18.28	**–70.95**	44.66	**67.79**	**5.07**	**5.31**
b = 30 mm								
80	40	91.54	–30.46	**–118.25**	74.43	**110.89**	**3.04**	**3.25**
100	50	73.23	–24.37	**–94.60**	59.55	**89.96**	**3.81**	**4.00**
120	60	61.03	–20.31	**–78.84**	49.62	**76.08**	**4.57**	**4.73**
160	80	45.77	–15.23	**–59.13**	37.22	**57.63**	**6.09**	**6.25**

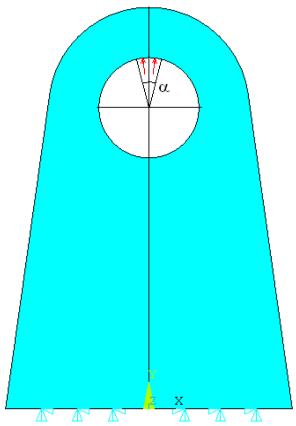

Fig. 6. FEM model

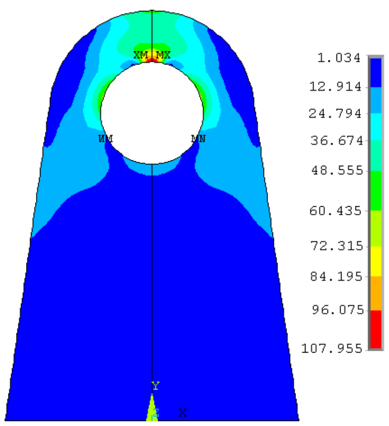

Fig. 7. Distribution of equivalent stresses Tresca for R_1 = 100 mm, R_2 = 50 mm, b = 25 mm and F = 40 KN.

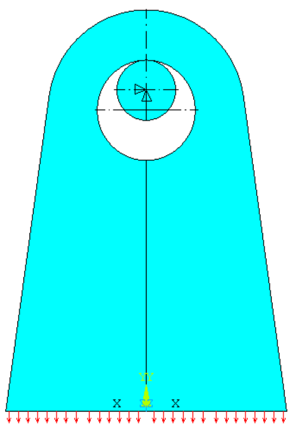

Fig. 8. FEM motel (contact problem).

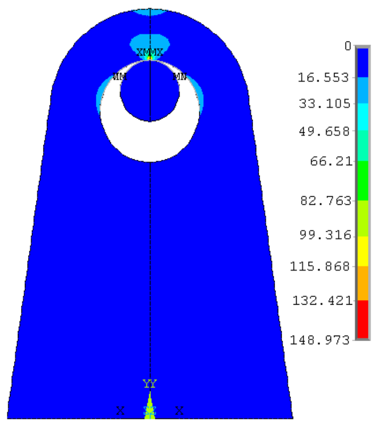

Fig. 9. Distribution of equivalent stresses Tresca for R_1 = 100 mm, R_2 = 50 mm, b = 25 mm and F = 40 KN.

As the size of the angle depends on the tension α, whose value cannot be assessed accurately, it has developed a model in which it has been introduced and the crane hook (fig. 8). It was considered that the crane hook section is round with radius $R_3 = R_2 - 20$ mm. For model considered, in addition to being used, we used PLANE183 and TARGE169 and CONTA172 finite elements modeling contact between the hanger and the crane hook.

In Figure 9 are presented distribution of equivalent stresses Tresca for $R_1 = 100$ mm, $R_2 = 50$ mm, $b = 25$ mm and $F = 40$ KN.

Conclusions

The hangers of large structures or equipment for the purpose of handling can be treated in most cases with large curvature of beams.

Design calculation and analysis of the distribution of stresses for hangers (fig. 2), highlighted the following issues:

- the maximum stresses increase with decreasing radius of curvature (tab. 1);
- analytical calculation is thinner because stresses determined by MEF are smaller than the specified analytic tensions (tab. 1);
- the use of crane hook singled out higher stresses $\sigma_{max} = 148{,}97$ MPa, versus those obtained analytically, $|\sigma_{\text{int}}| = 113{,}52$ MPa, but also to those obtained without the crane hook; this is explained by the fact that in the case of crane hook the value of the angle of contact α is less than that considered in calculations $\alpha = 20°$;
- it consisted of the values specified in table 1 that identical values of maximum stresses are obtained for different sizes of hangers, in which case records are technological considerations relating to dimensions of lift being used.

If the hanger is made of S235JR steel with tensile strength $R_m^{\min} = 360$ MPa, the value of the factor of safety for the situations examined is presented in table 1. On the basis of these values may be optimal hanger.

References

1. Posea, N. – *Rezistența materialeor*, Editura Didactică şi Pedagogică, Bucureşti, 1979.
2. * * * – *Relise 10.0. Documentation for ANSYS.*

Asupra proiectării elementelor de susținere la ridicare

Rezumat

In lucrare este prezentată o metoda analitica de proiectare a elementelor de susținere la ridicare (urechi) şi este făcută o analiză numerică folosind FEM a stării de tensiuni pentru diferite dimensiuni ale acestor elemente. Analiza este efectuată cu şi fără luarea in considerare a elementului de ridicare (cârligul de macara).