BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXVII No. 4/2015	61 – 66	Seria Tehnică

Evaluation of Stresses in MI20 Well Servicing Mast with Long Activity

Alexandru Pupăzescu

Universitatea Petrol-Gaze din Ploieşti, Bd. Bucureşti 39, Ploieşti
e-mail: pal@upg-ploieşti.ro

Abstract

MI masts are metal structures defined by the characteristic shape of the "A" letter used for well servicing. The evaluation of MI mast with long activity was made used the manufacture drawing and analysis in situ. From the point of view of behavior under load, MI20 mast was analyzed with FEM considering the real dimensions of masts. It was also made a calculation of the stability of these structures.

Key words: *servicing mast, damage survey, FEM*

Introduction

MI20 mast used for well servicing, are metal structures defined by the characteristic shape of the "A" letter. The main elements of strength are the two upright frames that transfer the loads to the ground. The connections of two uprights frames whit the mast substructure is done by cylindrical joints. Stiffening of the two uprights is done by horizontal bars. The mast is maintained in working position by means of 12 anchors. Structural analysis of the 48 of masts MI20 used for well servicing was carried out on the basis of drawings, sketches and measured in situ values. Values of the stresses and the deformations for each mast in hand, was carried out using the finite element method.

The Critical Conditions of the Loading which May Occur after Long Activity

For MI20 mast normal working, used to design, is characterized by the following parameters: maximum working load to hook on 4 – 20 tf; proof load – 25 tf; the maximum permissible wind speed for operating state – 70 km/h; the maximum permissible wind speed for stoppage – 120 km/h.

As part of a long-running operation, the dimensional characteristics of the two and horizontals of mast may mark changes due to the corrosive action of the environment. It also may occur displacements as a result of lateral or vertical soil settlement where is buried the foundation.

It appears so need for a resistance calculation which takes into account: the failure of support of an upright; changing the angle of inclination of the mast; the reduction of the wall thickness of the pipes of uprights.

Because of this we achieved a plan for checking the geometric characteristics and the material upon which such measurements have been carried out in the field.

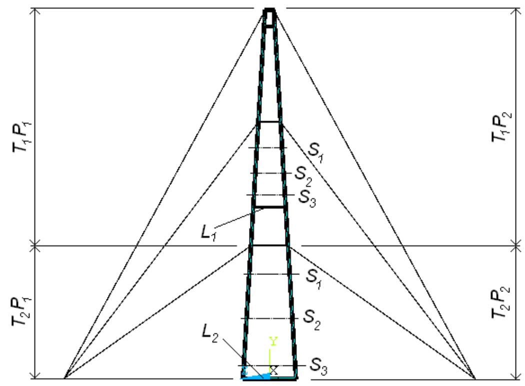

Fig. 1. The sections where was measured thickness of sections of the walls of uprights.

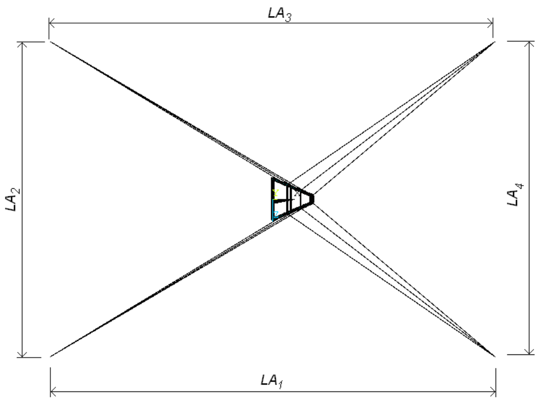

Fig. 2. The symbolization of distances between the fastening points of ground anchors of the mast.

Thus for each upright were determined wall thicknesses in three sections (S_1, S_2, S_3) upright section (T_1P_1, T_1P_2, T_2P_1, T_2P_2) (fig.1) and for each horizontal sections L_1 and L_2. In each section of the wall thickness considered was measured in four points *A*, *B*, *C*, *D* are situated at the ends of two perpendicular diameters. Another measured parameter was the distance between fastening points of ground anchors of the mast LA_1, LA_2, LA_3, LA_4 (fig. 2). For each of the surveyed 48 of MI20 mast data obtained were processed and presented in tabular form synthetic one in Table1.

Structural Analysis of MI20 Mast

To assess the stresses and deformations in elements of MI20 mast used finite element method. To this end it has developed a parametrical model set up on the basis of drawings and geometric characteristics listed in Table 1. Numerical analysis used the FEM with the finite elements: BEAM188, BEAM188 and uprights for LINK8 for horizontal, i.e. LINK19 for anchors.

Pipe material from the uprights and the horizontal are made is OLT45 and uppers for which, at the request of bending with tensile or compression, tension was considered permissible σ_a = 170 MPa.

The values of wall thicknesses used to define the geometric characteristics, have minimum measured values corresponded to each section and horizontal.

The Connections and Loads for MI20

The loads acting on the MI20 are grouped in the following load assumptions:

IP1 Hypothesis – The fundamental hypothesis:

- The weight of mast;
- Maximum static load hook.

IP2 Hypothesis – Additional weight hypothesis:

- The tasks of the IP1;
- The action of the wind allowed for operating state.

Table 1. Dimensions and lengths measured on situ for MI20 mast examination.

Cod of mast	Wall thickness measured, mm							The minimum thickness of the wall section, mm	Wall thickness used in calculations, mm	LA_1, m	LA_2, m	LA_3, m	LA_4, m	Maximum displacement, mm	Maximum stress, MPa
	Upright	Measuring section	Nominal size	Measuring point											
				A	B	C	D								
108SR	T_1P_1	S1	Φ168x10	9.8	9.4	9.7	10	9.4	9.4	32	27	32	27	54.503	61.416
		S2		9.9	9.6	9.5	9.6	9.5							
		S3		9.7	9.4	9.8	10	9.4							
	T_1P_2	S1	Φ168x10	10.2	10.4	10.3	10.5	10.2	10						
		S2		10.4	10.6	10	10.3	10							
		S3		10.2	10.3	10.4	10.6	10.2							
	T_2P_1	S1	Φ168x10	9.7	9.4	9.1	9.3	9.1	9						36.354
		S2		9.6	9.5	9.2	9.4	9.2							
		S3		9.8	9.6	9	9.3	9							
	T_2P_2	S1	Φ168x10	9.9	9.7	9.6	9.4	9.4	9.2						
		S2		10.1	10	9.8	9.5	9.5							
		S3		10	9.6	9.4	9.2	9.2							
	Horizontal L_1		Φ89x8	7.9	8.2	8	7.6	7.6	7.6						2.242
	Horizontal L_2		Φ168x10	9	8.7	8.9	9.5	8.7	8.7						

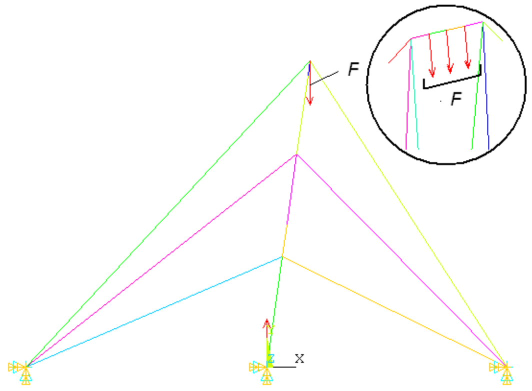

Fig. 3. Modelling the load F applied on crown block.

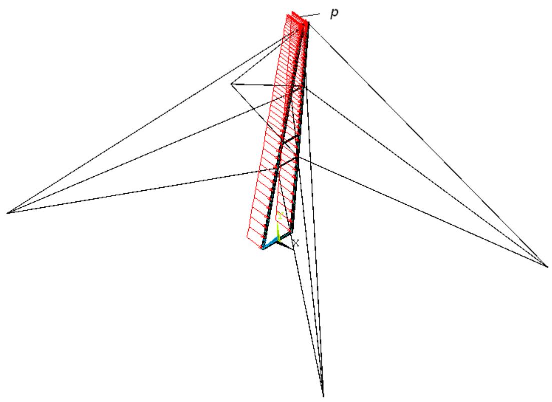

Fig. 4. Modeling of wind pressure.

IP3 Hypothesis:
- The weight of mast;
- The action of the wind allowed for stoppage (v = 120 km/h).

IP4 Hypothesis:
- Permanent action revolving of the mast.

Since structural analysis has been made for the masts with long operation was felt that:
- Maximum load to hook 20 tf;
- The maximum permissible wind speed for operating state – 70 km/h.

Based on the values of the measurements it was determined that:
- The pipes of which are made the uprights and horizontals have uppers outer diameter and wall thickness as different (generally smaller) than the design;
- There were no displacements of supports points of uprights.

It was also considered:
- The rake angle of 8° of mast is not modified;
- The axis of the mast is positioned at half distance between fastening points of ground anchors (fig. 2).

Therefore the assumption of worst-case load considered includes:
- Maximum load hook is F = 20 tf (fig. 3);
- The pressure exerted by a wind with speed v = 70 km/h, the verticals and horizontals traced, p = 0.07917 N/mm (fig. 4); Wind pressure given what manifests itself on the surfaces exposed shall be determined by the relationship:

$$p_v = k_v \cdot g_v \cdot A_v \quad (1)$$

  in which k_v is a coefficient of form; g_v – basic dynamic pressure; ; A_v – the area exposed to wind. For items which included in mast, A_v it is understood the breadth of section downwind and p_v it appears that uniformly distributed load along the length of the element (N/mm). For round pipe $k_v = 1,25$ (STAS 1909/89). Dynamic pressure is determined by the relationship $g_v = v^2 / 1630$, that, by inserting the wind speed in m/s, it follows g_v in kN/m^2. If the wind with v = 70 km/h (working condition) basic dynamic pressure is considered constant throughout the height of the mast.
- The weight of mast.

The mast connections were modeled as follows:
- For cylindrical joints of mast were blocked all translations and rotations, less the rotation Z axis, the axis along which is positioned horizontally at the base of mast (fig. 1 and 3);

- For the points relating to ground anchors were blocked all movements (fig. 3).

It notes that in structural analysis, it was considered that the mast geometry is perfect, in other words, were not taken into account deviations of shape and position of the mast project.

The Results Obtained and Their Interpretation

For all 48 of the MI20 mast afferent programs were run.

The results were retained:
- The maximum displacement, which takes place at crown block;
- The maximum stresses for each section of the mast;
- The maximum stresses from horizontal.

All data used in the calculations, as well as the values of tensions and calculated movements, are specified in Table 1.

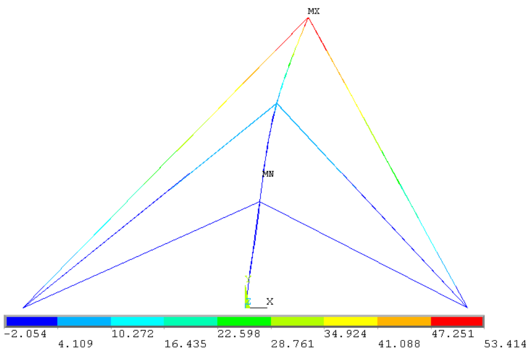

Fig. 5. The maximum displacements of mast nr.25 for the proper unfavorable loading.

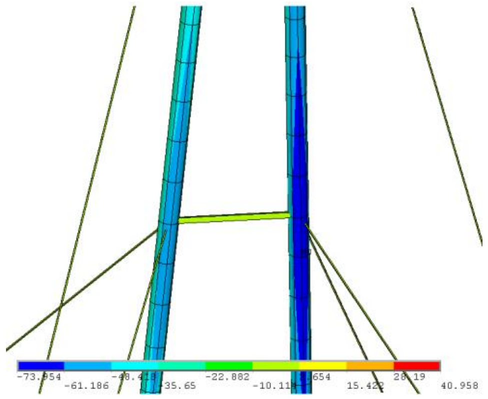

Fig. 6. The maximum stresses of mast nr.25 for the proper unfavorable loading.

It is noticed that:
- The uprights of the mast are compressive request;
- The maximum stress, in absolute value, $|\sigma_{max}|$ = 73.954 MPa (fig. 6) develops in the uprights in the grip area two anchors;
- The tensile stresses are supported for the permissible tension than steel pipes from which are made σ_a = 170 MPa;
- The stress most of horizontal, in absolute value, it is σ = 4.921 MPa and develop in horizontal upper part of the first section.
- The maximum axial load in anchors FA_{max} = 25.165 kN develops into rear anchors (opposite the working winch) of mast, three-level, corresponding to crown block.

For the mast no. 25 was studied the situation in which one a cylindrical joint has a vertical failure.

If vertical displacement is Δy = –15 mm when the horizontal base of the mast the maximum stress is σ_{max} = 180 MPa > σ a = 170 MPa.

Accordingly, specified MI20 mast surveyed listed in Table 1, satisfy the condition of resistance for load hypothesis includes:
- The weight of mast;
- Maximum load to hook 20 tf;
- The maximum permissible wind speed for operating state – 70 km/h.

It makes clear that tensions and movements presented in Table 1 correspond to a perfect geometers of mast.

Because the uprights are request to compression, a calculation stability of mast was performed. Using ANSYS program, it resulted a critical force F_{cr} = 70.626 tf (distorted shape of mast is presented in fig. 7). It is noticed that there is not a danger that mast to lose stability.

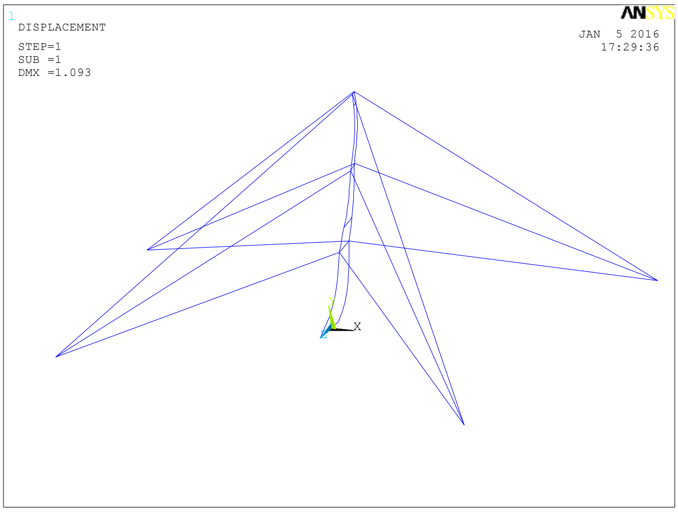

Fig. 7. Deformed shape of buckling of mast

References

1. Pupăzescu, Al., Popa, I., Hotea, Gh. – Comportarea statică a turlelor de producţie cu exploatare îndelungată, *Construcţia de maşini*, Vol. L, Nr. 9, 1998.
2. * * * – API - 4F, *Specification for Drilling and Well Servicing Structures*.
3. * * * – SR EN 1991-1-4:2006, *Acţiuni generale - Acţiunea vântului*.

Expertizarea masturilor de intervenţie MI20 cu exploatare îndelungată

Rezumat

Masturile MI sunt structuri metalice definite prin forma caracteristică literei „A” şi sunt destinate lucrărilor de intervenţie la sondele aflate în exploatare prin pompaj de adâncime. Având o durată de exploatare îndelungată expertizarea lor s-a efectuat pe baza desenelor de execuţie şi a măsurătorilor efectuate in situ. Din punct de vedere al comportării sub sarcină, masturile MI20 au fost analizate numeric cu metoda elementului finit pe baza dimensiunilor reale. De asemenea s-a efectuat un calcul la stabilitate al acestor structuri.