УДК 621.791

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RESEARCH OF THE CAUSES OF FATIGUE DAMAGES OF METAL STRUCTURE WELDED ASSEMBLIES OF LOADING CRANES «TAKRAF»

The basis of the most of the machines and mechanisms is the metal structure, more often a welded one, which has a significant effect on reliability and safety of their operation. In case of prolongation of the unique equipment service life, such as ore-clamshell loading cranes, year by year this problem becomes more and more acute and burning [1].

Metal structure of the reloading crane is a complex spatial object. Main box-section beams rest upon the flexible and rigid support. Truss is also of a box section type. Operational reliability of the reloading crane mainly depends on the quality of metalware welds [1–3]. Welds of the main beams are made by automatic welding modes - no defects of these seams have been detected during the ore-clamshell loaders operation. Weld geometry: width, reinforcement, uniform ripple, all of them conform to the technical documentation [4, 5]. There are various design diaphragms and stiffening angles located along the main beams to increase rigidity and strength of main beams structure. Three types of diaphragms are mainly used: type a (fig. 1), type b (fig. 2), type c (fig. 3).

Fig. 1. Diaphragm type A

Fig. 2. Diaphragm type B

Fig. 3. Diaphragm type C

Diaphragms and longitudinal stiffness angles create spatial rigidity in longitudinal beams. The reliability of welded seams of diaphragms and stiffening angles is ensured by several factors: design shape of the welded seam, quality of welding, stress concentrators, residual stresses and deformations after welding and transmission of power flow through the welded assembly [5].

When investigating the longitudinal beams and determining the maximum load on longitudinal beams it is reasonable to construct moving loads influence lines at the operation of the ore-clamshell loaders. It is particularly important to determine the load power in power flow transmission assemblies, in the attachment point of rigid pole strut to main beam (elements 1-5, 1-6, 5-6, 6-7) (fig. 4) [1].

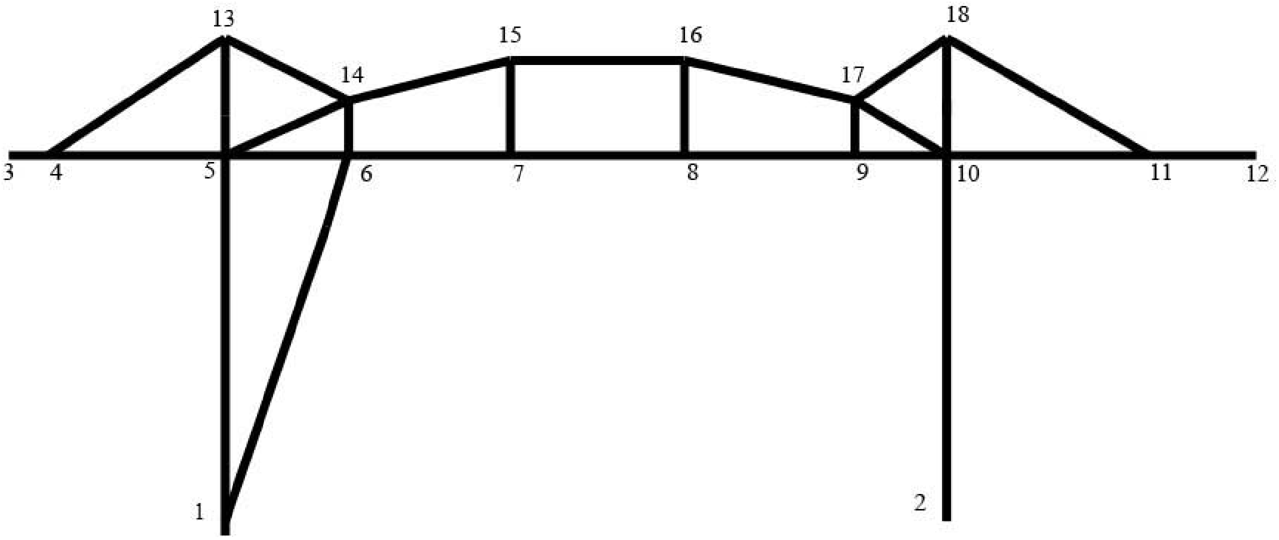

Fig. 4. Welded assemblies layout

By putting a single load, we construct influence lines in the rods 1-5 and 1-6. Influence lines diagrams designed with program Mav.Structure are shown on fig. 5.

Analyzing influence lines diagrams we can conclude, that the maximum load on rods 1-6 and 1-5 will be at location of a moving load between welded assemblies 5 and 3 (cantilever) [1, 6].

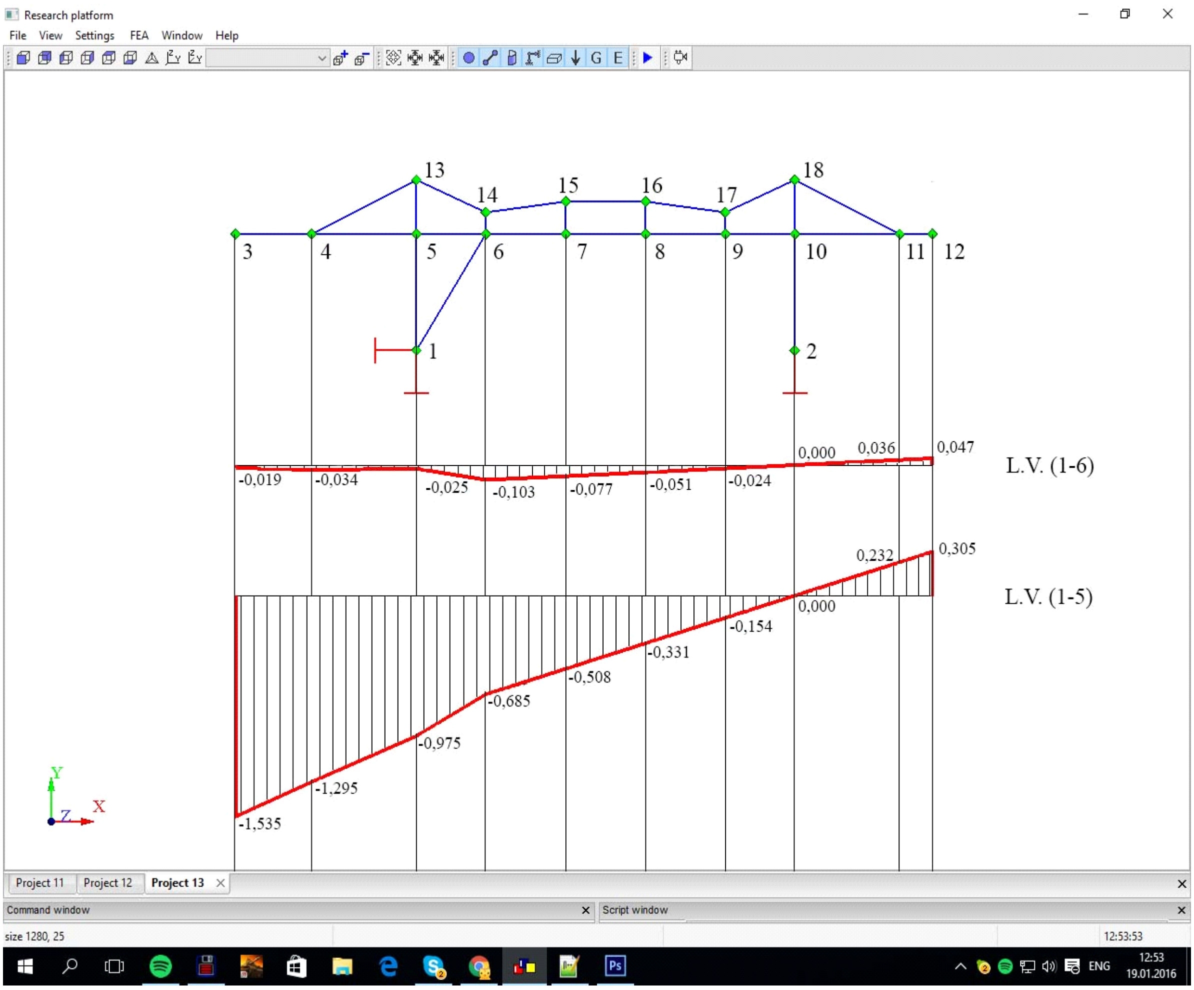

Fig. 5. Force influence lines in rods 1-6 and 1-5 from moving load location

The formation of fatigue damages in metal structures is affected by the intensity and type of cyclic loads. The symmetrical cyclic loading is the most dangerous. To determine the actual load in the rods 1-5, 1-6, it is necessary to load the influence lines with moving load of 100 tons calculated basing on weight of car loaded to the limit.

Expert survey of metal structure of ore-clamshell loader in the rods 1-5, 1-6, 5-6, 6-7 confirmed analytical calculations. Welded seams of stiffness angles with bottom boom are interrupted unlike welded seams of the walls and main beam flanges, which creates a concentration of stress. Fig. 6 shows the defects of the bottom boom of main beams, formed when operating the loader.

Fig. 6. Defects of the bottom boom of main beams

Cracks in the bottom boom, in attachment point of stiffness angles have been formed due to the crossing of longitudinal and cross seams. A second reason for cracks occurrence is significant operational loads.

Let’s construct influence lines in the rods 5-6, 6-7 at rigid pole sway strut. Fig. 7, 8 show diagrams of force in rods under a single movable load.

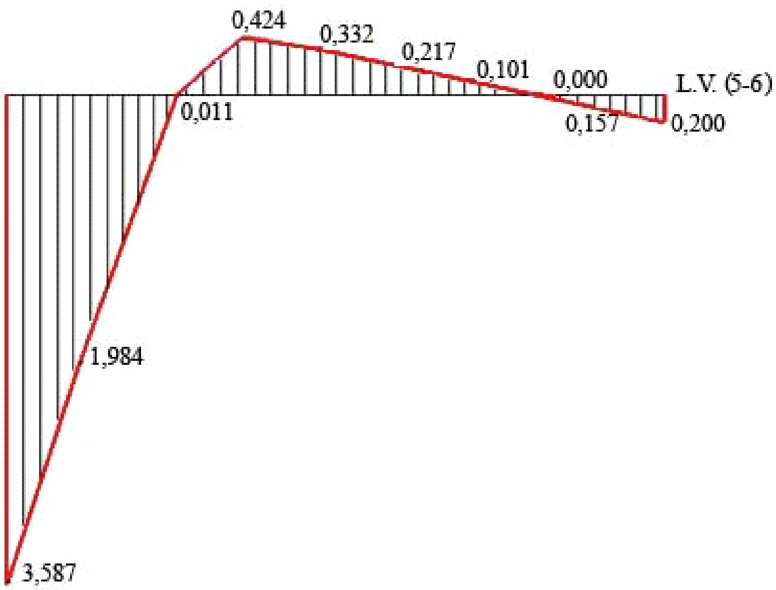

Fig. 7. Force influence line in rod 5-6

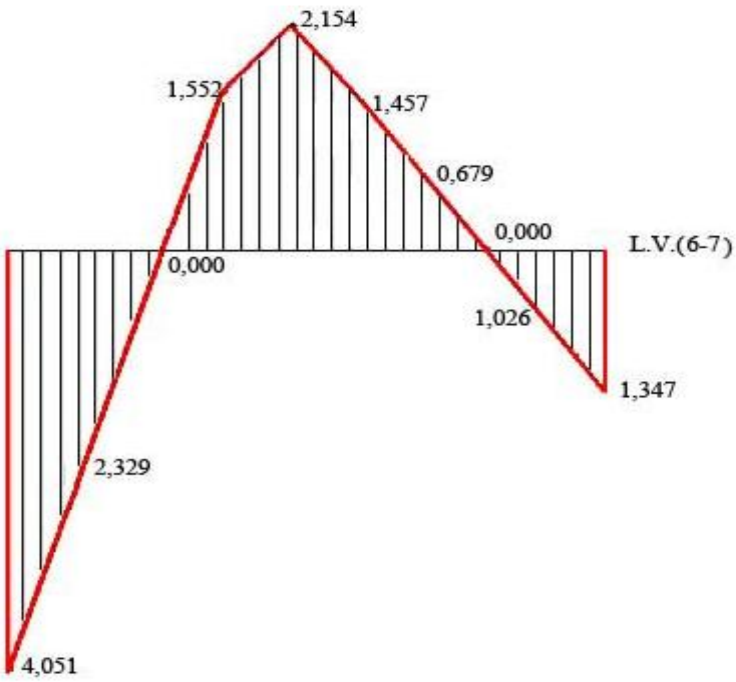

Fig. 8. Force influence line in rod 6-7

The analysis reveals that the force in rod 5-6 from the single load changes from +0.424 to -3.587 according to cyclic law. Thus, the actual forces from the actual maximum load, when car is moving on loader main beams, vary from + 42t to -360t. Table 1 and 2 show the evolution of the forces in the inspected points of the bottom boom (elements 5-6 and 6-7) gauged by 2.5 m.

Table 1

Force in the bottom boom (rod 5-6) when car is moving

Distance, m	2,5	5,0	7,5	10,0	12,5	15,0	17,50	20,0	22,5
Force in the bottom boom, t	-360	-233	1	42,0	33	22	10	0	-20

Table 2

Force in the bottom boom (rod 6-7) when car is moving

Distance, m	2,5	5,0	7,5	10,0	12,5	15,0	17,50	20,0	22,5
Force in the bottom boom, t	-405	-307,4	0	155	215	146	68	0	-135

Results of research made by analytical method using Mav.Structure program and results of visual inspection when expert investigation of ore-clamshell loader reveal that design of welded seams of bottom boom stiffening ribs and the method of their making does not meet the requirements for the metal structures under cyclic loading. Quite heavy duty routine and cyclic loadings caused formation of fatigue damages in welded assemblies of loader metal construction.

CONCLUSIONS

1. Fatigue damages in welded assemblies of loader metal construction are caused by intense cyclic loadings and design stresses concentrators in welded assemblies.

2. The analyzed elements require:

- design modification of attachment hubs of longitudinal stiffness ribs;
- strengthening of bottom boom area with maximum power flow.

3. Direction for further research – analysis of constructive design and load rate of other welded elements of the loader, where fatigue damages have been detected during investigations.

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Статья поступила в редакцию 11.05.2016 г.