EVALUATION OF STRESS-STRAIN STATE OF REPAIRED BUCKET WHEEL EXCAVATOR SH630

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ABSTRACT
An analysis of excavator SH630 type, manufactured by O & K Germany, which is used in the open pit mine in Lukavac is presented in this paper. For the purpose of the commissioning of this complex mining plant and confirming the correctness of activities performed on excavator repair, among other things, perform static and dynamic stability testing of the main load-bearing structural parts excavator was required. In that manner, one of the segments of the analysis is the measurement performance of the stress-deformation state of the vital parts of the excavator by strain gauges in working conditions, and analysis of measurement results. Stress analysis results showed that the main mast and pylon during normal working regime are not exposed to stresses that would in any way jeopardize their safety. The measured stress values are significantly less than the allowable stress for this type of construction. Dynamic stress changes taking place around a relatively low medium stress with small stress amplitude, which is desirable from the standpoint of strength. Stress change character fully agrees with the expected changes caused by normal operating excavator operations.
Keywords: bucket wheel excavator, stress-strain analysis, strain gauges.

1. INTRODUCTION

Excavator SH630 has a working wheel with buckets (1) which in the normal working process turns with 7 min^{-1}, and thus achieves the designed capacity of 1,000 t/h, Figure 1. Working wheel is powered with 5 hydro-motor with gearing located at the operating point. The procedure of material digging is done by 14 buckets on the upper side of the working wheel with discharging through the openings in the structure where the excavated material over receiving hopper directs to the primary belt conveyor (2).

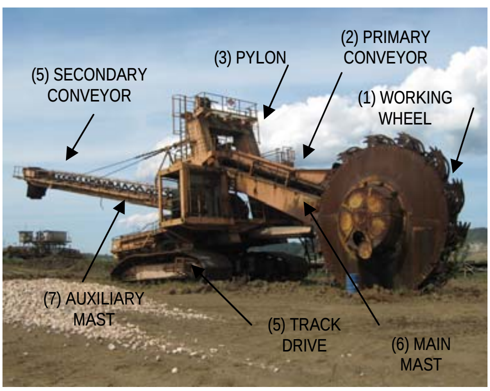

Figure 1. Excavator SH 630 before overhaul

Figure 2. Excavator SH 630 after overhaul

Working wheel and the primary conveyor over the main mast rely on the support excavator structure, so called pylon (3). Pylon is a welded steel frame which takes all the load and over a large circular support the load is transferred to the substrate. Pylon construction has the option of circular motion. The main mast is welded steel box-shaped construction which hanged with two shafts to the pylon, and over the hydraulic cylinder placed at the lower part of the pylon gets vertical movement. On the supporting structure there is also outpouring system through which the excavated material is directed to the secondary conveyor and transported further to the main system of transport for the material excavated from the mine. Construction of pylon is the main bearing structure through which all workloads are transferred to the substrate. Pylon is supported on caterpillars of the excavator which facilitate the movement of the entire system. The rehabilitation of the excavator is related to all vital parts of the steel structure, transport system, working wheel buckets and hydraulic system. Drive of the excavator is realized with electricity that powers the pump and the entire hydraulic system. On a steel frame main mast and pylons are provided measurements of stress-deformation state and acceleration during operation to assess the dynamic and static stability in terms of workloads.

2. STRUCTURAL ANALYSIS AND EXPERIMENTAL RESULTS

Before experimental measurements an analysis of structure using the finite element method were done (not shown in the paper) in order to establish a preliminary distribution of stress and strain on the structure as a help to define measuring points with strain measurements. The aim of the planned experimental measurements is to determine whether the structure is uniformly loaded and whether the stress intensity reaches a critical value. Based on the analysis of stress it has been shown that the zone transitions from horizontal to vertical load-bearing part of the structure is exposed to the highest pylons acting stresses. Operating force and force of bucket penetration in the ground, so called, cutting force, acting eccentrically in relation to the central axis of the main mast, and centrally in relation to the axis of the pylon, so that this displacement of the working force from the axis causes complex stresses, [1,2].

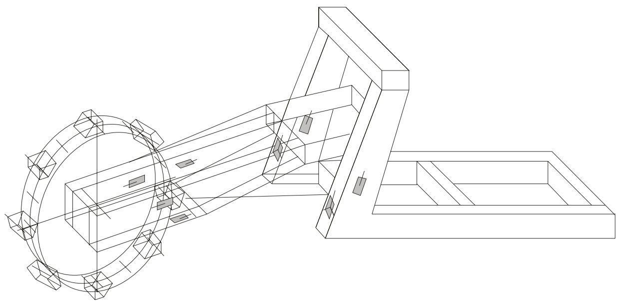

Figure 3. Scheme of measurement points on the bucket wheel excavator construction

Complex excavator construction in static and dynamic sense requires that on the pillars of vertical pylon frame two measuring three-grid rosette gauges must be placed at the same position and one single-grid measuring gauges on the sides of the vertical pylon pillars on both sides. Measuring strain gauges are installed on identical positions on both vertical pylon pillars for comparison of results. Another significant part of the construction excavator is a main mast, which carries the working wheel and the primary conveyor. The main mast is welded box-shaped steel construction loaded with bending in two planes and to assess its behavior four strain gauges must be installed at the outer contour of the mast. Position of gauges are shown in Figure 3. Data acquisition was made for the characteristic working phases of the excavator, such as moving the excavator, idle operation phase, excavator rotation, digging with all necessary movements. Data acquisition was performed with rate of 5 [Hz] with 8-channel system "Spider 8-30" and the accompanying software, "Catman – Professional'' and strain gauge type 1-LY91-10/120 "HBM" Darmstadt, Germany. Data acquisition is done in "real-time" mode and software post-processing results are shown in sizes that define stress states. Measurements of strain were carried out in more specific working states of the excavator, which are common during operation, [3].

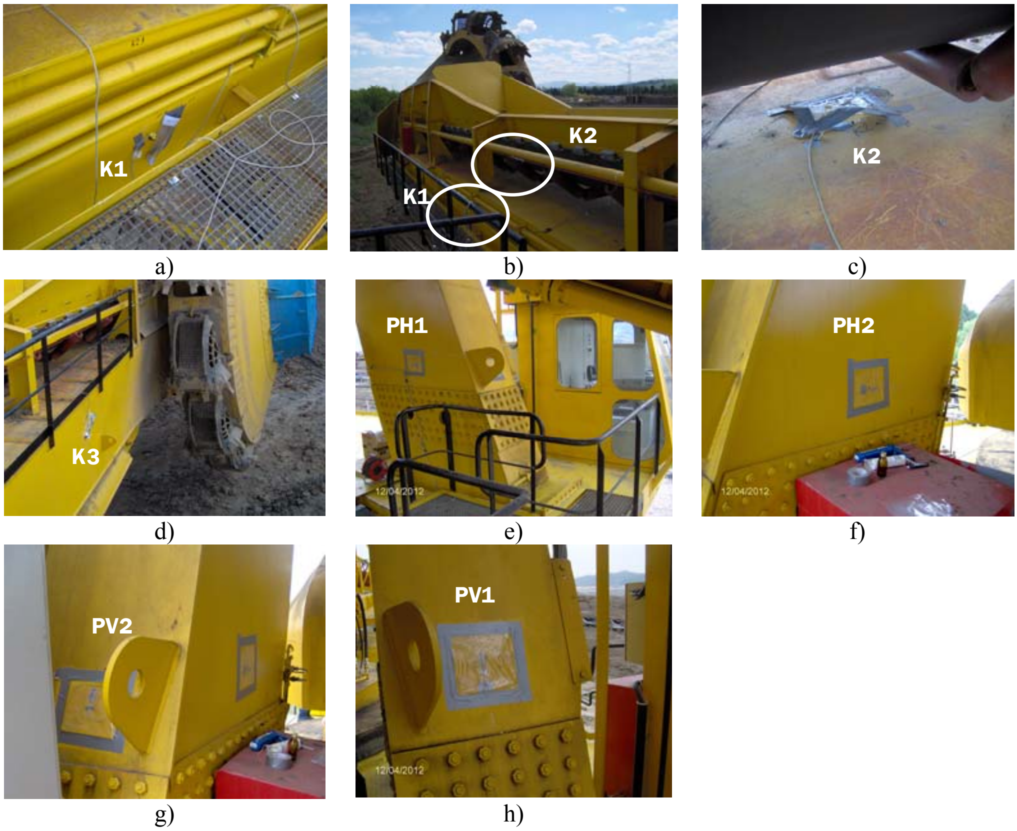

Figure 4. Measuring places on the main mast of excavator K1, K2 and K3: a) to d), the position of measuring places at a pylon PH1, PH2, PV1 and PV2: e) to h)

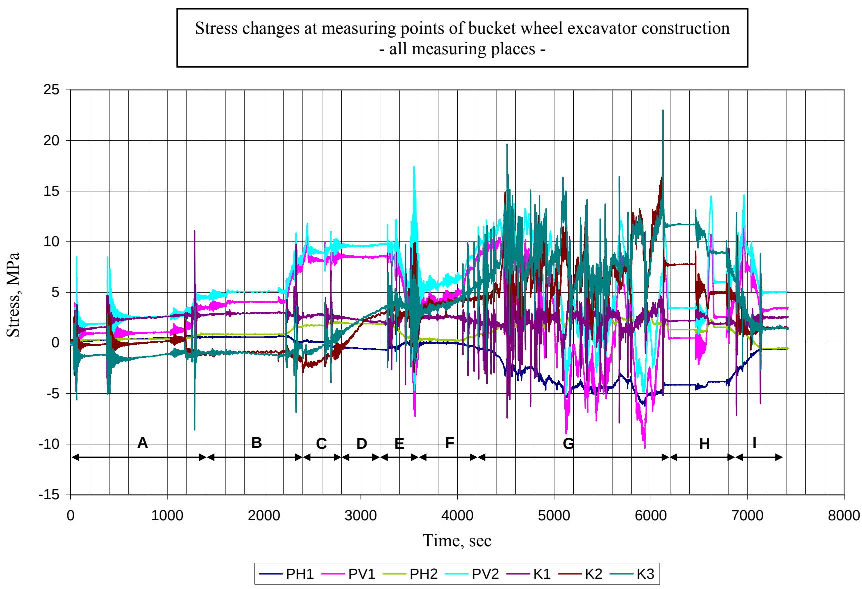

Figure 5. Diagram of stress changes vs. time for all monitoring measuring places

This specific operating conditions are indicated in the graphs, and relate to: A-moving of excavator, B-mast rotation + rotor spinning without digging, C-belt conveyors turned on + increasing of wheel rotation speed without digging, D-excavator rotating + conveyor belts turned on, E-moving forward without excavator digging + excavator rotation + lowering the working wheel, F-moving forward + rotation, G-digging + excavator rotation + mast lifting + mast lowering + normal operating regime of digging, H-mast lifting + belts turned on, I-working wheel works with no-load + excavator rotation + turning off. During the measurements, a change in pressure is followed within the system of working wheel. The usual range of registered pressure, during the measurements, was in the range 51 to 56 (bar). The highest level of pressure registered was about 80 (bar) corresponding to the highest measured stress. Because of that the projected maximum pressure in cylinder can reach 2.5 times higher value (up to 190 bar), which is caused by digging conditions (digging resistance), it can be expected that in such working conditions and maximum operating stress reaches a significantly higher value. As shown in Figure 5, it is clear that the character of the change in stresses at all points are of a stochastic (random) character. The highest measured tension character stress has a value of +23 MPa, and the highest measured pressure character stress is -10 MPa. Allowable stress for alternating variable load is σ_{allow} = 80÷100 MPa (S235). Maximum measured stress values correspond to the hydraulic pressure of about 80 (bar). For maximum design pressure in the cylinder of 190 (bar) it can be expected for stress to achieve proportional greater value σ_R = 60 MPa < σ_{allow}. The highest measured stress at the measuring point K2 is 17 MPa. Stresses are mostly of tension character. Character of stress changes at measuring points K1 and K3 is the same, with the difference in intensity. The highest measured stress is the measurement of K3 and is about 23 MPa, while the maximum stress measured at the point in the K1 is about 10 MPa. After analysis of the stress character at the two measuring points, it is clear that there is presence of complex stresses - tension and bending, but it is bending to the left with a little more intensity. The dynamic nature of the changes is with low intensity and does not endanger the dynamic stability of the main mast. Stresses measured on vertical pillars of pylon at points of PV1 and PV2 have approximately the same intensity and character changes. All measured values vary between -10 MPa and 17 MPa. The difference between the values PV1 and PV2 is higher than 2 MPa, which is negligible. This result indicates that there is no difference in the vertical deformations of the main pillars of the pylon. Maximum dynamic activity was observed in a field marked with "E" what is a period of excavator's moving and working wheel's lowering. Differences were detected in the sign of the measured stress at the measuring point PH2, where tensile stress occur, and at the measuring point PH1 - pressure. This difference suggests that there is a torsion of pylon pillars, which results in the fields marked with a "C", "G", "H" and "I", and these are precisely the operations in which the excavator rotation is performed and this phenomenon were expected.

3. CONCLUSIONS

The construction of bucket wheel excavator is very complex and so static and dynamic states are. The assessment of those states must be based on several groups of measurements. In this paper only one field of interest is covered. The measured stress values at the specific measuring points are significantly less than the allowable stress for this type of construction. Dynamic stress changes, taking place around a relatively low medium stress with a small stress amplitude, are desirable in terms of strength. Stress change character fully agrees with the expected changes caused by normal excavator operations. Based on the measurements and analysis, it can be stated that the main mast and pylon, as the most important carrier of the excavator, during normal working regime are not threatened in terms of static and dynamic load capacity and strength.

4. REFERENCES

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