ABSTRACT

Draglines, the giant single-bucket excavators in existence today, are used mostly for the removal of overburden in large scale surface mines. Normally the, draglines are more than 4000 tons in weight, with boom length ranging from 70 m to 110 m and bucket capacity ranging from 10 m^3 to 120 m^3. The dragline boom is a key component in dragline operation. Different designs of booms are in practice to enhance the effective utilization of the dragline with minimum downtime due to major breakdown in boom. During dragline operational cycle, as bucket is directly attached to the boom point sheave, the boom is subjected to the loading and unloading loads cyclically. This cyclic loading and unloading produces high to very high stresses in the boom structure and may lead to boom failure.

The booms are constructed using hollow structural steel pipes. It consists of 3- 4 main chords and 5 -6 bracing members connected along the length of the boom. The bracing members form complex overlapping or non-overlapping joints known as boom clusters. These clusters are the complex joints, which may fail over a certain period of time.

Because the boom design incorporates number of joints, hence any design or analysis of boom structure remains incomplete without critical investigation of joints. Therefore, critical joints observed on the basis of field investigation have been chosen for the analysis of stresses within the joints. Four critical locations of the joints have been selected for in depth analysis of stresses around the interaction point of brace with the main chord. These joints have been chosen on the basis of field understanding that the repairing and maintenance activities are carried out frequently at these locations.

Two type of loading conditions, namely static and dynamic loading were observed. The static loading conditions occur during the operation, when the boom and bucket of the dragline become static for a very short period of time.

The dynamic loading conditions occur during the swing-to segment of dragline bucket cycle

with filled material for unloading the material from face to disposal site. It also occurs during the swing-back segment of dragline bucket cycle with empty bucket after dumping the material at the disposal site and returning back to the blasted face.

Accordingly, a solid 3D Model of the boom was constructed in SOLIDWORKS software as wireframe design. For performing simulations, the constructed model was imported to ANSYS software in compatible file format. Simulations were performed on ANSYS 18 using finite element analysis.

The overall structural behavior of the boom along with suspension rope, A-frame, and mast has been predicted by constructing and analyzing the structure as global beam model. The global beam model has provided the stresses in the form of direct or axial stress, bending stress and maximum combined stress on the boom structure. Deformation of the boom structure and tensile axial forces in the suspension wire ropes has also been predicted to ensure the safe functioning of the structure under the applied loading conditions. Further, the selected joints have been evaluated by analyzing the models as solid submodel. The solid sub-model has provided the Von-Mises stress; fatigue life and factor of safety in the boom cluster (joints). A separate parametric study has further been performed for the critical joint to predict stress level within this critical joint.

The design of dragline boom structure as a beam model and its analysis by using the state –of –art techniques has provided suitable insights in investigating the behavior of boom under static and dynamic loading conditions. The study has been able to propose a safe design of boom structure as the values obtained for the direct stresses, maximum bending stresses and maximum combined stresses are within the safe limits. The proposed design of the boom reveals that the main chord remains in axial compression or axial tension during the loading while bracing members are subjected to bending loads. The solid sub modeling of boom cluster (Joints) reveal that the stresses within the joints are concentrated at the fillet region. However, the stresses in the joints in the given loading conditions are within the yield strength of material of tubular steel members. The study further brings forth an important feature that deformation and stress values attain max magnitude in the vicinity of boom point sheave both in static and dynamic loading conditions. However, the magnitudes of these parameters are slightly higher in the dynamic loading conditions in comparison to static loading conditions.

CIDECT design guide for the boom cluster (joints) should be followed in order to create a safe design of the structure. The joint design model, C2, C3 and D3, which do not follow the design criteria are stressed beyond the yield strength of material. The study reveals the importance of CIDECT design guidelines in the design and evaluation of boom cluster joints.