ABSTRACT

Draglines, the giant single-bucket excavators in existence today, are used mostly for the removal of overburden in large scale surface mines. Generally, draglines are more than 4000 tons in weight, with bucket sizes ranging from 15 m^3 to 120 m^3. The dragline bucket is a key component in dragline operation. Although numerous factors affect the productivity of dragline operations, one of the important factors is the dragline bucket. Different designs of buckets are in use to enhance the productivity of removal of blasted material. In the digging process, variable rock conditions are faced by the bucket teeth. The buckets are dragged against the blasted muck to fill the overburden materials. For the dragline bucket itself, the primary mode of wear is material abrasion. As a result, the areas of the bucket that spend the most time moving through material tend to receive the highest levels of wear. During contact with the ground the maximum chances of wear and tear have been observed in bucket teeth and its assemblies. The bucket teeth must have an appropriate geometrical design for longer life. The shape of the bucket teeth is normally governed by ground resistive forces. In the bucket assembly, the arc anchors, hitch elements and teeth are crucial components of the bucket and analysis has been done separately for them with different boundary and loading conditions. In the bucket teeth, the influence of rake angle of teeth has been rigorously investigated. The shape of the bucket teeth is also directly dependent on the rake angle.

From the foregoing discussion, it is evident that bucket and its assembly is subjected to maximum stress and wear while interacting with the blasted ground. In this light, the present study aims at critically investigating the stresses in the bucket and its assembly.

The study has been done for static loading and dynamic loading condition of bucket. In the static loading, there are two conditions one is while the bucket is empty, and another one is while bucket is loaded. In static loading condition, bucket dead load and payload

(mass of loaded material) are considered for the stationary state of the bucket. During the swing to unload and swing back cycle of the dragline static loading conditions occur for a very short period of time when the boom and the bucket become static with bucket loaded or empty while the bucket is loaded or empty. In dynamic conditions, the bucket is assumed to be moving in forward and unidirectional way with a constant velocity.

In the present study, the three-dimensional (3D) solid bucket model was developed in AutoCAD, and it was investigated for the Von-Mises stress, fatigue life, deformation, damage and factor of safety on the dragline bucket in the static and dynamic loading conditions using the ANSYS18. FEM outcomes, highlighted teeth, arc anchors and hitch elements and maximum value of stress and minimum value of the factor of safety under the various loading conditions have also been investigated.

The purpose of this study is to prognosticate the bucket failure, identify the critical areas of the bucket, optimise the rake angle of the bucket and minimise the resistive force acting on the bucket.

For excavating of the rock by bucket, it is important that the digging force provided by bucket should be more than the resistive force provided by the rock. Various forces act on the bucket teeth, and these forces depend upon the different angle of bucket teeth. In this study, a relationship between the different angle of bucket teeth and resistive force has been established to optimise the rake angle and minimise the resistive force.

In this analysis, it has been found that when the bucket is in a static and empty condition (only dead load is applied), then equivalent stress and damage was maximum near the hitch elements, arc anchors. The fatigue life and factor of safety was minimum in these locations. When the bucket is loaded with overburden materials, similar observation has been found, but the magnitude of equivalent stress and damage was increased. Further,

the value of fatigue life and factor of safety was found to be reduced near the hitch elements and the arc anchors.

Under dynamic loading condition, the maximum equivalent stress value was found near the teeth of the bucket and near the hitch element and factor of safety was minimum at these locations. The simulation outcome also revealed that maximum Von Mises stress values exist on the bucket teeth and hitch element. The study found the maximum value of stress and a minimum factor of safety in the bucket assembly. The results indicate, the maximum probability of failure at these locations. Therefore, for these critical locations, high-grade steel, or alloy steel instead of structural steel is used in the manufacturing process.

Rake angle plays a critical role in designing of teeth. From the analysis, it has been observed that the optimum value of the rake angle lies between (30^0 to 45^0). The study revealed the relationship among the bucket width, teeth depth and ground resistive force. With the increase in bucket width, the resistive force has also been found to increase. Similarly, when teeth depth increases, ground resistive force increases and vice-versa. For the optimum value of rake angle, the material flow along the teeth will be very smooth, at the same time specific pressure acting on the teeth will have a lesser value, which increases the tool life.