Design of ROPS (Roll Over Protective Structure) For Operator Cabin

Vidya Pardeshi
Mechanical Engineering Department ,AGPCE Nagpur
Email: kanojiya.vidya@gmail.com

Abstract: For the mobile working machines the important criteria for evaluation is the safety of the machine operator. The design of machine should ensure higher safety of the operator during machining in extreme conditions. The protective structure for the mining and self-propelled machine consists of structural components arranged on the machine in such a way that it reduce the risk to the operator. The shape and the location of the protected space is dependent on the position of the operating when operating the machine.

The majority of fatal accidents occurs in mining machines during operation is because of the absence of protective structure on the machine. The preferred strategy to overcome this accidents is to install FOPS (Fall Over Protective Structure) on the mining machines. FOPS in combination with ROPS (Roll over Protective Structure) can prevent all major accidents occurring during mining operation. Strength tests are conducted for checking feasibility of protective structure which uses experimental and numerical method.

Keywords: Operator Safety, Fall over Protective Structure (FOPS), Roll over protective Structure (ROPS)

1. INTRODUCTION

Earth moving machines are subjected to various kinds of loads during operation which results in accidents such as roll overs or hitting by falling objects. The machines equipped with FOPS (Fall Over Protective Structure) prevents the leading cause of work-related deaths in the field. Machines used in construction and mining are subjected to the possibility of roll over on an uneven surface or slope. In such machines the most important function of the protective structure is to protect the operator’s safe space i.e. DLV (Deflection Limiting Volume—a protective space where no part of the cabin or frame should enter). As per ISO 3449:2005 (E) , two levels of performance criteria are specified for impact testing based on machine end use. [1]

a) Level I: protection against the impact of a round test object dropped from a height sufficient to develop an energy of 1365 J.

b) Level II: protection against the impact of a cylindrical test object dropped from a height sufficient to develop an energy of 11600 J.

Level II acceptance is intended for protection from falling trees, rocke and overhead demolition. All types of construction and mining machines fall under category of Level II

Apart from protecting the operator from falling object, the structure of the cabin should transmit the forces connected with machine rollover and absorb a certain amount of energy. Three strength test are generally required in the following order: Lateral load (where the horizontal load is applied in the lateral direction of safety structure), side load (where horizontal load is applied to the upper part of the safety frame), vertical load (where vertical load is applied to the given place of the safety structure in the same plain as the side load). For such extremely challenging condition the designer need to have extensive experience in design. The protective structure must be sufficiently stiff to transmit the lateral force and flexible enough to absorb energy.[2]

Figure 1.1 Working Machine Condition in Mines.

2. LITERATURE REVIEW

Currently protective structures for construction and mining machines are required to provide safety in case of a rollover during engineering work (ROPS – Rollover Protective Structure – ISO 3471, EN 13510:2004) and protect construction machines against falling objects (FOPS – Falling Object Protective Structures – ISO 3449, EN 13627:2002). It specifies the categories of machine for which strength tests are mandatory, the method of testing, particularly method of performing tests for different load, structure and mass of
The term Roll Over Protection Structure (ROPS) defines the system of structural component mounted on the machine which reduced the risk of accidents of the operator in case of machine roll over [2]. In the case of mining machines safety at much higher impact energies than the ones specified by ISO 3449 must be ensured. This is dictated by the operating conditions and the danger of rock slides. Depending on the needs, the cabin may have adjustable height, which facilitates transport and increases the field of view of the machine operator when drilling blast holes. This paper presents the methodology of conducting simulation tests for such units with the application of finite element.

3. DESIGN METHODOLOGY:

3.1 Lateral load carrying capacity and strength analysis of cabin

According to the data of the FOPS report it is important to check lateral load carrying capacity of cabin so that the designed new structure should capable to handle lateral load carrying capacity of cabin if in case of machine tip over too.

3.1.1 Simplified finite element model for lateral load

As the cab and the front part of the main frame with steel plates welded steel, the majority of thin-walled structures, suitable for use shell element finite element model. When simplified geometric model with steel and steel contact surface dimensions of the standard will simplify the plate into the surface, the steel according to the external dimensions reduced to a combination of cross-sectional surface established as follows:

1) Strictly in accordance with the cab and front frame skeleton structure and size, to establish the cab and front frame skeleton Shell Model.

2) The site of the skin is required, only the outer surface of the skeleton is filled between the borders, the equivalent plate, steel plate and spent overlap. This plane can be easily used after plane unit model into the finite element analysis software meshing; statics calculated using the finite element model can be more realistic reflection of the details of each part of the stress cab. Models are used Shell Model.

Requirements of the load index as per ISO 3471: 1994 is given in below

<table>
<thead>
<tr>
<th>ROPS analysis each condition</th>
<th>Load values</th>
<th>Loaded point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum lateral bearing capacity analysis</td>
<td>Uniformly distributed static load $F=151218N$</td>
<td>Distributed in front of the two pillars of the side Beam unit</td>
</tr>
<tr>
<td>Minimum vertical static load carrying capacity analysis</td>
<td>Static load $F=372590N$</td>
<td>Uniformly distributed on the top surface of the cab unit</td>
</tr>
<tr>
<td>Longitudinal analysis of the load carrying capacity</td>
<td>Uniformly distributed static load $F=120974N$</td>
<td>uniformly distributed on the rear beam unit</td>
</tr>
</tbody>
</table>

Table 3.1 ROPS / FOPS Loading Table

Lateral load carrying capacity analysis by finite element model of the lateral load capacity of the front frame of the analysis results. According to the requirements of the international standard ISO3471, first lateral load applied to the ROPS model, load of $F = 151218N$. By the results of deformation and stress distribution resulting lateral load applied to the front frame model as shown.
3.2 Lateral load FEA model of vertical bearing capacity of the front frame

According to international standard ISO3471, after removing the lateral load, vertical load tests. Standard states: "For more than two pillars for lateral load, the vertical load is applied to the position of the center of the vertical load of the role of the cab should not be more than the corresponding lateral load any closer to a column of lateral load." By the results of deformation and stress distribution resulting vertical loads applied to the front frame model. Vertical loads found, the cab vertical displacement of about 35.8mm as shown:

3.3 Longitudinal load FEA of the carrying capacity of vertical front frame model

According to ISO3471: 1994 international standards, after removing the vertical load, longitudinal load test. Uniform load acting on the beams. As shown by applying the results of longitudinal deformation and stress distribution resulting load front frame model maximum deflection of loads found, the cab vertical displacement of about 97.1 mm

### Table 4.1 Lateral Load Defection Summary Table

<table>
<thead>
<tr>
<th>Lateral load Analysis Each Condition</th>
<th>Load Value</th>
<th>Loaded Point</th>
<th>Maximum Deflection Observed</th>
<th>Safe Distance Available</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum lateral bearing capacity analysis</td>
<td>Uniformly distributed static load F=151218 N</td>
<td>Distributed in front of the two pillars of the side beam unit</td>
<td>198 mm</td>
<td>331.3 mm</td>
<td>Safe</td>
</tr>
<tr>
<td>Minimum vertical static load carrying capacity analysis</td>
<td>Static load F=372590 N</td>
<td>Uniformly distributed on the top surface of the cab unit</td>
<td>35.8 mm</td>
<td>209.4 mm</td>
<td>Safe</td>
</tr>
<tr>
<td>Longitudinal analysis of the load carrying capacity</td>
<td>Uniformly distributed static load F=120974 N</td>
<td>Uniformly distributed on the rear beam unit</td>
<td>97.1 mm</td>
<td>328.68 mm</td>
<td>Safe</td>
</tr>
</tbody>
</table>

4. CONCLUSION:

Since there is a risk of roll-over while tramming there is necessary to provide the drill rig with a roll-over protective structure (ROPS). The ROPS structure ensures that the cabin doesn’t collapse over the operator in case of a roll-over. The below table shows the FEA analysis result for later loading condition which is nothing but roll-over simulation in FEA and the figure shows that after FEA analysis the maximum deflection is well below of limiting value, Hence this cabin structure is safe to sustain the roll-over load. hence the designed thickness of structure and wieldable profile/geometry of cabin is safe for both FOPS and lateral load condition.
As the displacement distribution of the cabin is within the limit, the cabin is safe under ISO 3471:1994 ROPS test loading condition.

REFERENCES


★★★