Up-gradation of Rollers in Track of Open Pit Drill Rig

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ABSTRACT

The present project relates to the modification of roller in track frame design. The work will carried out with up gradation and design of roller used in tracked vehicles. The Difficult geological conditions and more intense mining processes taking place today in many building sites lead to a high mechanization level of building works. Because of this, specialized self-propelled Drilling machines are constructed, which enable a sufficient progress in the mining works. Among the machines most frequently used in the mining and building sites, there are those directly used in the preliminary works.

In this project, track tension monitoring methodology will develop so that the track tension can be estimated under various maneuvering tasks. That is, the information of the track tension should be obtained both in real-time and on-line when the proposed methodology will implemented on tracked vehicles. So the need of project is to upgrade the roller for track frame to sustain the increased weight of new upgraded technologies on the machine and by maintaining minimum cost of manufacturing of machine so making it compatible to all surface drilling machines.

Thus to validate the part as per specifications some design modification needs to be done. This project develops the track frame with additional number of roller.

Keywords - *Track Frame, Roller Design, Undercarriage, Crawlers, Drill rig, Mining Equipment.*

I. INTRODUCTION

Surface Drilling Machines are large crawler mounted mining machines which have various component assemblies like boom, Feed assembly, Rotation assembly and Track assembly etc. While working in mines, machine needs to take various position of drilling for making a hole. Hence machine need to move from one hole position to another by tramming. Tramming is the process for moving the machine from one place to another. Drilling is the process of making a hole into a hard surface where the length of the hole is very large compared to the diameter. In the context of mining engineering drilling refers to making holes into a rock mass. Surface mining requires drilling for different purposes that include:

1. Production drilling i.e. for making holes for placement of explosives for blasting. The objective of drilling and blasting is to prepare well-fragmented loose rock amenable to excavation with better productivity from the excavation machinery. The holes drilled for this purpose are defined as blast hole.
2. Exploration drilling for sample collections to estimate the quality and quantity of a mineral reserve. The samples are collected as core and the drilling for such purposes are referred as Core drilling. As diamond bits are used for such drilling, core drilling is often called diamond drilling.
3. Technical drilling during development of a mine for drainage, slope stability and foundation testing purposes.

Opencast mining involves removal of waste rock and subsequent winning of the mineral. In case of deposits underlying hard and compact waste rock called over burden loosening of the rock mass is essential prior to excavation. Thus drilling and blasting is the important ground preparation job. Unless the rock mass is highly weathered and very much unconsolidated drilling of holes for placement of explosives and detonating them for blasting is required for any mining operation. Modern machines like continuous surface miner can however eliminate the need of drilling and blasting in certain surface mining operations. Successful drilling under specific site conditions requires blending many technologies and services into a coherent efficient team, particularly if it is for deep exploration drilling. Blast hole drilling is comparatively simpler. However, to minimize costs and optimize the performance and post drilling operations technical managers and decision managers must understand the language and technology of drilling operations.

The modern hydraulically operated drills have number of advantages over pneumatic drills. These are:

1. The self-contained diesel powered hydraulic percussive drills do not require auxiliary compressor for drill operation.
2. Energy delivered per stroke being higher, hydraulic percussive drills offer higher penetration rate compared to the pneumatic drill.

3. Less noisy
4. Many hydraulic drill claims energy saving as high as 66% than pneumatic drilling. Vertical blast holes are most common. However, to avoid formation of hard toes and to obtain better fragmentation and reduced vibration level inclined blast holes are more useful in many situations. A hard strata occurring at depth in the lower horizon of a high bench is better blasted by horizontal blast holes. However, horizontal drilling is not normally carried out in opencast mining due to the difficulties associated with drilling and charging.

1.1 Problem Statement

Fig -1: Actual wear of roller

The up gradation of roller in existing track is required to maintain the ground pressure as per Drilling Rig safety standard. Existing machine consist of 6 number of roller per track hence total number of roller becomes 12 including both track. As per Company field report analysis there was wear in roller after approx. 300 working of hours of machine. There are several drawback they found during the inspection. Out of draw bags it is suggested to change the roller size including number of Roller pre track system.

Load distribution is not equal in sprocket mechanism of track vehicle due to less number of rollers. Hence more chances of failure due to uneven loads. More wear and tear of rollers. Less life of roller. The purpose of up gradation of roller for track frame was to overcome the failure problem at various worst load conditions and to develop a universal track assembly that would sustain the maximum weight with higher capacity.
So the need of project is to upgrade the roller for track frame to sustain the increased weight of new upgraded technologies on the machine. And by maintaining minimum cost of manufacturing of machine so making it compatible to all surface drilling machine. Thus to validate the part as per specifications some design modification needs to be done.

1.2 Objective

The main objective of this thesis is to develop a systematic approach to apply computer aided design and analysis during early design stages to improve product quality from manufacturing point of view.
This research provides the groundwork for the development of a design-analysis tool that allows the designers to build manufacturability into a design through analysis of its cross section. We upgrade the rollers in such a way that, equal load distribution is occurs in sprocket mechanism. By using the upgrade rollers we reduce the wear and tear of rollers. Also increase roller life. Load carrying capacity is increased.

1.3 Expected Outcomes

- Cost effective solution for the highly under stressed Track
- Track frame design to sustain the load without fracture and wear at its extreme downward position of drilling.

1.4 Methodology

To find the solution for identified problem, we will go through the steps given as below.
- Theoretical calculation over roller
- Selection of roller based on calculation
- Creation of 3D model and drawing using Pro Engineer software
- Verification of proposed design by FEA analysis using analysis software ANSYS.
- Correction of Design Model on the basis of FEA Analysis.
- Updating and Release the Drawing for Fabrication.
- Fabrication of Model & Radiography for Fabricated Track frame.
- Assembly of roller and track on machine.
- Test and validation of actual component on site.

2 LOAD CASES AND CALCULATION

2.1 Introduction to various load cases

This report describes a few load cases for surface drill rigs. It is specifically targeted for dimensioning of crawler tracks, the load cases can be static loads, i.e. maximum loads that should occur at most a few times during the drill rigs entire lifetime. When they occur fluently, they should be considered fatigue loads and treated accordingly. Fatigue loads can be seen as a slowly progressing wear down because of every day usage, it¡¦s associated with initiation and also propagation of cracks.

Lifetime: The normal drill rig lifetime should be 8 years at average two-shift usage, i.e. 8 years, 220 days/year and 16 hours/day. This amounts to 28,000 hours of operating time.

Usage: A drill rig performs different tasks. The following time distribution is to be assumed:

- 60% hole drilling
- 25% positioning of boom system
- 10% tramming with boom system in drill position
- 5% tramming with boom system in stress-relieving support

In this report fatigue loads are specified as a certain number of loads cycles at an equivalent size of a constant amplitude load. Their combination, however, represents a constant amplitude load with the same damage, according to the Palmgren-Miners rule, as a field measurement would result in when scaled to the usage specified above. Scaling between load levels has been made assuming a Wohler curve with slope three, i.e.

$F_1^3 N_1 = F_2^3 N_3 =$ constant _ _ _ _ _ _ _ _ _ _ (1)

It is thought to represent the damage to notched components, particularly welds.

The approximate mass of the drill rig was m=15500 kg and its moment of inertia towards rotation sideways was estimated to be about $J_{cg}=60{,}000 kgm^2$. Note that figures given may represent smaller drill rigs and usage in severe terrain poorly.

2.2 Static load case

One of the tracks is prevented from moving relative to the ground while the other track pulls at maximum traction force, Ft. The non-moving track is subjected to a bending moment Ms and the shear force Ft at the shaft and the force couple R1 & R2 form a couple at shaft of mainframe from the ground.

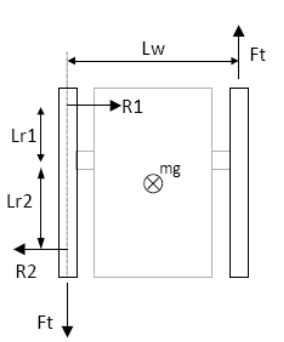

Fig -2: Static Load Case

The bending moment on the shaft pivot (at the side of the locked track) becomes

$M_1 = F_1 L_w =$ (52000X2.4) =124800Nm_ _ _ _ _ _ _ (2)

(Gear box torque=15490Nm, sprocket R=0.3m hence Ft=52000N)

The size of the force couple becomes

$R1 = \frac{F_1 L_w}{L_{r1}}$ = 124800/1.25 =99840N_ _ _ _ _ _ _ _ _ (3)

$R2 = \frac{F_1 L_w}{L_{r2}}$ = 124800/1.325=94188.6N _ _ _ _ _ _ _ (4)

Contact surface area of idler for R_1 reaction is

$Ai = 15127.535 mm^2$ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ (5)

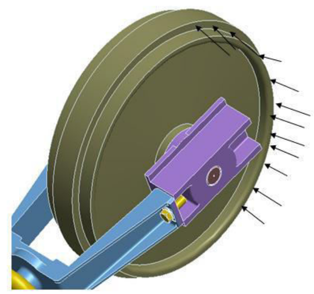

Fig -3: Contact Surface

3 FEA

3.1 Pre-processing-setup

1. Export Geometry to ANSYS Workbench

After creation of simulation surfaces over all concerned regions the geometry is exported in ANSYS Workbench 11. Pro-Engineer 4.0 have an added advantage of having interface with Ansys 11 and above versions. It is always desirable to keep the units of all components same while it is to be appropriately imported in Ansys.

2. Geometry Settings and Drag Desired Analysis System (Structural)

The Ansys window opens with the geometry content. It is desired to make the proper settings of geometry. Whereas on the main screen add the desired analysis system, in this project Static Structural analysis was done.

3. Assign material properties

The engineering data should be specified. In this step the engineering materials and their parameters like density, Poisson's ratio and other important properties are added. All the materials that are associated with geometry should be specified as this act as library for material selection in analysis.

4. Assign Connections on contact surfaces

When a model is imported into Workbench Mechanical, the default setting of the application automatically detects instances where two bodies are in contact and generates corresponding contact region objects in the tree outline.

5. Contact Tool
The contact tool allows you to examine contact conditions on an assembly both before loading, and as part of the final solution to verify the transfer of loads (forces and moments) across the various contact regions.
6. Applying boundary condition
Total assembly load is used for determining principle stress in FEA analysis. Analysis is done for the three cases of drill guide.
Traveling speed: 0 to 3 km/h
Max climbing slope angle: 25°.
Max gearbox output torque: 15490 N-m.
FOS used, for fatigue loads is: 1.3
For other loads is: 1.5
Mechanical properties: SAE1541
Yield strength σ_S : 520 MPa,
Tensile Strength σ_b : 360-460 Mpa,
Elastic modulus E : 210 Gpa
Poisson's ratio: 0.3

3.2 FEA Results

Pre-processing of model was carried out and processing was done in ANSYS

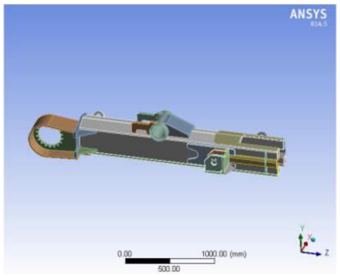

Fig -4: Static Structural Diagram of Frame

Table -1: Load Cases for FEA

Sr. No	Load at Center Support	Load at Outer Hinges			
	Load (N) Downward	Angle	Load	Horizontal (N)	Vertical (N)
1	75500	0	0	0	0
2	75500	41	203.53	153606	133528
3	75500	41	-152.7	-115274	-100206

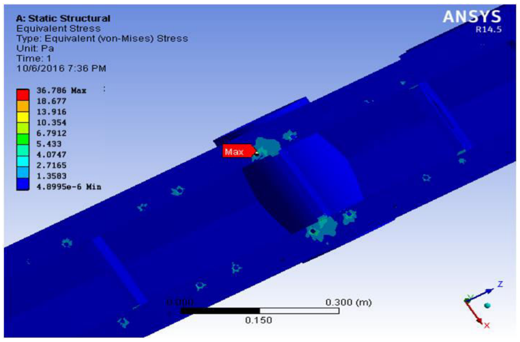

Fig -5: Stress Plot for Load Case 1

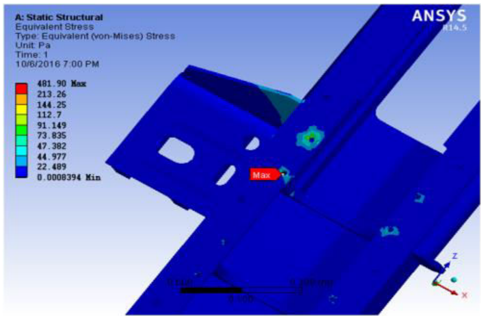

Fig -6: Stress Plot for Load Case 2

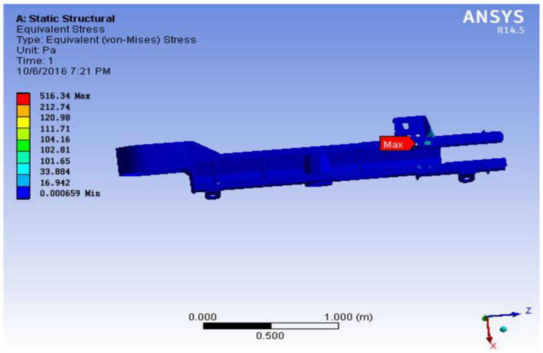

Fig -7: Stress Plot for Load Case 3

4 EXPERIMENTAL VALIDATION

FE analysis on base model was carried out as explained earlier. To check resemblance of simulation result strain gauge test was performed on base model. Test for Track frame and Roller as follows.
The Track was design under static loading condition and it was tested under actual loading condition. This report will describe the performed measurements and the measurement technique used during the stress and strain measurements of the Track frame on the Rock drills. The aim of the measurements was to provide the stress levels and dynamic behaviour of the Track frame system for Drill rig in order to provide data for a FEM model check.

The measurements were performed at the test area near by Nashik. All the different measurements and the measurement configurations are showed in Appendix. The measurements were made with four different types of measurement probes:

- Strain gauges for direct stress and strain measurements in the frame
- Dynamic pressure transducers in all major hydraulic cylinders in order to calculate the forces action on the track frame
- Wire transducers for measurement of the position of the different moving parts during the operation
- Accelerometers for measurement of vibrations action of the different parts and calculation of inertia forces.

The rig was operated in well-defined ways, called time sequences, in order to be representative to all expected situations for a rig on a customer site. This means the rig was operated in drilling, positioning and several tramming tramming i.e. on varying ground conditions and with the boom and feed in different positions.

5 RESULT

By combining FEA result with theoretical analysis we have got and it compared with test results. Compares Results are tabulated as follows.

Table -2: Analytical, FEA and Test Result Comparison for Base Model

Parameter	Analytical Result (Mpa)	FEA Test Result (Mpa)	Strain Gauge Test Result (Mpa)
Case I	36.55	36.786	35.88
Case II	476.87	481.90	480.12
Case III	512.15	516.34	514.12

6 CONCLUSIONS

At the end of extensive literature survey and FEM analysis and testing the following conclusions have been reached.

1. Study of the existing rollers and its failures in static analysis was the most important step to begin the new design
2. Modification of the design by increasing no of rollers from 6 to 7 satisfies the objective of even load distribution
3. Finite Element Analysis of modified track gives the behaviour of material or part on application of load.
4. Analytical solution with aid of FEA result matches well within a range of testing results
5. It is observed that the total stress induced in the track is less than the permissible yield stress of the material for static load conditions, that is equivalent (Von-Mises) Stress Maximum in vicinity of pin is 36.55 Mpa which is less than the permissible yield stress of track material 520 Mpa, which shows that our design is safe by considering distortion energy (Von-Mises) theory.
6. Similarly for other two load conditions the maximum stress are 476.87 Mpa and 512.15 Mpa which are less than the permissible yield stress 520 Mpa
7. Higher value of stress was a prime reason for failure of base model

The track and rollers designed in this work shall be useful as a standard assembly for all rig and would ease maintenance. Cost of manufacture of the basic machines is expected to be lowered.

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