

DESIGN & MODIFICATION OF ROLLERS IN TRACKS OF SURFACE DRILLING MACHINES

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ABSTRACT

Surface Drilling Machines are large crawler mounted mining machines which have various component assemblies like boom, Feed assembly and rotation assembly, 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 trammig operation. Trammig is the process for moving the machine from one place to another. Roller wheels mounted to the crawler frame to transfer machine weight to the track. The wheels, acting as contact points, help distribute machine weight evenly across the ground through the track. Roller wheels also help in guiding the track. Roller wheels are a wear item and need to be replaced periodically or after wear. Currently weight of rig is: 15.5 ton. According to report and their pre study it is required to take some improvement action on crawler.

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 trammig. Trammig 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.

PROBLEM IDENTIFICATION

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 Nos of roller per track Hence total No. of roller becomes 12 nos including both track. As per Atlas Copco field report analysis there was wear in roller after few 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 Nos 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 machines. Thus to validate the part as per specifications some design modification needs to be done.

INTRODUCTION TO UNDERCARRIAGE AND ROLLER

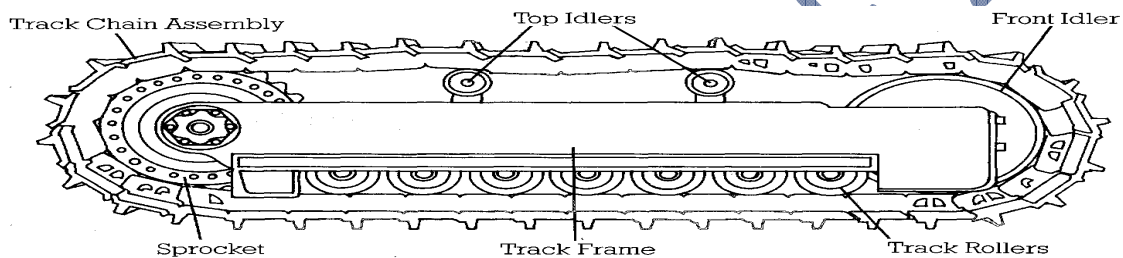


Fig 1 Roller part

UNDERCARRIAGE ASSEMBLY-The total undercarriage assembly of a dresser crawler is made up of components that transfer tractive effort from the tractor to create forward or reverse motion. Front Idler-It is basically used for making chain in tension. A large wheel at the front of the track frame that guides the track chain and absorbs shock loads. It is adjustable for proper track chain tension.

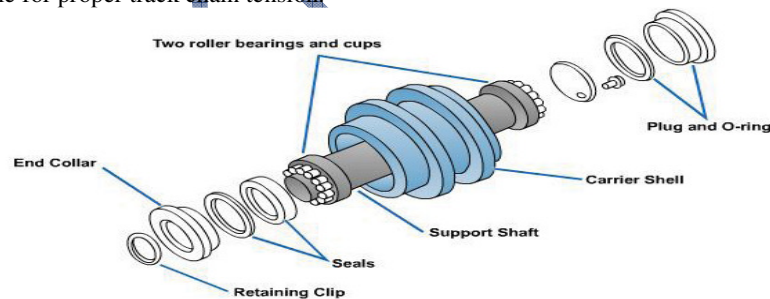
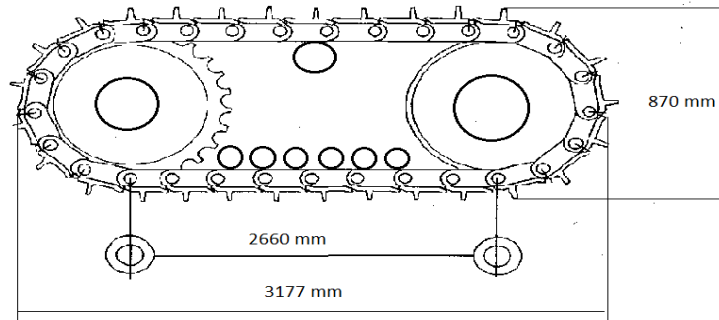


Fig 2 Undercarriage Assembly

- Roller wheels mounted to the crawler frame to transfer machine weight to the track. The wheels, acting as contact points, help distribute machine weight evenly across the ground through the track. Roller wheels also help guide the track. Roller wheels are constructed of a high-density plastic core with rubber bonded to the circumference. The rubber acts as a cushion. Roller wheels are wear item and need to be replaced periodically.
- the three key functions of undercarriage roller wheels are:
 1. Distribute weight of machine from the frame to the track.
 2. Guide the track.
 3. Provide a cushion between the tracks

EXISTING TRACKFRAME AND ROLLER



PRELIMINARY CHANGES SUGGESTED:

- Increase no. of roller from 6 nos to 7 nos.
- Increase the diameter of roller according to size available in market and feasible to machine.
- Modify the track frame accordingly.
- Increase in roller size will also help to improve the ground clearance of machine.

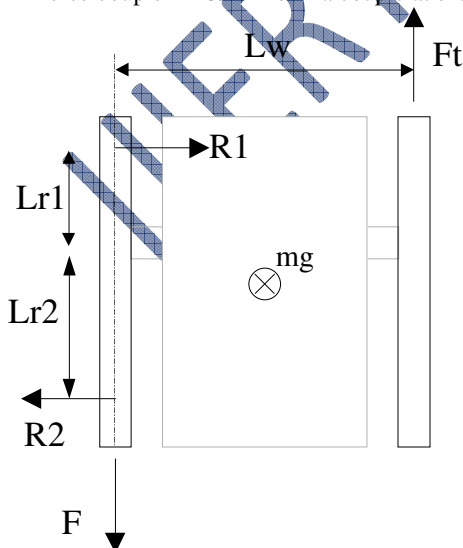
METHODOLOGY

- 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.

THEORETICAL CALCULATION

STATIC LOAD CASE

One of the tracks is prevented from moving relative to the ground while the other track pulls at maximum traction force, F_t . The non-moving track is subjected to a bending moment M_s and the shear force F_t at the shaft and the force couple R_1 & R_2 form a couple at shaft of mainframe from the ground.



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

$$M_s = F_t L_w = (52000 \times 2.4) = 124800 \text{ Nm} \quad \text{----- (gear box torque} = 15490 \text{ Nm, sprocket } R = 0.3 \text{ m hence } F_t = 52000 \text{ N)}$$

The size of the force couple becomes

$$R1 = \frac{F_t L_w}{L_{r1}} = 124800 / 1.25 = 99840 \text{ N}$$

$$R2 = \frac{F_t L_w}{L_{r2}} = 124800 / 1.325 = 94188.6 \text{ N}$$

Contact surface area of idler for R1 reaction is – Ai = 15127.535 mm².

And same time 1st three rollers will may have contact with track chain, then total surface area of roller contact is – Ar = 2550 mm²

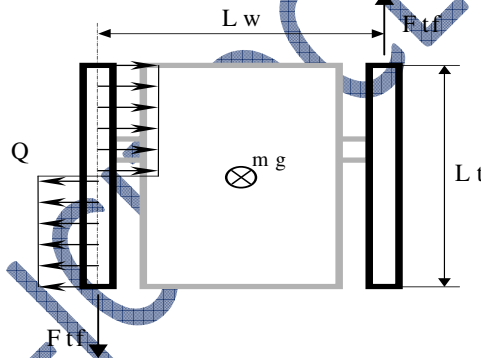
$$\sigma_b = \frac{R1 \frac{L_r}{2}}{W_b} = \frac{F_t L_w}{A_{total}} \quad \text{and} \quad \tau = \frac{R}{A} = \frac{F_t L_w}{A L_r}$$

$$= 99840 / 17677.5 = 5.64 \text{ N/mm}^2 = 0.564 \text{ kg/mm}^2.$$

Material is SAE 1541, Yield stress value is 520 Mpa = 520 N/mm².

FATIGUE LOAD CASE ON SHAFT AND ROLLER.

In this case the non-moving track is not locked to the ground. Instead the track is assumed to rotate relative to ground with friction forces developed. The maximum traction force available may not be needed to overcome friction.



The normal force acting on each track equals half of the rig total weight

$$N = \frac{mg}{2} = (15500 \times 9.81) / 2 = 76027.5 \text{ N}$$

Distributed friction force amplitude under the sliding track

$$Q = \mu \frac{N}{L_t} = (0.5 \times 76027.5) / 3 = 12671.25 \text{ N/m}$$

Required moment on the track shaft pivot to overcome friction forces

$$M_s = 2 \int_0^{L_t/2} l \cdot Q \cdot dl = 2 \cdot \int_0^{L_t/2} \mu \frac{N}{L_t} \cdot l \cdot dl = \frac{\mu N L_t}{4} = \frac{\mu m g L_t}{8} = (0.5 \times 15500 \times 9.81 \times 3) / 8 = 28510.3 \text{ Nm}$$

Design moment range, when drill rig moves back and forth

$$M_r = \pm F_{tf} L_w = 2 F_{tf} L_w = 2 \cdot M_s = \frac{\mu m g L_t}{4} = (0.5 \times 15500 \times 9.81 \times 3) / 4 = 57020.62 \text{ Nm}$$

Note that Ftf (traction force needed to overcome friction moment) can be smaller than Ft (maximum traction force) if the friction under the sliding track is sufficiently low:

Design shear force that acts on shaft pivot together with torque above

$$F_r = \pm F_{tf} = 2 F_{tf} = 52000 \times 2 = 104000 \text{ N}$$

The friction coefficient is difficult to estimate theoretically, the highest bending moments on the track pivot axle, about 57kNm. When the complete load spectrum from all kind of usage is normalised to a constant amplitude load at

1,000,000 load cycles, an equivalent bending moment range of 28.5kNm is obtained. With rig mass 15,500kg, track length 2.4m and a safety factor of 1.5 on the measured results, the following equivalent friction coefficient is obtained

$$1.5 \cdot 28.5 \cdot 10^3 = \frac{\mu \cdot 15.5 \cdot 10^3 \cdot 9.8 \cdot 2.4}{4} \Rightarrow \mu_{\text{equivalent}} = 0.49 @ 10^6 \text{ load cycles}$$

We have Distributed friction force amplitude under the sliding track is $Q=12671.25 \text{ N/m}$

Assuming track frame structure is rigid body, Hence all force will transmit to idler wheel, sprocket & roller of one track during turning.

Total area = idler wheel contact area+ all roller chain contact area+ sprocket contact area.

$$= 15127.535\text{mm}^2 + 5100 \text{ mm}^2 + 10215.8\text{mm}^2 \\ = 30443.335\text{mm}^2$$

Considering force generated by both track during turning in opposite side (force generated by gear box) =

$$104000\text{N}$$

$$\text{Stress} = 104000/30443.335$$

$$= 3.46 \text{ N/mm}^2$$

Material of roller is SAE 1541, Yield stress value is 520 Mpa= 520 N/mm².

Hence roller, idler is safe under turning.

CONCLUSION

- Cost effective solution for the highly under stressed Track
- Solutions for the Weakest part of the machine which must be very strong
- Trac frame design & selection of roller to sustain the load without fracture and wear at its extreme downward position of drilling.
- Newly design track will also be applicable for the machine which will going to use for 6" drilling Hole Applications.

NOMENCLATURE

m	Total mass of the drill rig	[kg]
g	Gravity constant 9.8	[m/s ²]
Lw	Width between tracks	[m]
Lt	Track length	[m]
Ft	Maximum traction force of one track	[N]
Ftf	Needed traction force for fatigue load	[N]
μ	Coefficient of friction	[-]
N	Normal force on one track	[N]

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