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Safety Preservation and Reliability Enhancement of 3M By Applying Varied Friction Methodology

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Abstract
A general trend shows that while purchasing equipment or a machine and using them it is taken as sacrosanct that the parts / assembly or the mechanism installed are free from any defect and no improvement is required there in. However it's not true always and now a days this has been taken up with at most concern to raise a pertinent question whether this is the optimum output from the component/assemblies fitted and being used.
Present paper is based on the above subject and deals with one of the assemblies fitted on a heavy earth moving machinery known as Walking Dragline (Ransome and Rapier, made in UK) operating in Jayant OCM one of the biggest coal mines in Asia. The component placed on the Boom structure of the machinery in question was a fixed one and subjected to static friction because of coming into contact with heavy duty steel wire ropes (2 numbers) in moving conditions. The impact of the wire ropes on the component was so heavy that it was taking only a few months to get the static wooden log worn out resulting into heavy loss to both the components on one hand, crores of rupees of revenue loss in production in addition to very high safety hazard because of their fitment/replacement at a height of 40 meters from the ground to which lifting by even general duty crane was not possible, thus to be handled by manually at times
Giving a serious thought to the problem and considering a possible solution that can't the existing component fitted originally with the boom structure of the machine subjected to the static friction be replaced by a rolling friction component? With a positive answer to this problem the proposed adopted methodology undergoes two steps: first removal of the component that is wooden log under the static friction and second design, fabrication and installation of two no. of rollers to withstand the impact of heavy duty steel wire ropes. The comparison between the proposed and existing was carried out on various parameters such as cost, maintenance friendliness, safety and reliability concerned with 3M i.e. man, machine & material.

Keywords—Walking Dragline Machine, Wooden Log, rollers, steel wire, ropes, friction, 3M- Man, Machine and Material.

I. Introduction

Research Object Walking Dragline Machine - The present research work is connected with a machine used in Jayant open cast coalmine under Northern Coalfields Limited, Singrauli (M.P.), a subsidiary of Coal India Limited. The heavy earth moving machine known as walking Dragline is used for extracting over burden above the coal seam. It has got three major operations to be performed for the excavation Job viz. Drag, hoist and swing. Drag and hoist operations are controlled and monitored by fastening the large sized bucket (24 m^3) with 2 No, drag and 2 No.hoist ropes. In case of hoist,the major part of the movement of hoist ropes is above the boom, (a robust steel structure to guide and balance the laden buckets weighing approximately 80 metric tones).of 96 meters length. With the machine originally there has been provided one no.large size of 10' x 10" x 10" wooden sleeper to guide and safeguard the costly steel structure (known as Mast,a part of Boom) and enhance the longevity of the hoist rope. The wooden sleeper originally designed by the designer of machine in general and the hoist trajectory in particular might have been meant to safeguard the steel structure (Mast) on one hand, not to allow fast wear of the hoist rope on the other. In addition to that the inclusion of wooden log (Sleeper) in trajectory was also meant to stop premature failure of hoist rope. But in actual practice it did not yield so, because of the line contact of ropes (2 No's) with the sleeper. Fast wear of the ropes started cropping up and both the hoist ropes started failing prematurely at working of around 1400 hours, in place of 2000 hours. Because of very fast wear of the wooden sleeper, it started demanding change very frequently. The system of lifting the heavy sleeper to the height of 40 meters was another cumbersome process in case of non-functioning of the lone lifting crane with telescopic boom available with OCM.

II. Problem Formulation

W-2000 model walking dragline excavator is working in JAYANT OCM of Northern coal fields

Limited under COAL INDIA LIMITED, for extracting over burden above the coal seam.

The component used as friction bearing part in form of static friction in combination with rolling friction, is put into the system to reduce the wear on one hand, to make the operation more maintenance friendly, conducive to working crew and eliminate safety hazards on the other. "Wooden Log" being the cheapest component to withstand wearing thrust is used on the structure but its demerits being observed in form of frequent changes required as because of the other mating part of steel wire rope, made of steel of very hard material. In addition to this the fitment of the static friction component being heavier and almost to be unconquered manually in lifting and thereafter fitment at a height of around 40m (120') with minimum 4 (four) replacements manually was a serious threat and posing magnified problems for the survival of the function in case of unavailability of lifting machinery. Thirdly, it was not giving a desired life of costly hoist ropes. To overcome all these problems of unreliability of the system in case of excess wear amounting to the damage of vulnerable structure of the machine, 2 no alloy steels rollers with requisite dimension was thought to be put into at the place of wooden log as replacement i.e. static friction component getting replaced by rolling friction component was proposed to be designed, fabricated and installed. This resulted into huge saving on one hand, eliminated safety hazards completely and enhanced reliability of all three i.e. men, machine and material together.

III. Methodology

- Study the function of Walking Dragline.
- Identify the drawback / problem in present working condition.
- Alternative approach for increasing performance.
- After applying alternative approach identify the material or component.
- Study the performance under new component.
- Effect of new component on safety preservation, economy and reliability enhancement.

3.1 **Study the function of Walking Dragline.**

The basic function of machine known as Walking Dragline Excavator used in an open cast mine of Coal India Limited is removal of over burden material above coal seam with the help of three main operations namely Drag, Hoist and swing. Whereas all the three operations are controlled electrically using generators, motors giving power to driving mechanisms through gear-boxes, in case of drag & hoist, the final power transmission is meant for dragging and hoisting of the large sized bucket with the help of rope-drums fastening the drag or hoist ropes on them. In case of hoist, the ropes (2 No.) of 64mm size were running above the vulnerable steel structure known as Mast(a part of Boom). To prevent this vulnerable steel structure from damage on account of impact of the hoist ropes, There had been provided one no. big wooden log of size 10′×10″×10″ at a height of 40metersfrom the ground on the mast.

3.2 Identify the drawback / problem performing in present working condition.

The machine although being full proof, robust and maintenance-friendly, the problem cropped up in replacing the big-sized heavy wooden log installed in the hoist trajectory on the mast at a height of 40meters from the ground. To change the wooden log at so much height in case of unavailability of lifting machinery i.e. crane to that much capacity (as regard to the lifting) either because of its breakdown or otherwise, was a serious problem; and this situation is being faced by maintenance crew every three months during which the wooden log under the impact of steel wire rope would get worn out beyond permissible limit and require replacement which if not done, the steel structure would get damaged to any extent putting the costly machine to a grinding halt for any amount of time. In addition to this, not getting desired life of hoist rope is one of the major drawback.

3.3 Alternate approach for increasing performance

The machine is scheduled to be stopped for 10000 hourly maintenance on every two year basis as per manufacturer's guidelines. During this time the steel structure i.e. mast and boom are scheduled to be brought down to the ground, so searching out or availability of a lifting machinery or a crane will not be required at all for placing any component in place of wooden log, a static friction component. With the idea of rolling friction component in place of static friction component, it was considered to be a full proof alternative of this problem full of safety hazards of all three 3m's i.e. man, machine and materials on one hand and eliminate unreliable state of affairs during breakdown (worn out static friction component). The only thing is to be matched the life of rolling friction component with 10,000 hourly maintenance of the machine.

3.4 After identifying alternative approach identification of the material or component.

The change of methodology from static friction to rolling friction to limit the wear pattern to enhance the life from three months to two years, rollers (2 Nos.) of alloy steel materials was considered as suitable alternative. Also, 2 Nos. rollers in place of one no. wooden log was thought to be more practical because of maintenance easiness specially with regards to its handling.

3.5 Study the performance under new material / component.

The performance of new component in form of 2 No rollers in place of one No. Wooden log was studied and found that this change has performed better on many counts:-

i) There is no safety hazards involved during the lifting of rollers to that unaccesible height manually in case of unavailabilty of lifting machineryas lifting machinery is not required at all because of of boom & mast being on ground during 10000 hourly maintenance.
ii) Avoidance of unwarranted stoppages of productive machine every three months.
iii) Enhancement of the life of costly steel wire ropes(2 no.)from 1400 working hours to 2200 working hours.
iv) Motivation to the working crew .

3.6 Effect of new material used on safety preservation, economy and reliability enhancement

Effect of new component in place of the existing one i.e. replacement of static friction component wooden log by rolling friction component. Steel rollers has been found manifold which summarily is being produced here under three main heads:

i) Safety Preservation
ii) Economy / Techno-economics
iii) Reliability Enhancement.

3.6.1 Safety Preservation

Fitment of Wooden Log and its replacement incase of getting it worn out and unusable after three months was whereas full of risks and safety hazards because of lifting at a height of 40mtr (Approx.120') manually and fitting thereafter, in case of the new component i .e. steel rollers(2 no.), this aspect was completely controlled, as during their replacement after wear-out, the vulnerable steel structures i.e. boom & mast are already in lowered position as per the maintenance schedule of the machine. (Every 10000 hourly maintenance boom and mast are required to be lowered for their thorough checkup).In addition to the safety hazards of the workmen, the safety of material steel rollers along with Boom structure and machine i.e. walking dragline excavator had also been fully taken care of; Because had the wooden log not replaced periodically during need, it not only wears out the wooden log alone, it would damage the structure and machine as a whole .

3.6.2 Economy / Techno-economics

Although the initial first time cost of the wooden log would be much less with comparision to steel rollers, however if it is viewed in totality, steel rollers in place of wooden log has not only been much more economical rather it has given a saving of more than rupees fifty five Lakhs on a year basis in totality on account of the following:-

(i) There is no Production loss during the replacement of worn out steel rollers by new ones because the machine is otherwise also stopped for scheduled maintenance.
(ii) The effect of steel rollers (A rolling friction Component) was found in form of an appreciable increase in the working hours of steel wire ropes to the tune of 160% (1.6 times). The steel wire ropes which were giving an average life of 1400 working hours during the fitment of wooden log shot up to 2200 working hours. Steel wire ropes(2Nos) of very specific application costing enormous was also saved a lot..

3.6.3 Reliability Enhancement.

The effect of new component had been in the area of reliability as well. By using the wooden log on the mast, a part of boom, whereas the system of operation as a whole was unreliable because of uncertain wear pattern of the component subjected to static friction. The contact because of impact being in line, the rubbing effect was much more with comparision to the steel rollers as the contact to the steel rollers in this case is a point only, that too for a very less time during the impact. Also once the component gets cracked, sheared or worn out, this would make the machine as whole unreliable which was taken due care by application of steel rollers.

IV. Result

A Comparative details has been shown here under on all three parameters discussed [1, 2]:-

S No.	Parameters	Application of wooden log	Application of steel rollers
1.	Cost of items	Rs.9000	Rs. 13,000
2	Annual cost of hoist ropes	Rs 9 x 259 x 160 = Rs.372960 (rounded)	Rs 6.5 x 259 x 160 = Rs. 269360
3.	Down time cost because of changing hoist ropes per annum	Rs 4.5 x 5 x 25000 = Rs.5,62,500	Rs 3.5 x 5 x 25000 = Rs.4,06,250
4.	Down time cost because changing sleepers per annum	Rs 6 x 12 x 25000 = Rs. 18,00000	8 x 25000 = Rs. Rs. 2,00,000
5.	total cost	Rs. 2,7,44,460	Rs. 8,88,6610

6	Net Saving / Dragline	NIL	+ Rs 18,55,500
7.	Net Saving for 3 No Dragline of the project	NIL	+ Rs 55,50,000
8	Safety	Fully unsafe method in case of unavailability of required capacity lifting device	100 % safe practice as rollers are changed while structured on the ground.
9	Maintenance -Friendliness	Partial	Full
10	Reliability	Not Reliable	Fully Reliable

Table 1

The Proposed work has already been executed by the Author1 in Walking Dragline (W 2000 Model) operated at Jayant Open Cast Mines Northern Coal fields Limited Singraulli (M.P.).

V. Conclusion and Discussion.

Friction may it be static or rolling has always been an important topic of research in the field of Mechanical Engineering, be it a manufacturing industry, mine, steel, fertilizer, oil or the process industries. The industry may be any type, it is most widely accepted of applying rolling friction technique over static friction technique.

However this technique is not very well suited to be implemented to such operations, where static state has to be kept alive to make the system alive e.g. railway track and running of locomotives over that cannot be thought of switching over from static to rolling one. In a nutshell the methodology although being profit-making because of less wear and more life of the components in use cannot be adopted abruptly without going into pros and cons in the totality.

The proposed method already had been tested on different alike machine's and by comparing both i.e. Original system fitted with the machine and system proposed on the basis of various parameters, It is concluded that the proposed methodology /technique works better, trouble free, profitable, with total safety preservation.

The result generated as shown in table 1 shows that by using the proposed system in one machine has brought the saving to the tune of Rs 18.5 lakhs which is certainly a huge amount from any consideration.

VI.Future Scope of Work

Rollers whereas designed such that match with the lowering of the boom on every two year basis but there is ample scope of enhancing the life span of steel wire rope than whatever achieved presently from the proposed technique adopted.

There may be also a possibility of providing intermediate sheave(pulley) in the trajectory of hoist, at the place of roller anchoring as this may eliminate the loss / wear on account on impact.

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