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Design & Analysis of Puller Cum Pusher with Two Drives for 25 ton Pulling Capacity

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ABSTRACT

Now a days Thermal Power Plant are built in the Capacity range of 100MW or even larger Capacities. These plants are located at sites where the fuel transportation facilities either by rail or ship are available.These plants are used basically as base load plants. Coal is brought by railway Wagons. The equipment's used are car shakes, rotary car dumpers for unloading from closed wagons, cranes, grab buckets and accelerators. After preparation of coal, it is transferred from the site of preparation of coal to dead storage by means of various equipment's like belt conveyors, screw conveyors, grab bucket conveyors, bucket elevators. Objective is to carry out analysis and to get the maximum stresses and deformation in individual components like connecting arm Between Puller- Pusher & Wagon, Guide Wheel, Runner Wheel and reactions at runner wheels. This equipment is used in wagon unloading area in conjunction with transfer platform, wagon tippler & side arm charger. All these equipment's operate in co-relation with each other to perform 25 cycles per hour. i.e to unload 25 wagons per hour. Once wagon is unloaded with help of Wagon tippler & side arm charger, puller cum pusher pulls this wagon on transfer car. Transfer car changes its position from one rail track to another parallel rail track & stop.Puller cum pusher pushes the empty wagon out of the transfer platform. While pushing empty wagon, puller cum pusher also has to push already emptied wagons which are there at outhaul side of transfer platform. This cycle of operation repeats till complete rake of 59 wagons are unloaded & empty wagons are transferred to parallel track. To push out 59 loaded wagons & to operate to perform 25 cycles per hour, puller cum pusher needs 25 Ton pull.

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I. INTRODUCTION

In order to accelerate the pace of development,the infrastructure industries of the economy, consisting mainly of steel plants, ports, mining, power generating units etc,large sums of investment are required. The power sector, especially the thermal power sector needs to add capacity and increase efficiency to meet the development need to economy. The full rake of 58 wagons shall be brought in by locomotive andstopped with the first wagon within range of the Side ArmCharger. The locomotive is then taken away. The charger shallbe driven towards the first wagon, its arm is lowered and it iscoupled to the first wagon of the rake. The charger then haulsthe rake forward by one wagon length and stopped.Here the first wagon is decoupled from the rake manually. Thecharger then propels the first wagon on to the tippler tablecentrally and then automatically decouples and clears off thetippler. Now the wagon tippler is ready for operation. In themeanwhile, the side arm charger is moves back to initialposition for next cycle.

In next cycle, the rake is drawn up by theone wagon length, and the previously tippled wagon is ejected Simultaneously. After tippling of the last wagon, thecharger is used under manual control to eject the last wagonfrom the tippler, if the next wagon is not already in position.The Side Arm Charger is run on a separate pair of rails whichruns parallel to wagon tippler rail. Approximate travel length ofthe charger is 33M. Side Arm Charger movement on rail isactuated by the rack & pinion arrangement. Three numbers ofdriving pinions are mounted on output shaft of planetary gearbox coupled with hydraulic motor or directly coupled withhydraulic motor. The hydraulic motor is driven from hydraulicpressure and flow generated from a power pack positioned atoperator cabin. Side Arm Charger is a marshaling device to position the loadedwagon centrally on tippler platform one by one for unloadingoperation by wagon tippler. Side Arm Charger is a rail mountedmachine used to pull the loaded wagons along with the rake &push out the empty wagon from the tippler platform after tippling.

Large quantities of coal are required in the thermal power plants. Most of this coal is delivered to the power plants by railway wagons,which need to be emptied with speed and efficiency and then send out of the power plant as rakes. This is not only challenge that power plants face while managing the movement of wagons. A normal coal size rake is about 700 metres long and consists of 58 wagons.This means that a similar length of space is required to re-form the rakes on the out-haul side, once the wagons have been emptied at the wagon tippling station.

I. LITERATURE SURVEY

[1] The wagon Puller Cum Pusher helps in improving the efficiency of the power plant by reducing the cycle time of the process of emptying the wagons and saves the hassle of acquiring land, which has to be about one kilometer long so that the rakes can be re-formed on the out –haul side.

TSCHADE has over 130 years of experience in the mining industryaltogether. Over the last 60 years, the company has specializedin the design and development of chain scraper type reclaimersfor power plants, mining and minerals, coal preparation plants,bulk terminals as well as steel works and cement plants. [2]Withover 600 references worldwide including notable recentsuccesses in China and Australia delivering ground-breakingstate-of-the-art equipment to consumer and supplier, SCHADEremains a major player in the bulk handling market.

The layout of the rail tracks shall be such that the track will be straight and horizontal for one rake length on the inhaul side and also on the outhaul side. [3] In case it is not possibleto have straight length to accommodate one full rake on either side, at least about 250m on either sides of the track shall be made straight and the balance could be on asmooth curve. It would be preferable to provide Merry Go Round (MGR) system of railtrack so that the rake can enter the plant in one direction and go out of the plant withoutany need of disconnecting the loco from the rake. Earlier works dealing with demurrage have tended to focus on the development of astrategic model for a freight railway system operating in a given region. Chelstet al.[4] discuss a finite queuing system that can be used to model the coal unloading process. Inthis case, the model describes the relationship between the number of trains, queuethroughput and queuing delays. In this case the queuing system built was a modifiedversion of a standard single and multiple finite source queuing model, which allowed forserver breakdowns.

With the release of coal blocks by the Government of india to the private sector and the public sector enterprise, Coal India, the future of thermal power generation is very bright. Many companies are adding new capacities by expanding their existing sites or by setting up new generation capacities in Greenfield locations.[1] However land availability for power plants or any industrial application is not only becoming difficult, but also becoming very expensive in the country – land price has gone up by 3-4 times in the last 5 years. In this situation, it is very essential for all power generation companies to plan their plant with minimum land requirement. [5] Typically, if the plant is unidirectional movement of the coal rakes, the additional land requirement is to the tune of 50 m x 800 m.A wagon puller cum pusher design has been developed indigenously at TRF to reduce the land requirement, leading to reduction in capital investment.

[2] There is an increasing pressure on the power plants to reduce their operating expenses forprofitable operations. This has motivated the management to look closely at each facet ofits operations. In India, one of the important components of cost in thermal power plantsis the demurrage expense incurred by them in the coal receipt process. The plants usewagons of Indian Railways to transport coal from the coal mines (in case of domesticcoal) or from the ports (in case of imported coal) to the plants. Once these loaded railwaywagons have reached the power plant, they need to be unloaded and released within astipulated time frame. If there is any delay beyond the stipulated time, the power planthas to pay a penalty cost, known as demurrage cost to the Railways. This paper aims toanalyze the underlying causes behind this demurrage, understand the constraints in theprocess and model the process mathematically to arrive at solutions that can reduce thedemurrage costs

TABLE I

III.TECHNICAL DATA FOR PULLER

1) Capacity	2) To shift one empty wagon to the transverse direction
3) Objective	4) To complete the travelling
5) Travel Length	6) 30 m
7) Travel Speed	8) 0.5 m/s
9) Drive Arrangement	10) Rack and Pinion
11) Type of Drive	12) Hydraulic
13) Total Power	14) 15 KW
15) Total Weight	16) 25 Tonnes (approx)

TABLE II
IV.TECHNICAL DATA FOR PUSHER

Capacity	To push 58 wagons
Objective	To complete the travelling From pushing the empty counter track and returning to its original position within one Tippling cycle of the wagon Tippler
Travel Length	35 m (approx)
Travel speed	0.5 m/s
Drive arrangement	Rack and Pinion
Type of Drive	Hydraulic
Total Power	55-75 KW
Total Weight	5 Tonnes (approx)

V. LOAD CALCULATION

Pulling force at Arm Coupler: = 25000 Kg
= 245250 N
Gravity Force := 22000Kg
= 215820 N

Pushing force at Arm Coupler: = 25000Kgs
= 245250N

Drive Forces:
Power of motor= 520 kw
Actual power consumption when wagon load is 13 Tonne/Drive
Gear Forces :-P_T = 243055.55 N
$P_R = P_T x \tan\alpha$ = 88464.987 N.
Total load per Drive isP_{T1}= 127530N.
Total Pulling Load is= 255060 N.

VI. FEA OF PULLER CUM PUSHER ASSEMBLY

A general-purpose commercial finite element code, HyperMesh and Ansys is applied to conduct the static simulations, optimization and analysis. The FEA model of Puller cum Pusher in this study is constructed based on the geometry. A full 3-D solid model is constructed for the static test simulation. The schematic of an FEA model used in static test simulations is shown in figure.

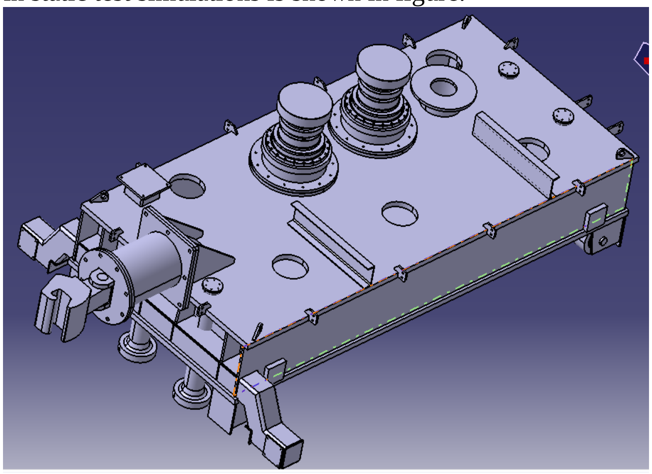

Fig.1 3D Model of Puller Cum Pusher Device

VII. MESHING OF PULLER CUM PUSHER

The cad model in IGES format is imported in HyperMesh for the preparation of FE model. Then geometry cleanup was done by using options like 'geom. cleanup' and 'defeature' to modify the geometry data and prepare it for meshing operation. This process involves deletion of curvature of very small radius (less than 2mm) which has less structural significance. Mixed type of elements which contains quadrilateral as well as triangular elements, have been used in analysis. The sensitive regions have been re-meshed by manually considering the shape and size of the parts. Quality check of all the elements has been performed and mesh is accordingly optimized.

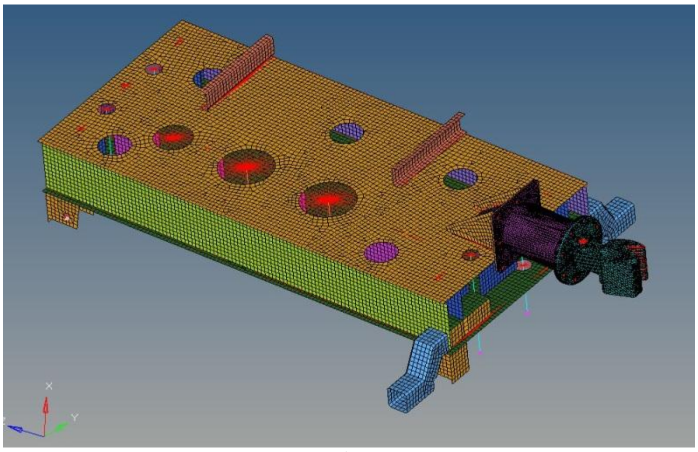

Fig.2Meshing model of puller cum pusher

TABLE III

A. Element Table:

17) Element type	18) Shell
19) Element Size	20) 40 mm
21) No. of Elements	22) 20528
23) No. of nodes	24) 21309

V.LOADING AND BOUNDRY CONDITION

1 .Power Pack Weight = 8.7 X 10^4 N
2 .Motor Weight = 8.26 X 10^3N
3. Concrete Weight = 6.96 X 10^4N

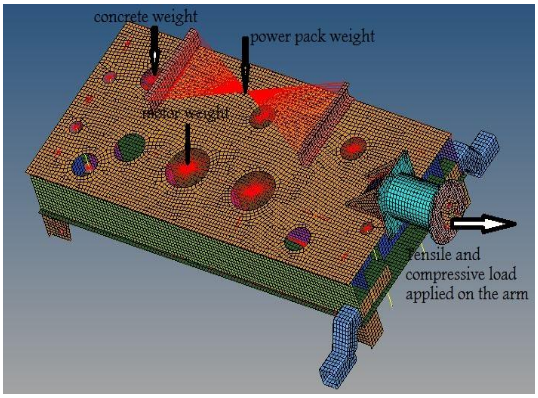

Fig.3 Various Load applied on the puller cum pusher Devic

B. Displacement Plot:

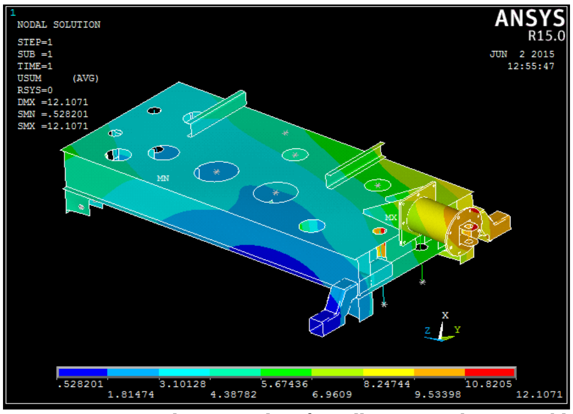

Fig .4 Displacement plot of a Puller cum Pusher Assembly

From above plot the maximum displacement value for Puller cum Pusher is 11 mm and which is very less hence design for the given load is safe.

C. Stress Plot:

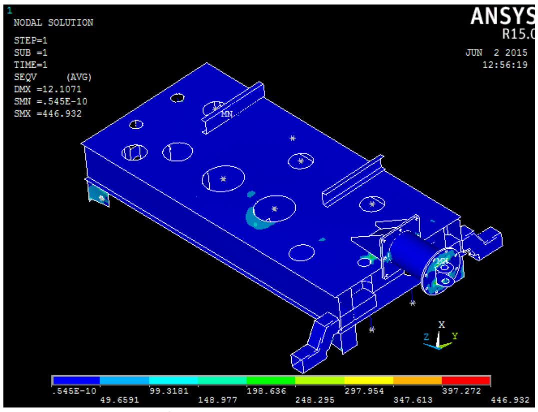

Fig .5 Stress plot of a Puller cum Pusher Assembly

From above plot the maximum Stress value for Puller cum Pusher is 446.932 N/mm^2 and which is very less hence design for the given load is safe.

VIII.OPTIMIZATION OF PULLER CUM PUSHER

For above mentioned results we need to optimize the model for specified upper and lower plate thickness,so I have taken the trial of 30mm,34mm,38mm,40mm of its original 50 mm thickness value.The size optimization of is done to check the locations/ areas where a structure's mass can bereduced and or removed. This is done with the helpof RADIOS.

In fig 6 was the optimized cad we have to remove some masses from the original body. Then optimizedmodel we have to import the Hyper mesh softwarethen meshing was start to as follows.

TABLE IV

C.*Optimize Value of Stress and Displacement*

Thickness	Displacement, mm	Stress N/mm^2
30	40.727	766.738
34	30.033	601.981
38	23.0489	485.526
40	20.455	446.841

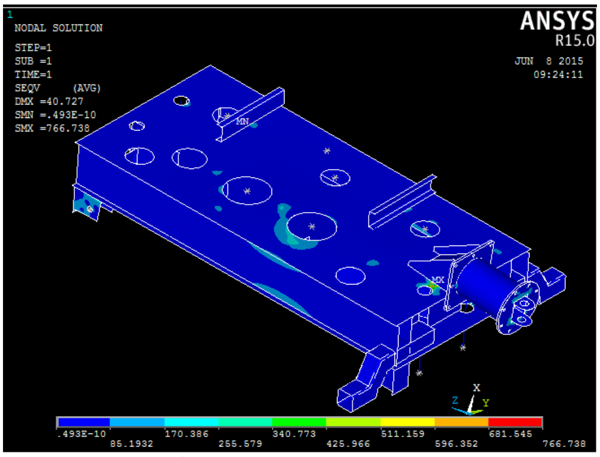

Fig. 6 Stress Plot of Puller cum Pusher Device (Optimized Design)

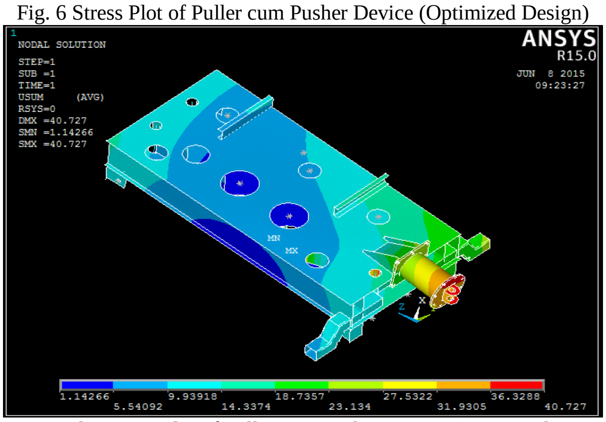

Fig. 7 Displacement Plot of Puller cum Pusher Device (Optimized Design)

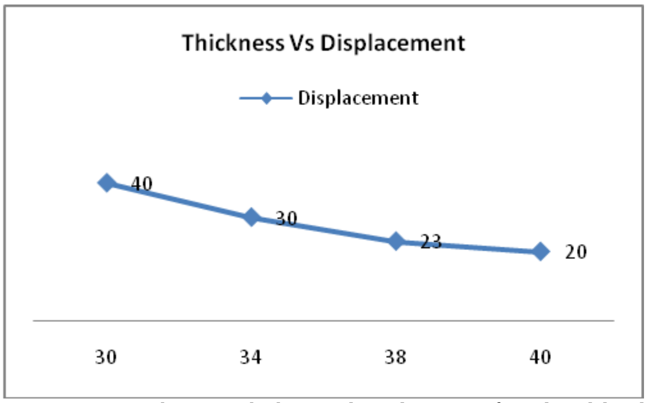

Fig.5 Comparison between Thicknessand Displacement ofinitial model and optimize model of Puller cum Pusher Device.

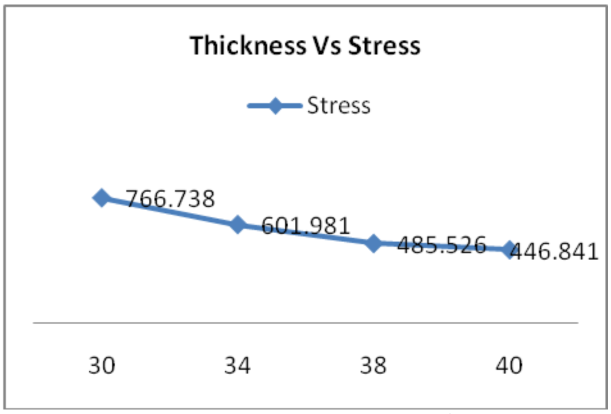

Fig.6 Comparison Between Thickness And Stress of Initial Model And Optimize Model of Puller Cum Pusher Device.

CONCLUSION

1. All reactions forces having positive value so there is no lift of runnerwheels.

2. FEA Successfully operated for different loading conditions

3. Optimization resultsin Material and Cost saving .

As per Bureau of Indian Standard yield point for IS-2062 is 250MPa, hence as the maximum stress range is 18 to 50 Mpa wasobserved considering self weight and external loads. Thus thecomplete structure is within the safe limit.

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