

Structural Analysis of Puller Cum Pusher System used in thermal Power Plant

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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.

Keywords— Puller cum Pusher,Coal Wagon,Rack and Pinion.

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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 and stopped with the first wagon within range of

the Side Arm Charger. The locomotive is then taken away. The charger shall be driven towards the first wagon, its arm is lowered and it is coupled to the first wagon of the rake. The charger then hauls the rake forward by one wagon length and stopped. Here the first wagon is decoupled from the rake manually. The charger then propels the first wagon on to the tippler table centrally and then automatically decouples and clears off the tippler. Now the wagon tippler is ready for operation. In the mean while, the side arm charger is moves back to initial position for next cycle.

In next cycle, the rake is drawn up by the one wagon length, and the previously tipped wagon is ejected simultaneously. After tipping of the last wagon, the charger is used under manual control to eject the last wagon from the tippler, if the next wagon is not already in position. The Side Arm Charger is run on a separate pair of rails which runs parallel to wagon tippler rail. Approximate travel length of the charger is 33M. Side Arm Charger movement on rail is actuated by the rack & pinion arrangement. Three numbers of driving pinions are mounted on output shaft of planetary gearbox coupled with hydraulic motor or directly coupled with hydraulic motor. The hydraulic motor is driven from hydraulic pressure and flow generated from a power pack positioned at operator cabin.

Side Arm Charger is a marshaling device to position the loaded wagon centrally on tippler platform one by one for unloading operation by wagon tippler. Side Arm Charger is a rail mounted machine used to pull the loaded wagons along with the rake & push out the empty wagon from the tippler platform after tipping.

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 meters long and consists of 58 wagons. This means that a similar length of space is required to re-form the rake on the out-haul side, once the wagons have been emptied at the wagon tipping station.

II. LITRATURE 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 industry altogether. Over the last 60 years, the company has specialized in the design and development of chain scraper type reclaimers for power plants, mining and minerals, coal preparation plants, bulk terminals as well as steel works and cement plants. [2] With over 600 references worldwide including notable recent successes in China and Australia delivering ground-breaking state-of-the-art equipment to consumer and supplier, SCHADE remains 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 possible to 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 a smooth curve. It would be preferable to provide Merry Go Round (MGR) system of rail track so that the rake can enter the plant in one direction and go out of the plant without any need of disconnecting the loco from the rake.

Earlier works dealing with demurrage have tended to focus on the development of strategic 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. In this case, the model describes the relationship between the number of trains, queue through put and queuing delays. In this case the queuing system built was a modified version of a standard single and multiple finite sources queuing model, which allowed for server 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 for profitable operations. This has motivated the management to look closely at each facet of its operations. In India, one of the important components of cost in thermal power plants is the demurrage expense incurred by them in the coal receipt process. The plants use wagons of Indian Railways to transport coal from the coal mines (in case of domestic coal) or from the ports (in case of imported coal) to the plants. Once these loaded railway wagons have reached the power plant, they need to be unloaded and released within stipulated time frame. If there is any delay beyond the stipulated time, the power plant as to pay a penalty cost, known as demurrage cost to the Railways. This paper aims to analyze the underlying causes behind this demurrage, understand the constraints in the process and model the process mathematically to arrive at solutions that can reduce the demurrage costs

III. TECHNICAL DATA FOR PULLER

TABLE

Capacity	To shift one empty wagon to the transverse direction
Objective	To complete the travelling
Travel Length	30 m
Travel Speed	0.5 m/s
Drive Arrangement	Rack and Pinion
Type of Drive	Hydraulic
Total Power	15 KW
Total Weight	25 Tonnes (approx)

IV. TECHNICAL DATA FOR PUSHER

TABLE

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

$P_R = P_T \times \tan \alpha = 88464.987$ N.

Total load per Drive is $P_{TI} = 127530$ N.

Total Pulling Load is= 255060 N.

VI. FEA OF PULLER CUM PUSHER ASSEMBLY

A general-purpose commercial finite element code, Hyper Mesh 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.

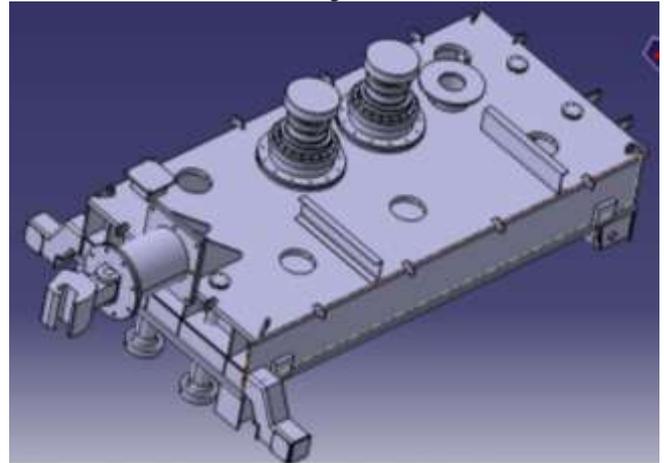


Fig.1 3D Model of Puller cum Pusher Device

VII. MESHING OF PULLER CUM PUSHER

The cad model in IGES format is imported in Hyper Mesh 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.

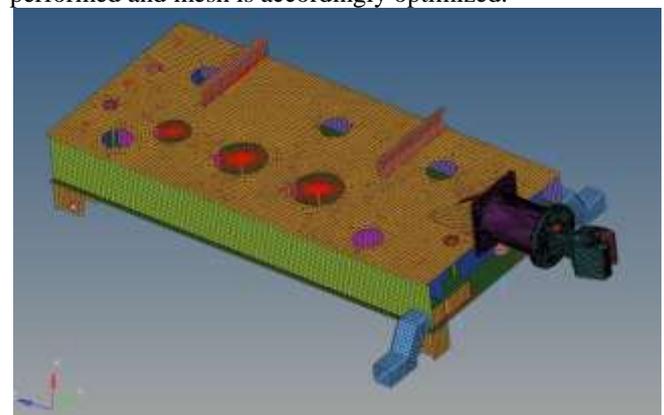


Fig.2 Meshing model of puller cum pusher

TABLE III

A. Element Table:

Element type	Shell
Element Size	40 mm
No. of Elements	20528
No. of nodes	21309

VIII. LOADING AND BOUNDRY CONDITION

1 .Power Pack Weight = 8.7×10^4 N

- 2. Motor Weight = $8.26 \times 10^3 \text{N}$
- 3. Concrete Weight = $6.96 \times 10^4 \text{N}$

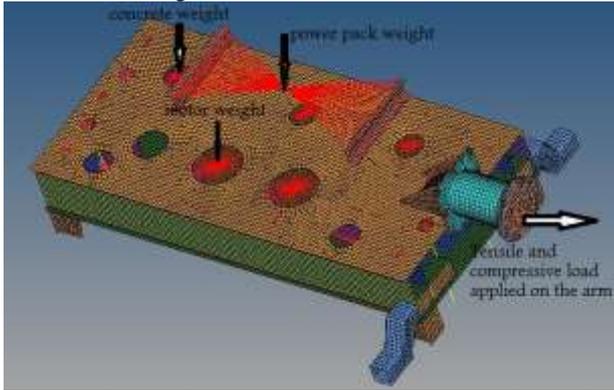


Fig.3 Various Load applied on the puller cum pusher Device

B. Displacement Plot:

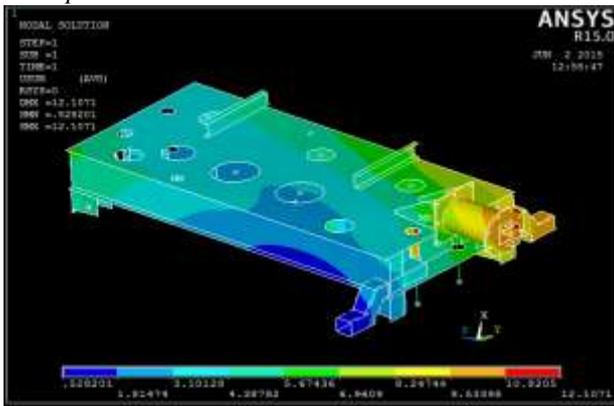


Fig .4 Displacement plot of a Puller cum Pusher Assembly

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:

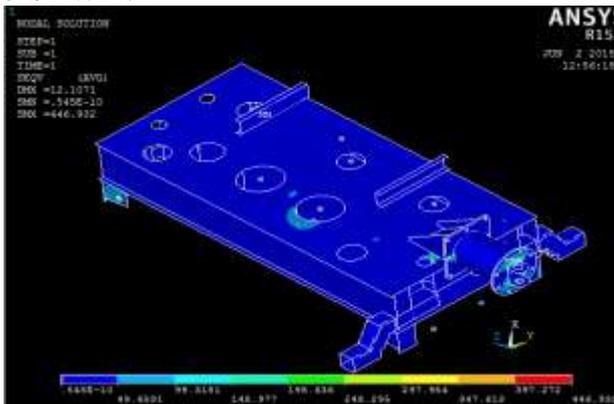


Fig .5 Stress plot of a Puller cum Pusher Assembly
From above plot the maximum Stress value for Puller cum Pusher is 446.932 N/mm² and which is very less hence design for the given load is safe.

IX. 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, 34 mm, 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 be reduced and or removed. This is done with the help of RADIOS.

In fig 6 was the optimized cad we have to remove some masses from the original body. Then optimize model we have to import the Hyper mesh software then 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

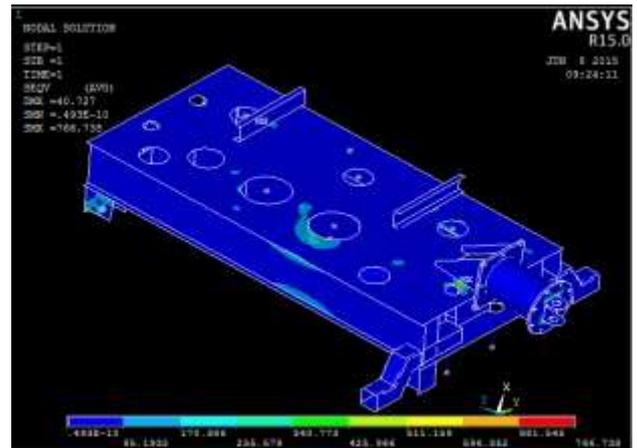


Fig. 6 Stress Plot of Puller cum Pusher Device (Optimized Design)

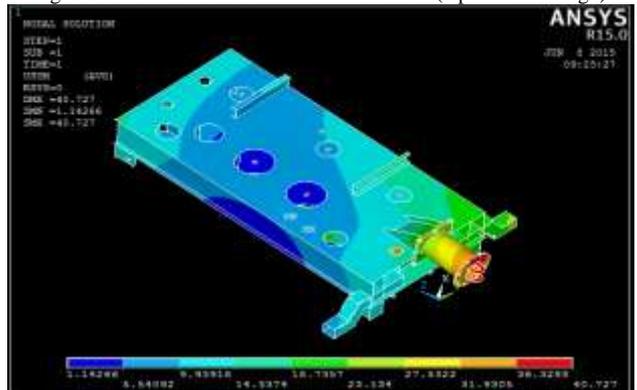


Fig. 7 Displacement Plot of Puller cum Pusher Device (Optimized Design)

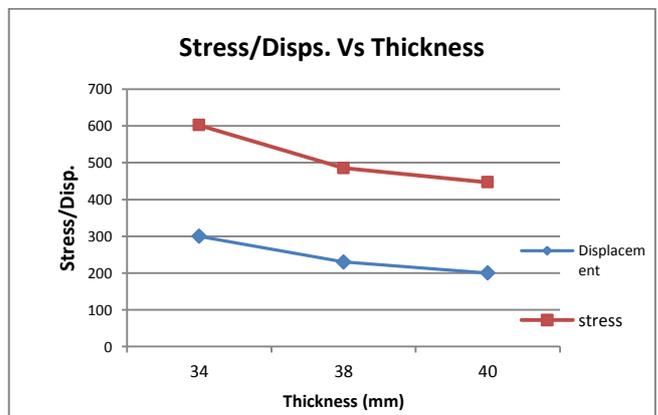


Fig.8 Comparison between Thickness and Displacement of initial model and optimize model of Puller cum Pusher Device.

X. CONCLUSION

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

2. FEA Successfully operated for different loading conditions

3. Optimization results in 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 was observed considering self weight and external loads. Thus the complete structure is within the safe limit.

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REFERENCES

- [1] Ashish Banerjee and Sudhir Kumar "Saving Land Space through Development of Wagon Shifter and Pusher" TRF Limited 20 INDIA.
- [2] Amit Bhatnagar, Ritesh Gupta, Sriharsha Pappu "Mathematical Modeling for Demurrage Reduction in Coal Transportation for an Indian Thermal Power Plant" Capital One Services, Inc 15000 Capital One Drive Richmond, VA 23238, USA
- [3] H Ramakrishna, "Wagon Loading And Unloading System ", Tata Consulting Engineers Limited Bangalore, India.
- [4] B. Malleswara Swami, K. Sunil Ratna Kumar "Design And Structural Analysis of CNC Vertical Milling Machine Bed" Swami et al, International Journal of Advanced Engineering Technology, Article 22, Vol III, issue IV, 2012
- [5] S. Kalpakjian, Manufacturing Engineering and Technology, 3rd Edition, Addison-Wesley, Reading, MA, 1995.
- [6] M.I.M. Negm, M.M. Sadek, S.A. Tobias, "Finite Element Prediction of Compliances of Grinding machine Structures and their Measured Correlation" Int. J. Mach Tool Des. Res. Vol 20 pp 9-24 Pergamon Press Ltd. 1980.
- [7] Ling Zhao, Wu-yi Chen, Jianfeng Ma, Yong-bin Yang, "Structural Bionic Design and Experimental Verification of a Machine Tool Column", Journal of Bionic Engineering Suppl. (2008) 46-52
- [8] M Bernard Budiansky, "On the minimum weights of compression structures", in International Journal of Solids and Structures, volume 36, (1999), pp. 3677-3708
- [9] K. Rajasekar Reddy, "Analysis of Plate Bending Machine using RADIOSS and OptiStruct", Larsen & Turbo limited, Heavy Engineering Ship Building Center, Godavari Gate, Scindia Road Visakhapatnam - 530 014, India
- [10] Sohan Ram, J N Dube, "Analysis of Milling Machine Structure For Ribbing of the Cross Arm", Computer and Structure Vol 30 No.6 pp.1355-1358, 1988.
- [11] Fengge Zhang, Yongxin Li, Xiuping Wang, "The Design and FEA of Brushless Doubly-Fed Machine with Hybrid Rotor", IEEE International Conference

on Applied Superconductivity and Electromagnetic Devices Chengdu, China, September 25-27, 2009