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Structural Analysis of the Mainframe of the Hydraulic Side Arm Charger for Heavy Load

Aniket A Nale[1], Dr. Kishor K Dhande[2]

[1]G Student, Department of Mechanical Engg. DYPIT , Pimpri , Pune , India -411018

[2]Professor, Department of Mechanical Engg.,DYPIT , Pimpri , Pune , India -411018

Abstract: ***Bulk handling represents a key advantage for rail transport. Bulk is transported in open topped Wagons, hopper Wagons and tank Wagons.The trend is to go for large capacity units, located close to the coal deposit and construct split located Power plant units nearer to the source of mines (Coal mines). As most of these Power plant units are receiving coal through railway rakes they need to install wagon tipplers. In thermal Power Plants , Wagon tippler , Side arm charger and Track hopper system is receiving facility of the material. Low costs combined with energy efficiency and low inventory costs allow trains to handle bulk much cheaper than by road. A side arm charger can handle 25-30wagons for pulling and pushing of Weighing 140 T on straight and leveled track efficiently and in least amount of time. The present work will an effort to design and analyze side arm charger mainframe. Design & 3D modeling of mainframe will be conducting static structural analysis by Finite Element Analysis (FEA).***

Keywords: Side Arm charger , Wagons, Finite Element Analysis.

1. Introduction

Today industries are growing with drastic speed due various facilities now available in India. Developments of Power, Infrastructure & Steel Sectors are important for the countries growth. Increase in power generation gives development of the nation directly and indirectly similarly for Infrastructures and steels. These sectors are related with material handling systems.
Indian industry has witnessed rapid growth in past 2-3 decades. The capacity of industries has more than quadrupled in about 20 years. Such rapid growth has posed several challenges in front of the Industry. Thermal power is the "largest" source of power in India. There are different types of thermal power plants based on the fuel used to generate the steam such as coal, gas, and Diesel. About 71% of electricity consumed in India are generated by thermal power plants. More than 62% of India's electricity demand is met through the country's vast coal reserves. Public sector undertaking National Thermal Power Corporation (NTPC) and several other state level power generating companies are engaged in operating coal based thermal power plants. Apart from NTPC and other state level operators, some private companies are also operating the power plants.

Bulk handling represents a key advantage for rail transport. For power sector, coal is to be handled for the ignition of the Boiler. This coal is generally handled with help of the Railway wagon in bulk quantity in India.Low or even zero transshipment costs combined with energy efficiency and low inventory costs allow trains to handle bulk much cheaper than by road. Typical bulk cargo includes coal, ore, grains and liquids. Bulk is transported in opentopped Wagons, hopper Wagons and tank Wagons. The trend is to go for large capacity units, located close to the coal deposit and construct split located Power plant units nearer to the source of mines (Coal mines). As most of these Power plant units are receiving coal through railway rakes they need to install wagon tipplers. In thermal Power Plants, Wagon tippler and Track hopper system is receiving facility of the material. As the Coal handling Plant is start with unloading facility and end with boiler bunker feeding refer fig.1 & fig.2.

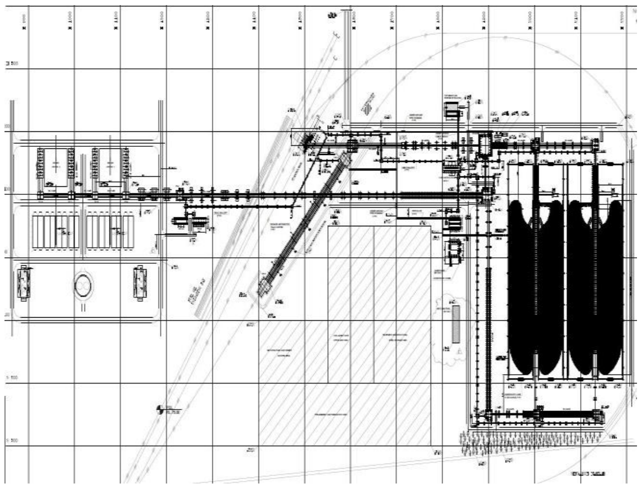

Figure 1: Coal Handling Plant Layout

For the effective utilization of wagon tipplers and to meet the time allocated by railways for unloading, it becomes must to have sufficient space(equivalent to one rake length) before and after the wagon tippler. Therefore even though the total land requirement for the power plant unit is only 5 hectares, about 7.5 hectares of land need to be acquired only for railways.

The material is received at the process plant by two different types of wagons as indicated above viz. BOXN wagons and BOBRN wagons. Different types of wagon unloading systems are adopted for unloading the material from these wagons. Generally, the material is discharged from the top from the BOXN wagons, while in the case of BOBRN wagons, it is discharged from the bottom. The hopper is provided below the ground for receiving the unloaded material from these wagons. Hence, the BOXN wagons need to be tilted for unloading the material into the hopper while the BOBRN wagons are provided with pneumatically operated gates at the bottom for unloading the material.

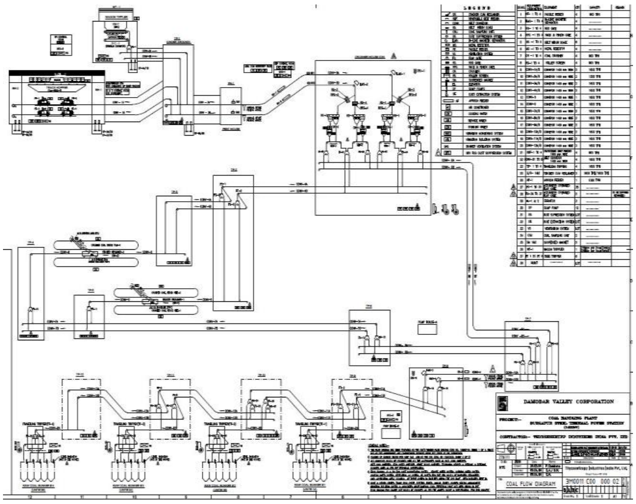

Figure 2: Coal Handling Plant Flow Diagram

1.1 Wagon Tippler

Wagon-Tippler is a machine used for unloading certain Wagons it holds the rail Wagons to a section of track and rotates track and Wagons together to dump out the contents such as coal, iron ore etc. The tippler structure consists of two drum-like cages resting on the eight support roller assemblies in which the coal wagons are rolled over and tipped to offload the coal. The coal falls onto a conveyor system which transports it to the grading plant. The wagon tippler consists of a table for positioning the wagon, wagon holding mechanism, gears and pinions for rotation, drive unit, hydraulic power pack etc.

The unloading cycle starts when the wagon is positioned over the wagon tippler table and the wagon along with the table rotates and discharges the material into the underground hopper. The time taken for the unloading operation is about 90 seconds. There are two types of wagon tipplers viz. rotaside which rotates about 150º and another rotary type which rotates by 180º. The rotaside wagon tipplers are provided in most of the plants in India. The drive for the rotation is the hydraulic type for smoother operation

Figure 3: Wagon tippler Equipment

1.2 Side Arm Charger

a) Application

The Side Arm Charger (SAC) shall be used for wagon positioning at the wagon tippler for unloading of materials. It shall be used for pushing / pulling a rake of 25-30 wagons and locating wagons one by one on tippler.

b) Specification

The Side Arm Charger consist of Mainframe , side arm , hydraulic power pack, power supply system, supports, electrics, buffer stop, rack & pinion, automatic Coupler/Decoupler etc. The Side Arm Charger shall run on its own track parallel to the main track. It shall have a stroke of suitable length from a point on the inhaul side of tippler to a point on the out haul side.

It shall be fitted with an arm pivoted at right angles and operated through a hydraulic system for raising and lowering. The arm shall have anautomatic coupler to couple/decouple the wagons. The charger frame shall consist of a single fabricated frame on which every other item shall be directly mounted to form a robust compact unit. The charger shall run on four steel wheels mounted on spherical roller bearings. To resist the moment reaction of the pushing force, two pairs of steel side guide rollers shall be fitted. They shall be fitted on spherical roller bearings and shall have a simple lockable adjustment for true running and to take up wear. The side guide rollers shall run on the sides of the rail heads of the charger running track. The arm shall be of welded construction. Raising and lowering of the arm shall be by hydraulic means. The charger shall have adequate power for pushing a train load of a Half rake of 25-30 wagons. It shall be hydraulically driven through rack and pinion arrangement.

The charger shall be electrically interlocked with tippler for proper sequential operation with respect to operational & safety requirements.

Easy access, adequate maintenance spaces, working platforms, inspection covers shall be provided for all the equipment located in the Side ArmCharger for safe and quick maintenance. All edges and openings shall be provided with guards.

Chequered plates on floor shall be provided to prevent slipping. Centralized system of lubrication shall be provided for the equipment. However, all parts of the equipment needing manual lubrication shall be easily accessible. All oil pipes and grease nipples shall be well covered to prevent damage from materials from falling on them. The Side Arm Charger shall be suitable to push or pull 25-30 loaded wagons on straight track and shall be suitable to position all types of wagons at the center of wagontippler. The hydraulic system/ components shall be designed / selected so that the working pressure shall not exceed 250 bars.

Figure 4: Side Arm Charger Equipment

The loco is decoupled and dispatched and the charger is driven to the leading wagon. Its arm can be lowered and it can be coupled to the first wagon of the train.

The train is hauled forward by the charger until the front of the first wagon is about 4 meters away from the tippler. The charger is stopped and the first wagon is uncoupled from the train. Then, the charger is forwarded onto the leading wagon, which forward onto the tippler. This automatically decouples the charger & its arm is raised before it travels back to the train. The tippler is rotated for tippling the wagon. On reaching near the standing train, the charger arm is lowered and coupled to the train ready for repeating the cycle.

In the next cycle, the train is drawn up by one wagon length, the front wagon is decoupled & the next cycle is repeated. When the next wagon is located on the tippler table the previously tippled wagon is ejected simultaneously. On the outhaul side, the empty wagon forms a new train ready for collection by a locomotive. The Side Arm Charger consists of hydraulic power pack, power supply system, supports, electrics, buffer stop, rack & pinion, control cabin, automatic coupler/decoupler etc.

2. Literature Review

Rehan H Zuberi et al. [2] (2008), studied design optimization of EOT crane thin walled welded box girder subjected to rolling loads. A simple and innovative procedure has been introduced to use nonlinear optimization code for optimization of various parameters of the welded box section bridge and then comparing the results with the FE simulation. Optimal girder so designed is efficient in respect of design technique and verified as cost-effective. Similar methodology can be implemented for the Mainframe of the Side arm charger Equipment.

Agyei-Agyemang et al. [1] (2008), studied finite difference numerical method of solving bi harmonic equation is presented. The bi harmonic equation and plate theory are used to solve a classical engineering problem involving the optimization of plate thickness to minimize deformations and stresses in the plate. Matlab routines were developed to solve the resulting finite difference equations. The results from the finite difference method were compared with results obtained using ANSYS finite element formulation. For ease of manufacture, the thicknesses at the various nodes could be adjusted upward to give a linear relationship and also to avoid the unwanted introduction of stress concentration spots on the plate. Plates used in the designing of the Side arm charger frame can be used with optimised thicknesses which can give Controlled deflection & load beaeing capacity.

Murali Maddali et al [1](2010), discussed about as increase in the use of computer aided engineering (CAE) technologies to optimize automotive and aerospace structures. Altair-OptiStruct is one such powerful tool which can generate an optimized design to meet the customer specified structural, cost and weight requirements. Also explained the use of OptiStruct in optimizing the thickness of a metal plate subjected to different magnitudes of forces in different directions. In the baseline model, a rectangular plate with constant thickness will be subjected to a static linear point load in three different directions at the edge location. A thickness optimization is performed using OptiStruct to obtain an appropriate thickness distribution for the plate for the same loading conditions which can bring down the stresses below the yield point.

3. Technical Data for Sidearm Charger

Table 1: Specifications of Side arm charger equipment

Sr.No.	Details	Quantity / Value
1	Capacity	To Pull 25-30 wagons of the 140T and To push 25-30 Empty wagons on straight and leveled track.
2	Objective	To index Wagons on the Wagon Tippler platform.
3	Travel Length	Approx.25 m
4	Travel Speed	0.5-1.0 m/sec
5	Drive Arrangement	Rack & Pinion
6	Type of Drive	Hydraulic
7	Total Pull	35 T

4. Load Calculation

Consider the worst condition of the Side arm charger working as 30 wagons with capacity of 140T.

Pulling force at Arm Coupler: = 35000 Kg
= 343350 N (Due to Curvature resistance, Rolling resistance, Slope resistance & acceleration resistance).

Gravity Force= 30000 Kg (Self Weight)
= 294300 N

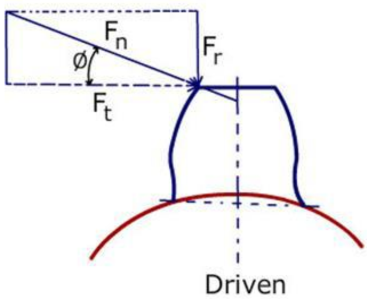

Figure 5: Pinion force analysis

Drive Forces:
Power of motor= 2 x 110 KW
Actual power consumption when wagon load is 17.5 Tonne/Drive
Gear Forces: PT = 174234.378 N
PR =PTx tanα = 88464.988 N.
Total load per Drive isPT1= 255060N.

5. Fea Modeling of the Side Arm Charger

A general-purpose commercial finite element code, Nastran is applied to conduct the static simulations and analysis. The FEA model of Side arm charger in this study is constructed based on the geometry. A Half 3-D solid model is constructed for the static test. simulation. The schematic of an FEA model used in statictest simulations is shown in figure.

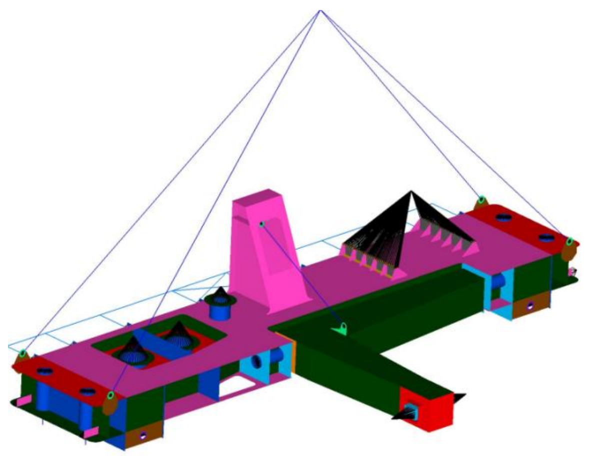

Figure 6: 3D Model of the Side arm charger Equipment

6. Meshing of the Side Arm Charger

The cad model in IGES format is imported in FEMAP for the preparation of FE model. Cleanup and defeature to modify the geometry data and prepare it for meshing operation. This process involves deletion of curvature of very small radius 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.

A. Element Type

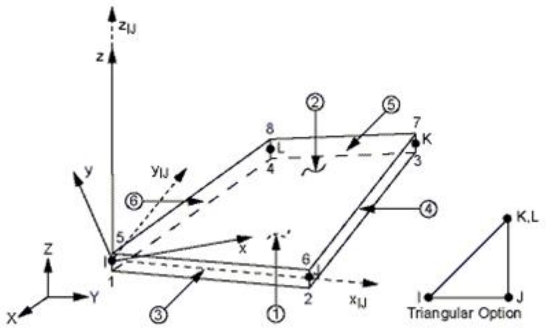

Figure 7: Element used for side arm charger Mainframe

SHELL63 has both bending and membrane capabilities. Both in-plane and normal loads are permitted. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z-axes.

Sr.No.	Details	Element Type
1.	Mainframe Plates	Shell 52
2.	Side arm plates	
3.	Stiffner Plates	
4.	Casing Frames	

7. Loading & Boundary Conditions

1) Power Pack Weight = 8.7 X 10^4 N
2) Motor Weight = 8.26 X 10^4 N
3) Force due to pulling at side arm = 343.35 kN
4) Transmission force at Pinion = 174.235 kN
5) Self weight = 12 kN/m

A. Displacement Plot

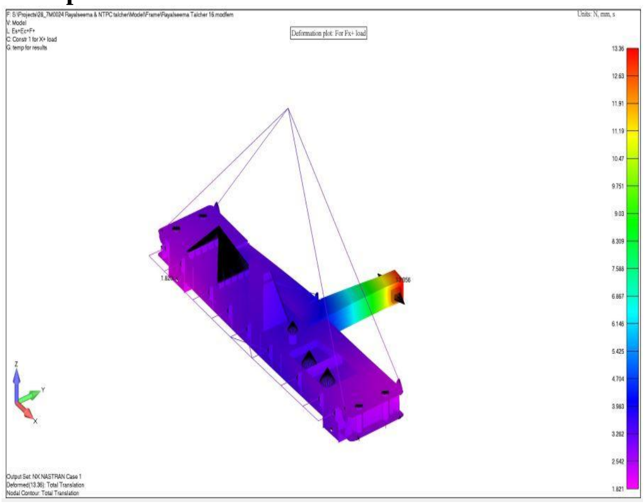

Figure 8: Displacement plot of side arm charger Mainframe

B. Stress Plot:

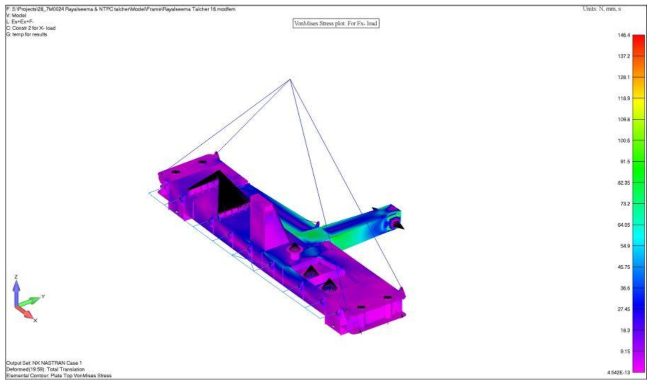

Figure 9: Stress plot of side arm charger Mainframe

8. Result & Conclusion

1. Deflection stresses in the mainframe of the side arm charger is less than the allowable limits.

Deflection:
Allowable Deflection (span / 500) = 21.94 mm.

Analysis deflection of side arm charger mainframe = 13.46 mm.

Stress :
Allowable Stresses = 166.66 N/mm^2
(With factor of safety of 1.5 on Yield Strenth of 250N/mm^2)
Analysis VonMises Stress of mainframe = 154 N/mm^2

2. All reactions forces having positive value so there is nolift of runner wheels.

Figure 10: Runner Wheels Reactions

3. FEA Successfully operated for given loading condition.
4. As per Bureau of Indian Standard yield point for IS-2062 is250MPa, hence as the maximum stress range is 154 Mpa was observed considering self weight and externalloads. Thus the complete structure is within the safe limit.

9. Acknowledgment

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