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Review Paper on Wagon Loading and Unloading System

Binta Bhargav[1], Hitesh Bhargav[2]
[1] *Mechanical Engineering department, Madhuben & Bhanubhai Patel Women Engineering College (MBICT), New Vallabh Vidyanagar,Gujarat Technological University*
[2] *Mechanical Engineering department, Birla Vishvakarma Mahavidyalaya (BVM), Vallabh Vidyanagar, An Autonomus Institution*

Abstract: ***This review paper covers the aspects of the wagon loading and unloading system currently in the Indian Industry. Today industries are growing with drastic speed due to 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. Every industry need productivity and it is possible for several equipment working in good condition with man power itself for care and maintain. So, as to require various types of technology has been summed up.***
Keywords: Wagon, bulk, transshipment cost, flowability, tippling system, feeder, and hopper

I. INTRODUCTION

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.

Generally the wagon loading systems are required in the mines and ports for loading the material into the wagons for further transportation to the process plants. Two major types of wagon loading systems are (a) Rake will be stationary and loader will be moving (b) Rake will be moving and loader will be stationary.

The wagon unloading systems are required in the process plants for unloading material received from the mines / ports by the railway wagons. Two types of wagons are generally used in the Indian Industry 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.

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.

II. WAGON LOADING SYSTEM

A. Introduction

Wagon loading systems are generally provided in the mines and ports for loading the material into the wagons. The following are the major types of wagon loading systems:

Rake will be stationary and loader will be moving. The loading systems under this type could be further classified into two types viz. (i) the mobile loader will be travelling for the complete length of the rake (ii) series of loaders will be provided with limited travel and would load a particular number of loaders at a time.

Rake will be moving and the loader will be stationary. This type is generally known as rapid loading system or flood loading system. The loading systems under this type could be further classified into two types viz. (i) Volumetric type: The type of wagon loading system depends on the properties of the material to be loaded and limitations in the layout. Hence each type of wagon loading systems mentioned above are applicable and are being adopted on different occasions. Generally one rake consists of about 58 wagons and capacity of each wagon is 55 tonnes. The total quantity of material in each rake would be about 3200 tonnes. The wagon loading system consists of a buffer storage silo and the wagon loader.

B. Storage Silo

The capacity of the storage silo will be generally equal to one rake load of material to enable loading of the rake without any interruption. However, this would depend on the properties of material like flowability, moisture content etc. In cases where higher quantity of material cannot be stored due to arching / chocking problems, the silo capacity could be lower. This silo would act as a buffer silo and the feeding conveyor to this silo shall be operated continuously to ensure that there will be no starvation of material while loading into the wagons. Fig. (1)

C. Mobile Wagon Loader

The mobile wagon loader consists of a long conveyor, a travelling tripper, a cross belt conveyor mounted on the tripper and a loading chute. This system will be provided parallel to the rail track where the rake containing 58 wagons will be parked. The travelling tripper will be travelling along the conveyor for loading the material into the wagons. The storage silo will be located at the tail end of this conveyor and feeds the material continuously onto the conveyor. At the start of the loading operation, travelling tripper will be located at the starting edge of the first wagon of the rake. The material from the silo will be fed onto the conveyor which will be conveyed to the cross conveyor mounted on the tripper. The material will be loaded into the wagon through the loading chute. The travelling tripper moves forward while discharging the material into the wagon at a constant speed. When the loading chute approaches the end of the wagon, the loading chute changes over from one wagon to the next wagon and thus there will not be any spillage between the wagons. The loading operation will continue to the next wagon without any interruption.
This process will be continued till the loading of the last wagon of the rake. This type of system is suitable for all types of material and especially for the sticky material. The limitation of this type of system is that the mobile loader will be too heavy and bulky. The time taken for loading one rake is about 3 to 4 hours. There is another type of mobile wagon loading system which consists of a set of six or seven short pivoted conveyors. The pivot of these conveyors will be such that the discharge chute of the conveyors will be travelling in a straight line. These conveyors will be pivoted at the tail end and mounted over the rail track at the head end. The bottom elevation of the conveyor will clear the wagons. The travel of the head end will be limited to one wagon length. A surge hopper will be provided at the tail end of each conveyor which ensures continuous supply of material. At the start of the loading operation, the rake will be parked below the conveyor system such that the forward edge of the first six wagons will be below the loading chute of each loading conveyor. The loading operation will begin at the starting edge of the wagon and as the material flows, the conveyor would travel along the wagon and loading will be completed as it reaches the other edge of the wagon. Each wagon loader will load one wagon at a time. At the end of the loading operation, the rake shall be shifted by six wagons so that the next six wagons will be ready for loading the material. This type of loader is simple and more compact. However it takes more time (4 to 5 hours) for loading one rake. The numbers of installation of this type of wagon loader are very few. The accuracy of the load in the wagons will be less. Fig (2)

D. Rapid Loading System

This type of loading system consists of a storage silo, a bin below the silo and the loading chute. This silo will be mounted directly over the rail track. The rake will be moving below the loading chute at a constant speed while material will be discharged into the wagons. The rake consisting of 58 wagons will be connected to the loco which will be provided with creep speed control system. With this system, it would be possible to maintain the constant speed of the train. The desired speed of the train is 0.8 KMPH for better accuracy. The track shall also be maintained truly horizontal to ensure that the train will not gain or lose the speed due to gravity. There are two types of Rapid Loading System (RLS) viz. volumetric type and gravimetric type. In the volumetric type, the loading chute will be operated hydraulically for a pre determined time for loading the material into the wagons. The volume of the material discharged into the individual wagons will be controlled. At the start of the loading cycle, the starting edge of the wagon will be brought below the loading chute. The loading chute will be lowered and the gate will be opened to allow the material to flow. At the same time, the rake would also start moving at a constant slow speed. The loading will continue till the end of the

wagon. When the edge of the wagon is sensed the gate closes slowly and the flow of material will be stopped. Uniform loading of material is ensured across the width and length of the wagons. The gravimetric type of loading system will be similar to the volumetric type. However; in this case, the bin below the silo will be weighed before discharging the material into the wagon. The rake below the silo will be moving at a constant speed and the weighed material in the bin will be discharged into the wagon at a controlled rate to ensure uniform loading of the material in the wagons. The chute provided below the bin will be either wheel mounted telescopic type or pivoted type. This chute will be moved out to allow the loco to pass through. When the wagon is located below the silo, the loading chute will be brought to the loading position. The storage silo will be similar to that elaborated in clause 1.2 above. It would be preferable to have the storage capacity of one full rake to ensure uninterrupted loading. However, if it is not possible to have the full rake capacity due to flowability problems, silo of smaller capacity could be provided. In this case, the constant supply of material shall be ensured at the required rate so that starvation of the material is not experienced during the loading operation. Various instruments will be provided to ensure uniform and accurate loading of the material into the wagons. The photo electric sensors will be provided for sensing the movement of the rake and would sense the loco for bypassing and senses the wagons to start the loading operation. The complete controls will be provided in the silo building at an elevated position. It would be possible to view the loading operation from this
control room. The volumetric type and gravimetric types of loading systems are similar in construction and operation. However, the accuracy of loading will be better in the case of gravimetric type as the weighed quantity of material will be loaded. The time required for loading one rake with the rapid loading system would be less than one hour

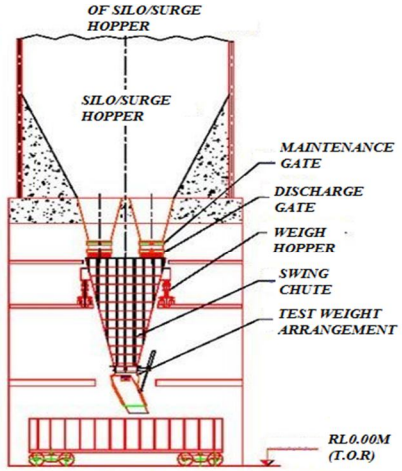

FIG - 1. STORAGE SILO TYPE WAGON LOADING SYSTEM


FIG 2. MOBILE WAGON LOADER

III. WAGON UNLOADING SYSTEM

A. Introduction

The material will be 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 would be adopted for unloading the material from these wagons. Generally the material will be discharged from the top from the BOXN wagons while in the case of BOBRN wagons, it will be discharged from the bottom. The hopper will be 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.

B. Wagon Tippling System

The wagon tippling system consists of wagon tippler, the wagon positioning equipment, underground hopper, and feeder below the hopper for evacuating the material unloaded into the hopper.

1) *Wagon Tippler :* 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 135º 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 will be hydraulic type for smoother operation. It would be possible to achieve average unloading rate of about 20 tips per hour with the rotaside wagon tippler. Fig (3)

2) *Wagon Positioning Equipment:* There are different types of wagon positioning equipment like hydraulically operated side arm charger, beetle charger and shunting locos. The hydraulically operated side arm chargers are being used in most of the plants in India as this equipment is much faster compared to the others. The tractive force of the side arm charger shall be suitable for hauling one fully loaded rake.
3) *Unloading Hopper:* The hopper provided below the wagon tippler could be either RCC type or structural steel fabricated type. In most of the plants this will be of RCC construction. Suitable liner would be provided for this hopper depending on the abrasiveness of the material handled. Generally steel grids of 250 mm square will be provided above the hopper to avoid higher size of material going through. The higher size material will be removed and broken separately and then passed through the grid. The grid will be sloping outwards for easy removal of such larger size material.
4) *Feeder Below The Hopper :* The feeder below the hopper could be either vibrating type feeder or apron feeder. The apron feeder would be more suitable for heavy duty application for taking the impact of the falling material. The apron feeder will be driven by hydraulic motor for smoother operation.
5) *Rail Tracks:* 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. This would be preferable for achieving faster unloading rate and the effort required by the side arm charger would also be minimum. In case it is not possible to have straight length to accommodate one full rake on either side, then shunting operation will be required using the plant loco and hence it takes the turnaround time will be more.
6) *Dust Control System:* Plain water spray type dust suppression system will be provided for suppressing the dust generated during the unloading operation. Spray nozzles will be provided at the top of the wagon tippler and also around the hopper for spraying the water and settling the dust. An enclosed shed will be provided for the wagon tippler so that the dust will be contained within and will not be spread to the other parts of the plant.
7) *Control Room:* A control room will be provided adjacent to the wagon tippler at an elevated position for operation and control of the wagon tippling system. The complete view of the unloading system will be available from this control room. Generally the time taken for unloading the rake would be about 4 hours with one wagon tippler in operation.

IV. UNLOADING SYSTEM TRACK HOPPER

The BOBRN wagons will be discharging the material through the discharge gates provided at the bottom of the wagons. This type of unloading system consists of track hopper below the rail track, mechanism for opening the pneumatic gates of the wagons and feeders below the track hopper. The loaded rake will be brought to the track hopper by the main line locomotive and the same locomotive will stay connected to the rake while the unloading operation is in process and the rake will be hauled out of the plant. It is not necessary to disconnect the loco from the rake unlike in the case of wagon tippler system.

Track Hopper

The track hopper will be provided below the rail track and will be suitable for holding the material unloaded from the BOBRN wagons. The length of the track hopper adopted in most of the Indian plants is about 200 m and the capacity of this hopper will be suitable for storing one rake material. With this, it would be possible to operate the wagon unloading system independent of the rest of the plant and the rake need not wait in case any of the downstream equipment is not available. There are few plants with shorter length of track hopper. It would be possible to adopt track hopper of reduced length as the reliability and availability of the conveying equipment is much higher. The track hopper will be of RCC construction and suitable liner will be provided depending on the abrasiveness of the material handled. Steel grid of about 250 mm square will be provided over the track hopper. Fig (4)

A. Discharge Gate Opening Mechanism

The BOBRN wagons have pneumatically operated gates at the bottom of the wagon. These need to be opened for discharging the material from the wagons. The wagons will have hopper like construction with slope at the bottom portion for effective clearance of the material. The pneumatic gates could be opened by energizing the solenoids provided on the wagons. The gates could be closed by de-energizing the solenoids. The opening and closing of the gates could be carried out either manually or with the help of line-side equipment. In case of manual operation, about 15 to 20 wagons will be parked on the track hopper for unloading the material.

Once this batch of wagons is unloaded, the next batch of wagons will be pushed forward and parked on the track hopper for unloading operation. This process will be repeated till the completion of unloading operation. In case of line-side equipment, the unloading operation could be done while the rake is in motion. The compressors required for supplying the compressed air could be either mounted on the locomotive used for hauling the rake or could be in a separate room near the track hopper.

B. Feeder Below The Track Hopper

The paddle feeders will be provided below the track hopper for evacuating the material from the hopper. The paddle feeder will be mounted on the table provided below the hopper from where the material will be evacuated and fed on the belt conveyor below. The paddle feeder will be driven by hydraulic motor for smoother operation.

C. Rail Tracks

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. In case it is not possible to have straight length to accommodate one full rake on either side, at least about 250 m 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.

D. Dust Control System

Plain water spray type dust suppression system will be provided for suppressing the dust generated during the unloading operation. Spray nozzles will be provided around the hopper for spraying the water so that the dust settles down.

E. Control Room

A control room will be provided adjacent to the track hopper for the operation of the line side equipment and the associated compressor if any. Generally the time taken for unloading the rake would be less than 1 hour. The unloading rate is quite fast for the sized material.

FIG 3 WAGON UNLOADING SYSTEM- WAGON TIPPLER

FIG 4 TRACK HOPPER UNLOADING SYSTEM

V. CONCLUSIONS

The rapid loading system has many advantages like better accuracy; more uniform loading and the loading operation will be much faster. The limitation would be the storage silo for the material which does not flow easily. The travelling wagon loader is more bulky and takes more time for loading the rake. However, this could be used for the material which does not flow easily. Considering the above aspects, it could be concluded that the rapid loading system could be adopted for most of the materials and wagon loader could be used where the material has problem associated with the flow.

Both the types of wagons viz. BOXN and BOBRN are being used extensively in India by Indian Railways. Hence both the types of unloading systems viz. wagon tippling system and track hopper system are being used presently. In case the process plants are

located nearer to the mines or to the port and dedicated rail tracks are available between the plant and mine / port, it would be certainly preferable to adopt the track hopper system with dedicated wagons and loco.

Industry must choose wagon loading and unloading system which increases their production rate and also helpful for management people for smooth operation.

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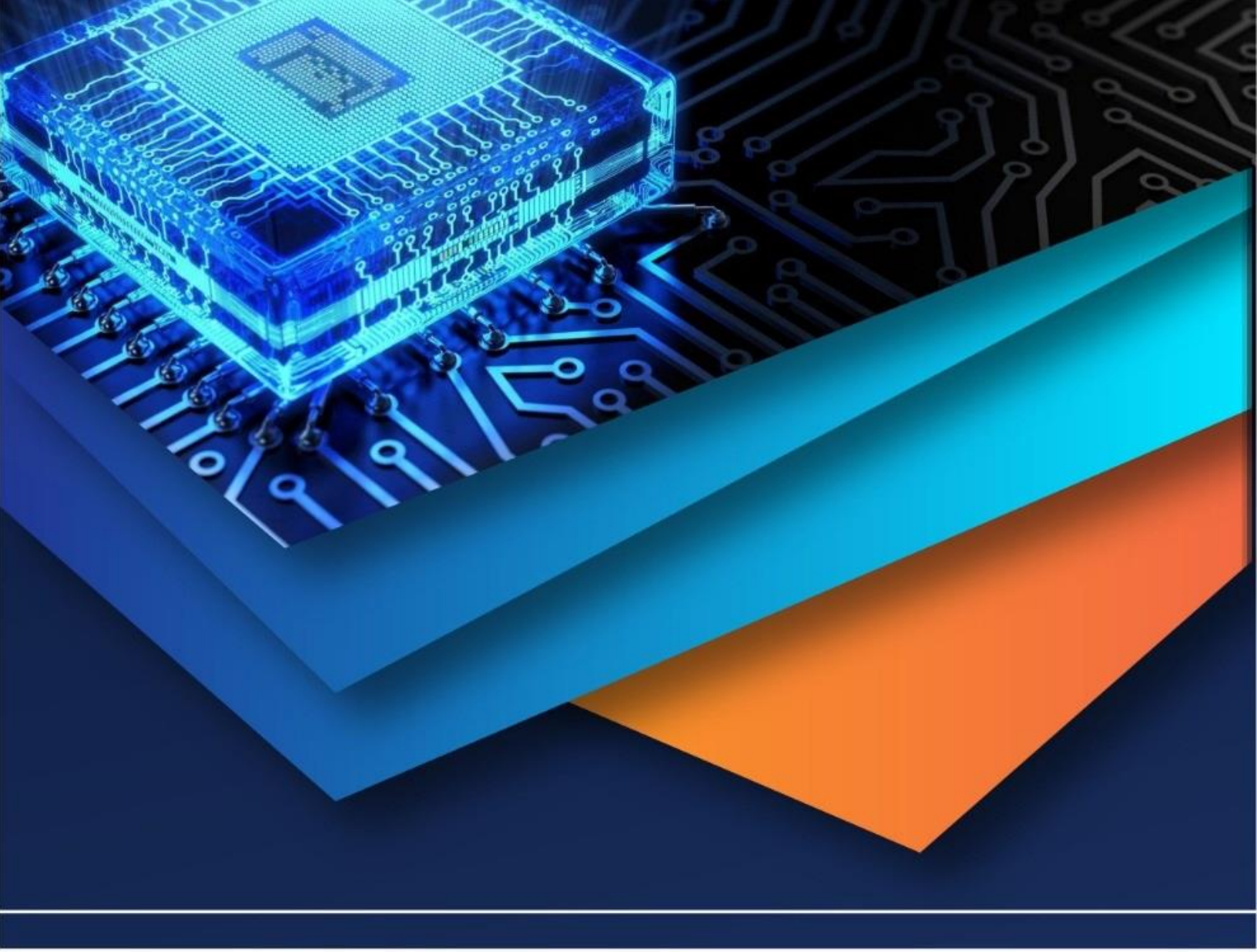

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