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Design, Fabrication and Testing of Linear Motion Bucket Wheel Reclaimer – A Prototype

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ABSTRACT

Reclaiming of coal, iron ore and grain are necessary/essential in industries like power plants and mining. Manual handling or usage of dozers for reclaiming operation requires lot of time, man power, and money and also involves risks of accidents. In earlier days both the manual and dozer operations were suitable for reclaiming of above materials due to lesser quantities and cheaper man power availability in the market. Earlier days the bucket wheel reclaimer on cantilever beam and requires huge counter weight mandating heavy structure that leads to high power consumption for the movement of equipment. Due to heavy weight and high power motors, the initial investment on the machine is also high. And it has a long cantilever and counter weight at the height of almost 100 to 150 feet" that reduces the stability of equipment. Chances of bucket wheel hitting to other machines or working areas is also possible due to long beam due to the negligence of operator. In linear type, it requires less counter weight and less power consumption. This paper involves function design, motor power calculation, load balancing, fabrication and testing of proto type linear motion bucket reclaiming machine with 4 major movements namely long travel, bucket wheel rotation, lowering and conveying.

Keywords: Research Paper, Technical Writing, Science, Engineering and Technology

I. INTRODUCTION

Bucket-wheel reclaimer have been used in mining for the past century, with some of the first being manufactured in the 1920s. They are used in conjunction with many other pieces of mining machinery (conveyor belts, spreaders, crushing stations, heap-leach systems, etc.) to move and mine massive amounts of overburden (waste). While the overall concepts that go into a BWR have not changed much, their size has grown drastically. Linear motion bucket wheel reclaimer is used for reclaiming of coal iron ore and grain are necessary in industries like power plants and mining Manual handling of dozers for reclaiming operation requires lot of time and man power and also involves risk of accidents In earlier days both manual and dozer operations were suitable for reclaiming of above materials due to lesser quantities and cheaper man power availability in market. Linear motion bucket wheel reclaimer involves 4 major mechanisms namely slider bearing, rack and pinion, luffing and conveying.

II. WORKING THEORY

A reclaimer is a large machine used in bulk material handling applications. A reclaimer's function is to recover bulk material such as ores and cereals from a stockpile. A stacker is used to stack the material. Reclaimers are volumetric machines and are rated in m^3/h (cubic meters per hour) for capacity, which is often converted to t/h (tonnes per hour) based on the average bulk density of the material being reclaimed. Reclaimers normally travel on a rail between stockpiles in the stockyard. A bucket wheel reclaimer can typically move in three directions: horizontally along the rail; vertically by "luffing" its boom and rotationally by slewing its boom. Reclaimers are generally electrically powered by means of a trailing cable Linear motion bucket wheel reclaimer is a simply supported machine which reclaims the material from the stockyard.it moves forward and backward on the tracks and having luffing columns which helps moves the boom upwards and downwards. The speed of the bucket wheel is 10 rpm and whereas

the sliding motion and luffing mechanism of the boom is 3 rpm. Spur gear is used to rotate the bucket wheel. Spur gears are the most easily visualized common gears that transmit motion between two parallel shafts. Since the tooth surfaces of the gears are parallel to the axes of the mounted shafts, there is no thrust force generated in the axial direction. A pinion is used to rotate the gear. Here we used conveyors for conveying material from the stockyard to the required place. Belt conveyors are used in the prototype of linear motion bucket wheel reclaimer

Figure 1. Motion bucket wheel reclaimer

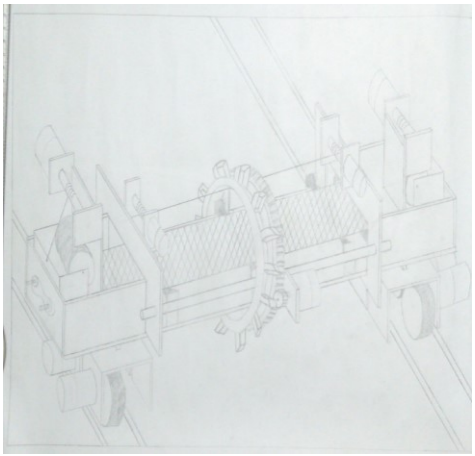

Figure 2. Linear motion bucket wheel reclaimer

III. DEVELOPMENT AND HISTORY

The Stacker Reclaimers are used extensively in stockyards and are ideal for ensuring end-to-end logistics between incoming raw materials and their processing in the plant. TRF has engineered and supplied Stacker Reclaimers for coal, iron ore, limestone, sinter and coke. TRF Stacker cum reclaimers are in operation at all major steel plants, ports and power plants in India. The stacking and reclaiming capacity of TRF Stacker Reclaimers vary from 300 TPH to 6000 TPH making TRF the premier supplier of Stacker Reclaimers in India. All the drives of the Stacker cum Reclaimers are provided with programmable logic controller to achieve synchronized motions. Stacker cum Reclaimers are also provided with weighing system and totalizer, hydraulic rail clamps, warning against storm weather and air conditioned electric room. Dust suppression system, radio control and Fire fighting systems are also provided as optional. The operator's cabins is so located that the operator gets a clear and unobstructed view of the operation. The cabin is air-conditioned and ergonomically designed for maximum comfort of the operator. The front screen is mounted in the operator's console and displays details of all operations enabling the operator to program according to the loading. The choice of design depends on factors such as the size and shape of the stockpile, the type of material to be reclaimed, the required reclaiming rate and the need for blending or homogenization.

IV. IMPORTANCE OF LMBWR

Technology drives our customized chute designs including 3D-modelling and discrete element method (DEM) which simulates continuous material flow ensuring optimal materials flow of dry and sticky materials at the bucket wheel chute and other critical transfer points. Each bulk material has different behaviour with regard to cutting forces, free flowing capabilities and adhesiveness. Reclaimers offers tailor-made designs for the complete range of bulk materials, to combine excellent cutting geometries with high abrasion resistance and prevention of bucket incrustations. Dust caused by the reclaiming and material transfer processes is environmentally problematic. It offers, wherever required, dust suppression systems such as water spray lines close to the bucket wheel and along the complete boom. Solenoid valves to shut off the sprays when no material is being conveyed control these sprays.

V. KEY FEATURES OF LMBWR

- Reclaimers usually reclaim the material from the surface of the stockpile in a longitudinal direction from one side of the pile only, down the full length of the pile.
- They discharge the material on to a conveyor belt along the stockpile.
- Because of the reclaiming path from the surface, traveling portal scrapers have limited ability to homogenize the material, unless a strict and rather complicated material layering scheme is implemented.

- They can be a good solution for small to medium capacities and where homogenization is not a priority

VI. FABRICATION OF A PROTOTYPE OF LMBWR

A. Bucket wheel:

Gear material: EN8
Bucket material: GI Sheet
Slider bearing, Inner RING: Mild Steel

Figure 3. Bucket wheel

B. Bucket

We designed the bucket as per the required dimensions
Material used: GI sheet

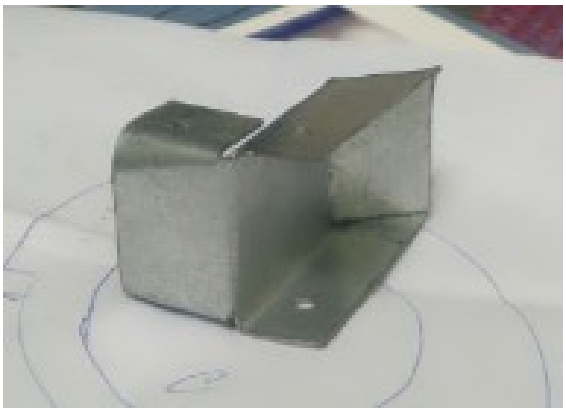

Figure 4. Bucket

C. Bucket wheel outer ring:

We designed the bucket wheel outer ring for fixing the buckets and the gear
Material used: GI sheet

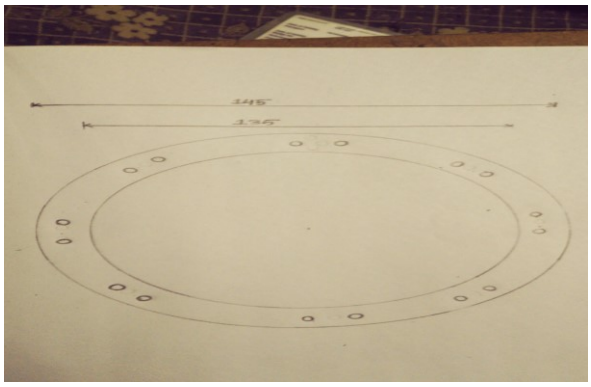

Figure 5. Design of Bucket outer ring

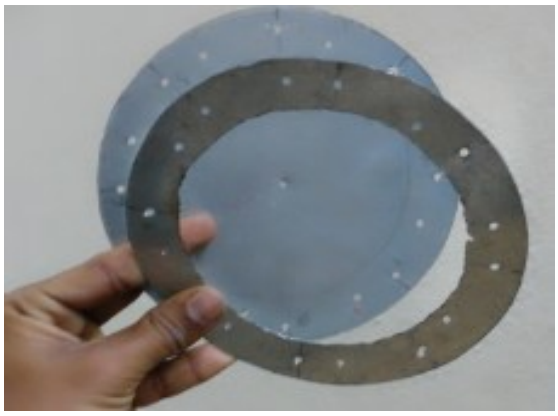

Figure 6. Bucket wheel outer ring

D. Gear:

Gear is used to rotate the bucket wheel
Material used: EN8

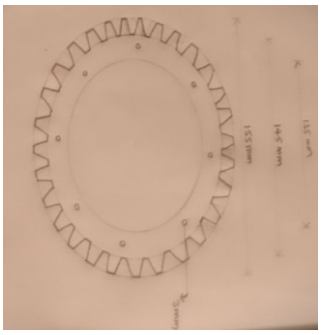

Figure 7. Design of Gear

Figure 8. Gear

E. Slider Bearing:

Slider bearing is used to rotate the gear and we drilled two travelling slots for the sliding motion of bucket wheel over the boom
Material used: mild steel

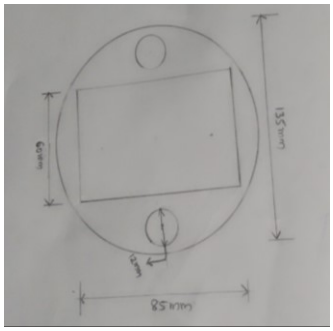

Figure 8. Slider bearing Design

Figure 9. Slider bearing

F. Bucket wheel inner ring:

We designed the bucket wheel inner ring for separating the gear and buckets
Material used: mild steel

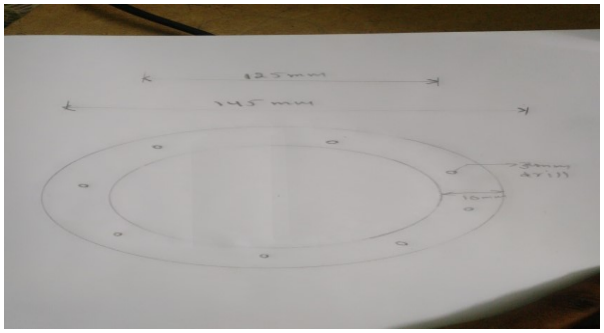

Figure 10. Design of Bucket Inner Ring

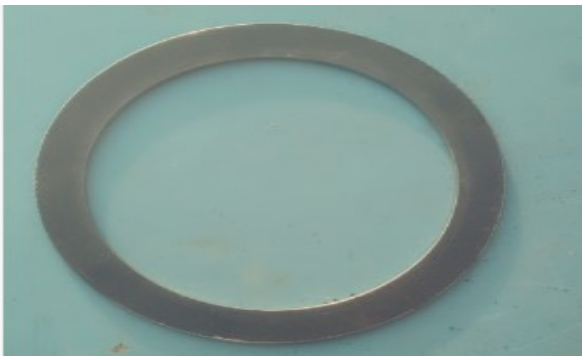

Figure 11. Bucket Inner Ring

G. Boom Bottom Plate:

Boom is used to move the bucket wheel with the sliding motion .Boom can move upwadrs and downwards by having the luffing columns on the both sides of the boom**.**

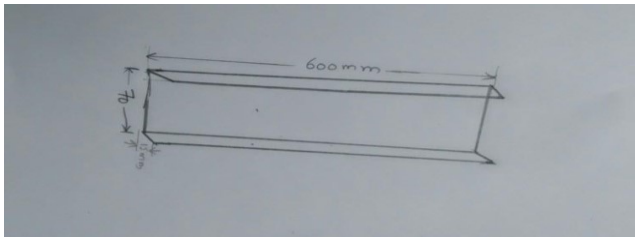

Figure 12. Design of Boom Bottom Plate

Figure 13. Boom Bottom Plate

H. Boom Conveyor Idler Supports:

Idler supports are placed on the both sides of the boom. These are used to fix the idlers

Figure 14. Idler Supoorts

I. Carrying Idlers:

Carrying rollers are used to support the conveyor belt and are installed on the groove shape frame, Groove shape forward inclined idler frame and transition idler frames. Rollers include high quality bearing, multi-labyrinth sealing, greased and sealed for life and critical specifications essential for high performance.

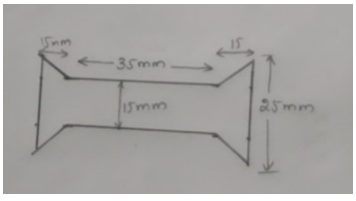

Figure 15. Design of carrying idler design

Figure 16. Carrying Idlers

J. Luffing Columns:

These columns are used to support the sliding movement of conveyor boom upward and downward motion.

Material used-Mild steel

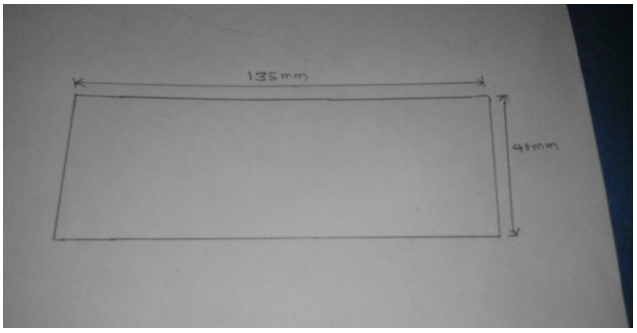

Figure 17. Design of Luffing Columns

Figure 18. Luffing Columns

K. Tracks:

We designed the tracks which are used for the forward and backward moment of machine.
Material used - G.I Sheet

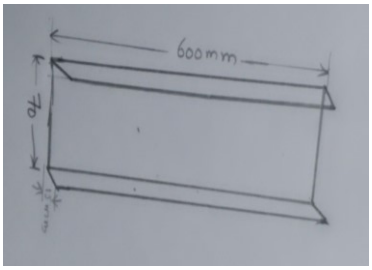

Figure 19. Design of Track

Figure 20. Tracks

L. Conveyors

Screw conveyor

A screw conveyor is a mechanism that uses a rotating helical screw blade, called a "flighting", usually within a tube, to move liquid or granular materials. They are used in many bulk handling industries. Screw conveyors in modern industry are often used horizontally or at a slight incline as an efficient way to move semi-solid materials, including food waste, wood chips, aggregates, cereal grains, animal feed, boiler ash, meat and bone meal, multiple solid waste and many others. The first type of screw conveyers used since ancient times to pump irrigation water.

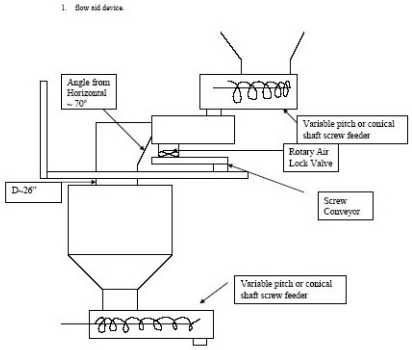

Figure 21. Mechanism of Screw conveyor

Belt conveyors:

One of the basic tool in material handling industry, belt conveyors are most commonly used in transportation of bulk materials (grain, salt, coal, ore, sand etc). Belt conveyor system consists of two or more pulleys and end-less loop of carries forward, one or both pulleys are powered. The powered pulley is called "drive pulley" the unpowered one is known as idler pulley. Belt conveyor is general material handling such as those moving boxes along inside a facility from a different class of belt conveyor from those are used to transport large volumes of resource and agricultural materials. Based on those that are used to transport large volumes of resources and agricultural

Figure 22. Belt Conveyor

Conveyors are the transportation means for moving of materials from one place to another.
Carrying, return idlers are utilized for movement of belt. Idlers are made of wood.

M. Pulleys

A pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable, supporting shell is referred to as a "block". A pulley may also be called a sheave or drum and may have a groove or grooves between two flanges around its circumference. The drive element of a pulley system can be a rope, cable, belt, or chain that runs over the pulley inside the groove of grooves. Hero of Alexandria identified the pulley as one six simple machines used to lift weights, pulleys are assembled to form a block and tackle in order to provide mechanical advantage to apply large forces. Pulleys are also assembled as part of belt and chain drives in order to transmit power from one rotating shaft to another.

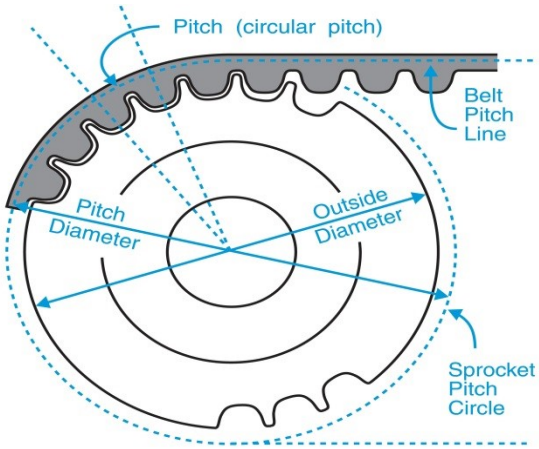

Figure 23. Rotating shaft of pulley

N. DC Geared Motors

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic ,to periodically change the direction of current flow in part of the motor.

Figure 24. DC Geared Motor

O. Final Finished Product Of LMBWR

Figure 25. Final Finished Product

VI. CALCULATIONS

A. Bucket wheel power calculations:

- Mass of the buckets Wbo = 1500gms

  = 1.5kg
- Mass of the material in buckets Wm = 4*50

  = 200gms (0.2kg)
- Total mass of the bucket wheel with material Wmb

  = 1.5+0.2=1.7kg
- Radius of the bucket wheel

  Wr =155+60=215/2

  =107.5mm=0.107m
- Force = mass*gravity

  =1.7*9.8 = 16.677N
- Torque = force*radius

  = 16.677*0.107 = 1.792N-m

  Power = 2∏NT/60 watts

  = 2*3.14*0.58*1.792/60
  = 0.108watts

B. Luffing Power Calculations:

- Mass of boom = 6000gms = 6kg

- Radius of pulley = 6/1000mts = 0.006m
- Force = mass*gravity = 6*9.8 = 58.8N
- Torque = force*radius = 58.8*6/1000

  = 0.3528 N-m
- Power = 2∏NT/60 watts

  = 2*3.14*3.5*0.3528/60
  = 0.1293watts

C. Belt Power Calculations:

- Mass of the carrying idlers = 3*40gms

  = 120gms=0.12kg
- Mass of return idlers = 0
- Mass of pulley = 2*50gms = 100gms = 0.1kg
- Mass of the belt = 100gms = 0.1kg
- Mass of the material on belt = 1000gms = 1kg
- Friction factor = 3
- Gravity = 9.8
- Force = friction factor * total mass *gravity

  = 3(0.12+0.1+0.1+0+1)*9.8
  = 3(1.32)*9.8
  = 38.808N
- Power = force*velocity

  = 38.808*0.0157
  = 0.6092watts

VIII. CONCLUSION

Finally we designed ,fabricated and tested the proto type of linear motion bucket wheel reclaimer.as per the prototype the bucket wheel consumed 0.108watts,luffing mechanism consumed 0.1293watts and belt consumed 0.6092watts.It consumed less power compared to arc motion bucket wheel reclaimer.

IX. ACKNOWLEDGEMENT

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