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MECHANICAL CALCULATION FOR REPOWERING OF A DRUM RECLAIMER RT-6001

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Abstract. *Drum reclaimers were initially developed to meet the needs of the mining process plants to ensure good dispersion of the material, increase recovery rates and ensure minimal degradation of particle size. This paper presents calculation steps of the efforts needed for the repowering of a drum reclaimer. The equipment in this study has a capacity of 4667 ton/h and need to reach a capacity of 5644 ton/h. The main objective of this study is to assess the need to change the drum drive, the drive of the translation and the belt conveyor drive. The calculations were based on international standards for handling and transportation of materials. The results showed the need to increase the forward speed of the reclaimer and the need to replace the gearmotor of the translation and the belt conveyor.*

Keywords: *Drum reclaimer, repowering, capacity*

1. INTRODUCTION

One of the big problems in the mining industry are fluctuations in the homogeneity of the iron ore that significantly affect the performance of processing plants. Thus, it is necessary a control of this variability. Homogenizing piles are one of the most common forms of homogenization and reduction of iron ore variability that feeds a mineral processing unit or the market directly. One way to build these piles consists of storing the material from the mining in horizontal layers and later resume them [Mular, 2002].

Drum reclaimers were initially developed and introduced within 30 years in order to meet the needs of process plants for the purpose of better homogenization of the material, increase rates of material recovery and ensure minimal degradation of particle size. [WET, 2013]. Reclaimers are designed to reclaim bulk materials from stockpiles at mines, ports, steel plants, power stations, etc. ina quick, efficient and orderly way. They are available in several main types, including bucket wheel, scraper and drum-type reclaimers, and in many configurations and sizes, with capacities from 500 to 20 000 tones per hour and more. The choiceof design depends on factors such as the size and shape of the stockpile, the type of material to be reclaimed, the requiredreclaiming rate and the need for blending or homogenization [Sandvik, 2008; Metso, 2010].

The drum reclaimers (Figure 1) consist of a horizontal drum with 3 to 4 meters in diameter that extends to the base of the iron ore piles. The drum has a series of buckets mounted on its circumference to collect the material while the reclaimer moves on the piles. The buckets discharge the material on a conveyor belt. The system also employs a rake (cutting pile) responsible for the material sliding toward the bucket drum [Wohlbier 1971].

Some projects about repowering of drum reclaimers can be found in the literature. IMASA [2004] present a project for the refurbishment of the reclaimer drums for the sinter mineral park at the factory of Gijón (Spain), including the supply of drum and hoppers, the supply of conveyor belt, the supply of new charging table and the assembly of the facility.

The repowering process is of great importance when it is necessary to modify the operating parameters of a device to avoid failures of components. Several studies about catastrophic failures in reclaimers can be found in the literature. Ghosal el al [2008] present a catastrophic failure of a Stacker-cum-Reclaimer led to loss of several days of service in one ore handling plant. The failure analysis included a visual inspection of the failed structure, metallographic studies, static stress and stability analysis under normal operating conditions, stress analysis for a possible impact load on the structure, experimental stress analysis, and fatigue life cycle analysis.

Araujo el at [2012] presents the structural collapse of an iron-ore bucket-wheel stacker reclaimer at the beginning of operation. The failure was investigated by means of mechanical tests, microstructural characterization, and computational structural analysis.

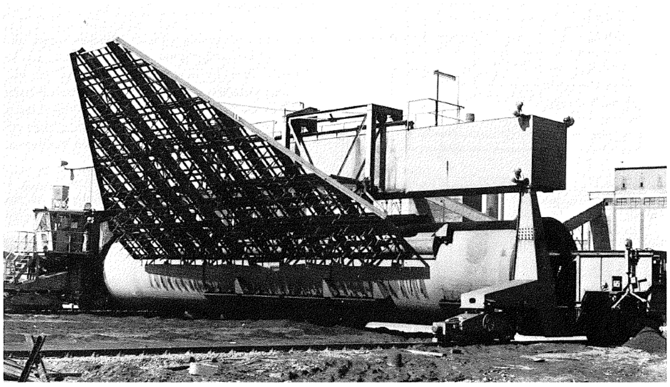

Figure 1. Drum Reclaimer [Wohlbier, 1971].

This work aims to conduct the mechanical calculation for repowering the reclaimer RT-6001 drum by changing their capacity to 4667 t/h of ore to 5655 t/h, to meet the new demand of the plant. The resizing comprises setting the following parameters: advance speed of the reclaimer; power to drum drive; power for belt conveyor drive. Drive systems of the translation of the reclaimer and rake were also checked.

2. METHODS AND RESULTS

2.1 Projetc Data

Table 1 shows the material data to be retrieved, as well as the design characteristics.

Table 1.Data of the material to be recovered.

Material	Hematite
Density	3.6 t/m^3
Accommodation angle	20°
Repose angle	38°
Granulometry	< 8 mm
Pile width	28.36 m
Pile height	11.68 m
Nominal capacity	4241 t/h
Design capacity	5655 t/h
Temperature	40 °C

2.2 Forward speed of the reclaimer

Considering the condition of repowering, the desired capacity is 5655 t/h (1570 m^3/h). The new capacity corresponds to an increase of 21% over current capacity, requiring new calculations of the rate of advance. The rate of advance is a function of the cross sectional area of the pile and the desired capacity, as shown in equation (1):

$$\boldsymbol{V = \frac{(2*Qm)}{(60*B*H)}} \tag{1}$$

where:
V = rate of advance of the reclaimer [m/min]
Qm = capacity of the reclaimer [m^3/h]
B= width of the cross section of the pile [m]
H=height of cross section of the pile [m]

Substituting the known values, the required advance speed is calculated by:

$$\boldsymbol{V} = \frac{\boldsymbol{2x1570}}{(\boldsymbol{60x28{,}36x11{,}68})} = 15.81 cm/min \tag{2}$$

2.3 Drum Drive System

To drum drive of the calculation are considered the tangential forces and the ore elevation. Different from bucket wheel reclaimers the drum reclaimers have no lateral cutting forces, since the buckets have no transverse movement relative to the iron ore piles.

The Tangential Cutting Force refers to the effort that the bucket wheel or drum are subjected to recover the ore pile. The lifting force refers to the relative amount of ore which a certain number of buckets increases until chute height during recovery, on the vertical upward direction. To determine the tangential force was used the method proposed by FEM [1997].

$$\mathrm{F_t} = \frac{\mathrm{f_A.c.A}}{\Psi} \tag{3}$$

where:

f_A: is the shear strength refers to the transverse cutting section

c : is the relationship between cutting height and the bucket wheel radius

A : is the is the cross-sectional area of cut

Ψis the number of buckets on the drum perimeter ($\Psi = \frac{2\pi}{z}$)

Table 2 shows the input data necessary to calculate the cutting forces and elevation.

Table2. Input data for the calculation of cutting forces and elevation.

Input Data	Value
Translation speed	15.81 cm/min
Material density	3.6 t/m^3
Design capacity	5655 t/h
Drum Speed	4.2 rpm
Bucket length	1.84 m
Bucket width	0.71 m
Bucket volume	0.64 m^3
Number of buckets	6
Bucket wheel radius	2.7 m
Cross-sectional area of cut	1385.26 cm^2

From the Ludwigcurve [1975] to a cutting surface equal to 1385.26 cm^2, the cut resistance f_A is equal to 1.9 kgf/cm^2. For c=1 andΨ= $\frac{2\pi}{6}$, is obtained:

$$\mathrm{F_t} = \frac{1{,}9 \times 1 \times 1385{,}26 \times 6}{2\pi} = 2514.64\text{kgf} = 24.669 \text{ kN} \tag{3}$$

To calculate the cutting power, the tangential velocity of the wheel lift (V_t) must be calculated:

$$\mathrm{V_t} = \frac{\pi \mathrm{xDxn}}{60} = \frac{\pi \times 5.4 \times 4.2}{60} = 1.187 \mathrm{m/s} \tag{4}$$

The power required to excavate the material:

$$N_{Dig} = F_t x V_t = 24.669\, x 1.187 = 29.26\, kW \tag{5}$$

FEM [1997] determined that the power required to elevate the material can be obtained by the following relationship:

$$\mathrm{N_{Lift}} = \frac{\beta * \mathrm{R} * \gamma}{367} * \mathrm{Q_{eff}}[\mathrm{kw}] \tag{6}$$

where:

γ : density of the material

$\beta * R$: height that the excavated material is elevated up to be discharged ($1 < \beta < 1{,}2$)
Q_{eff} : effective output material in m^3/h

For $\gamma = 3.6\ t/m^3$, R= 2.7 m, $\beta = 1.2$ and Q_{eff} =1570 m^3/h:

$$N_{Lift} = \frac{1.2 \times 2.7 \times 3.6}{367} * 1570 = 49.90 \text{ kw} \quad (7)$$

The friction power is a function of design capacity and coefficient of friction ($\mu = 0.27$).

$$P_{fric} = \frac{m_{des}}{3600} * g * \mu * R = \frac{5665}{3600} x\ 9.81\ \ x\ 0.27\ x\ 2.7 = 11.23 \text{ kw} \quad (8)$$

The total power required to excavate the material is calculated by summing the effort to dig and lift the material and the friction.

$$N = N_{Dig} + N_{Lift} + N_{fric} = 29.26 + 49.90 + 11.23 = 90.39\ kw \quad (9)$$

Verification of the drum drive motor power is prepared in Table 3. The motor utilization rate is 0.82 indicating that the engine is sufficient capacity specified for the repowering.

Table3. Verification of the power of the drum drive motor

Description	Value
Power installed	55 Kw x 2
Required power	90.39 Kw
Use Index	0.82

2.4 The Conveyor Belt Drive System

Table 4 shows the data for the conveyor belt of the reclaimer.

Table 4.Technical data of the conveyor belt.

Description	Value
Distance between drums	33.6 m
Diameter of the drive drum	670 mm
Belt width	1200 mm
Drive power	56 kW
Rotation of the drive drum	90.458 rpm
Filling Rate	75 %

The verification of the conveyor drive system was performed according to standard CEMA (2007) and ISO-5049 (1994) .Using the initial information, the first step in the conveyor design is determining the transport speed to the desired capacity. This speed is a function of volumetric capacity (C in m^3/h), the volumetric capacity to V = 1.0 m/s (C_t in m^3/h) and the inclination correction factor (K). For the conveyor belt of the reclaimer, $C_t = 627 m^3/h$ and k=0.98:

$$V = \frac{C}{C_t\ x\ k} = \frac{1570.83}{627\ x\ 0.98} = 2.56\ m/s \quad (10)$$

Due to the specification of the area, a degree of filling equal to 75% was adopted. The conveyor speed was:

$$V = \frac{2.56}{0.75} = 3.42\ m/s \quad (11)$$

With this speed value, the effective power required for the material transport is then calculated, using an effective stress calculated Te = 18.645 kN. A mechanical yield of 92% was considered.

$$N_e = \frac{T_e \times V}{\eta} = \frac{18.645x3.42}{0.92} = 68.64kW \quad (12)$$

3. CONCLUSIONS

For repowering of the reclaimer is required to fitness for a forward speed of 15.81 cm / min. The current drive power of the drum showed enough to meet the new demand, since the original equipment engines have installed power of 110 kW and the new calculated power was 90.39 kW. For the belt conveyor meets the new capability, the minimum belt speed should be 3.42 m / s, with a degree of filling of 75%. In the current configuration the belt speed is 3.17 m / s with the same degree of filling. The power currently installed on the conveyor drive is 65 kW. To meet the new condition the power of the belt conveyor drive must be changed, since the power calculated for the transport of the material was 68.64 kW. The current drive of the translation and rake systems meet the new condition.

4. ACKNOWLEDGEMENTS

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