International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Research Article)

Enhancing filtration efficiency: A study on moisture reduction in iron ore concentrates

Ratnakar Bonda [1], P. Sharath Kumar [1,*] and Attel Umashankar [2]

[1] *Department of Mineral Processing, Vijayanagara Sri krishnadevraya University Ballari, Karnataka, India.*

[2] *JSW Steels, Vijayanagara works, Toranagallu, Karnataka, India.*

International Journal of Science and Research Archive, 2025, 14(01), 1774-1779

Publication history: Received on 15 December 2024; revised on 22 January 2025; accepted on 25 January 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.14.1.0249

Abstract

Filtration is one of the Dewatering unit operations used in an Iron ore beneficiation plant to reduce the moisture % of the concentrated slurry. The moisture content of 9.50±0.50 % is desirable for Iron ore Pelletization plants to achieve desired green pellets for producing the required Tumbler Index. JSW Steel Limited includes beneficiation operation of capacity 23.6 MTPA. The integrated steel plants receive the iron ore resources from the local mines leading to large dissimilarities in the ore nature lead to beneficiation complex. which will finally increase the cost of pellet production affects the pellet quality. The moisture reduction in the iron ore concentrate filtration depends on solids concentration of the feed slurry, slurry flow rate (L/min), feed duration (min), density of the slurry, filter pressure (bar), filter hold time (min), air flow rate (L/min). In this paper, an attempt has been made to optimize the above said variables to obtain the filter cake of <10% moisture for pellet manufacturing. The validation study was done using statistical tools. The study resulted a final cake moisture 9.75 % suited for the quality pellet making operations.

Keywords: Moisture; Pulp density; Vertical pressure filter; Concentrate; Iron ore

1. Introduction

Filtration of iron ore concentrate gained much importance in recent times to reduce the operation time for pellet manufacturers. Despite of dry grinding followed by pellet makers, the beneficiation plant plants requires large amount of water to convert low grade resources in to quality concentrates. A mineral processing using wet method ultimately requires a efficient filters to supply right level of moisture in the iron ore concentrates. The challenges in filtration starts with extremely fine and ultrafine particles, which tend to adhere to the relatively coarser particles and due to their extremely high surface area have high energy of hydration and are responsible for high moisture content also blind the filter cloth leads to difficulty in cake release properties. Many existing concentrators and metallurgical plants have replaced or are replacing their vacuum filters by pressure filters (I. Townsend 2003) due to high ultra-slimes. The lower filtration rates and higher filter cake moistures indicate that dewatering of iron ore concentrate is generally more difficult. Ceramic filtration is best suited to dewatering slurries with high and consistent solids concentration and with particles in a size range between 30 µm and 150 µm (Pirkonen et al., 2010).An equivalent traditional vacuum filter unit would require about 10% more energy to create a similarly high vacuum owing to high air leakage through the filter cake(Gorres & Hindstrom, 2007).Optimization of slurry and operational conditions together with adherence to appropriate maintenance regimes would facilitate the achievement of sufficient filtration capacities with the requisite filter cake moisture content. Thus ceramic filtration is considered a suitable method for the metallurgical process of dewatering of iron-ore concentrate (J Smith et al 2018).

*Corresponding author: P. S Kumar

Copyright © 2025 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution Liscense 4.0.

The pressure filtration properties of slurries are affected by several particle properties, for instance the size and shape of the particles, the shape of the size distribution, and interactions between the liquid and the particles (Moat et al., 2003; Wakeman, 2007; Yu et al., 2017). Filtration can be made easier by a couple of methods based on changing the properties of the slurry. Pretreatment methods, such as slurry thickening, flocculation and particle classification are typically used in the mining and minerals processing industries (Anlauf et al., 2004; Hogg, 2000; Rushton et al., 2000). When the feed slurry contains very fine particles, which make the filtration challenging, the use of flocculants may be the most realistic, although not very cost-effective, option to improve the filtration capacity.

The earlier works have elaborated the importance and challenges of vacuum filtration and ceramic filter in iron ore concentrate filtration. Scanty works have been observed on the pressure filtration technology is available but process improvement at plant scale and laboratory studies are not available The area under study, JSW Steel Limited of Bellary District, Karnataka receiving the 30 mines of material with blending combinations of about 1500 No and huge variation in physical and chemical charctertics. The lower filtration rates and higher filter cake moisture leads to higher pellet moisture and its effect shown in figure 1.

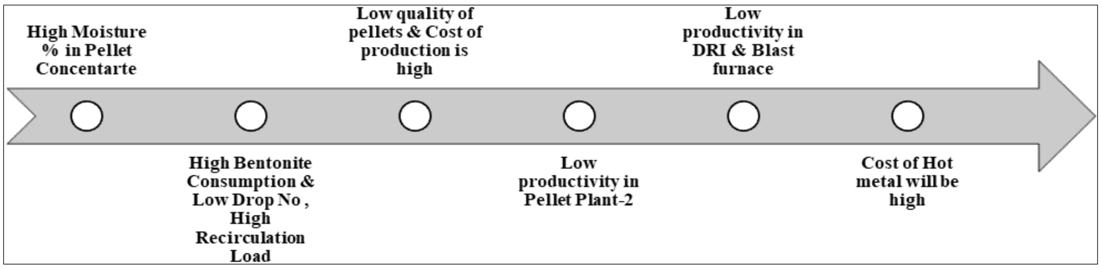

Figure 1 Effect of higher moisture percentages in iron making

2. Methodology

The samples analyzed during the filtration pilot tests refer to six iron ore resources of the study region. The composite sample by equal ration blending of a-f samples show distinct mineralogical features and chemical compositions; so that the filtration response can only be related to the physical and chemical effects. The composite sample composed by six different ore concentrates. The chemical composition of these six concentrates designated as samples A, B, C, D, E and F are presented in Table 1. The samples A, B, C, D, E and F are obtained via conventional beneficiation circuit consisted of grinding, gravity separation and magnetic separation followed by thickening operations. Those typical iron ore sample concentrates are produced in the daily industrial routine of the pelletizing plant is analyzed for filter cake moisture. The feed density, input pressure, holding time and air flow rates were studied to achieve the optimum final filter cake moisture with a constant feed rate of 5 lit/min as shown in the table 2.

The mineralogical characteristics of the feed samples were determined in four size class intervals 1000 μ, -1000+106 μ , -106+45 μ and -45μ. The scanning electron microscope (SEM) images of six different iron ore resources were shown in figure 2. Six different iron ore concentrates shows the presence of hematite, martitic hematite and goethite. It is also observed that, the porosity of the martitic hematite grains, magnetite transformation to hematite (Barbosa & Lagoeiro, 2009; Barbosa et al., 2011). The coexistence of hematite with goethite characterizes the hematite-goethite aggregates. Composite sample by mixing a to f samples were prepared and submitted to the grinding process in order to obtain a product with specific surface area of 1,800 cm^2/g. This condition guarantees a product size below 45μ. The determination of specific surface area values was conducted. The real density was determined by a gas pycnometer. The quantification of the moisture was made based on the difference between the mass of the natural sample before and after being dried in a lab for an hour at 105 °C. During the filtration tests, the vacuum pressure was set at 0.84 kg/cm2, the pulp density was maintained at 2.30 kg/L, and the final desired moisture for the filtered cake set between 8.5% and 9.5%. These conditions are kept the same as the applied to industrial operations.

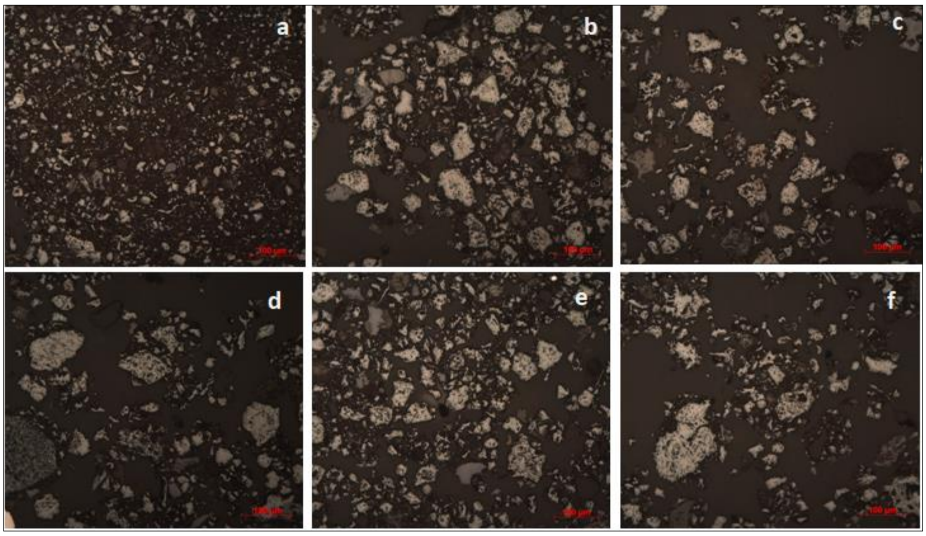

Figure 2 Scanning Electron microscopy images of the iron ore concentrates obtained from iron ore resources (a to f)

Table 1 Chemical composition of the iron ore resources and composite sample

Sample ID	Fe(T) %	SiO2 %	Al2O3 %	CaO %	MgO %	MnO %	TiO2 %	P %	S %	Na2O %	K2O %	LOI %
a	62.84	6.24	3.46	2.13	0.91	0.08	0.18	0.03	0.01	0.07	0.02	0.00
b	61.24	6.04	3.40	3.03	0.87	0.05	0.18	0.04	0.01	0.07	0.04	0.94
c	62.31	5.95	3.41	3.98	0.83	0.08	0.18	0.03	0.01	0.05	0.02	0.07
d	61.58	5.94	3.39	5.05	0.83	0.09	0.17	0.03	0.01	0.08	0.02	0.07
e	62.21	5.65	3.21	3.78	0.83	0.09	0.11	0.03	0.01	0.05	0.02	0.06
f	62.35	5.84	3.38	6.05	0.79	0.08	0.16	0.04	0.01	0.05	0.02	0.22
Composite	62.09	5.94	3.38	4.00	0.84	0.08	0.16	0.03	0.01	0.06	0.02	0.23

3. Results and Discussions

The experimental design is developed by identifying the key variables of the Vertical Pressure filter (VPF) using cycle time analysis. Table 2 shows the experimental design. Variable like feed rate and feed time is kept constant to study the effect of iron ore slurry pulp density, input pressure, holding time and air flow rates on the cake moisture.

Table 2 Experimental Design

Parameters	Variables						
Feed rate(L/min)	5						
Feed time(min)	4	4	4	4	4	4	4
Pulp Density	1.3	1.4	1.5	1.6	1.7	1.8	1.9
Pressure(bar)	8.5	9.0	9.5	10	10.5	11	11.5
Hold time(min)	1	2	3	4	5	6	-
Rate of Air flow(L/min)	200	250	300	350	400	450	500

3.1. Effect of pulp density

Figure 3 shows the effect of pulp density on the filter cake moisture. The study revealed that, at 1.7 g/cc of pulp density results lower cake moisture of 9.6% at 10.5 bar of pressure. Figure 3 also shows that as the feed density increases from 1.3 to 1.7 g/ccs the moisture level in the cake decreased, further increase in the pulp density reduces the filtration performance attributed to the resistance to filtration increases with an increase in the pulp density. This can be ascribed to the excellent resistance of the flowing water through the particle bed of higher volume. The solids composition will affect the filtration rate through density, surface charges, and compressibility. Higher feed solids concentration will increase the filtration rate. There is a direct relationship between filtration rate and cake moisture, and higher filtration rates can be achieved at the expense of higher filter cake moisture.

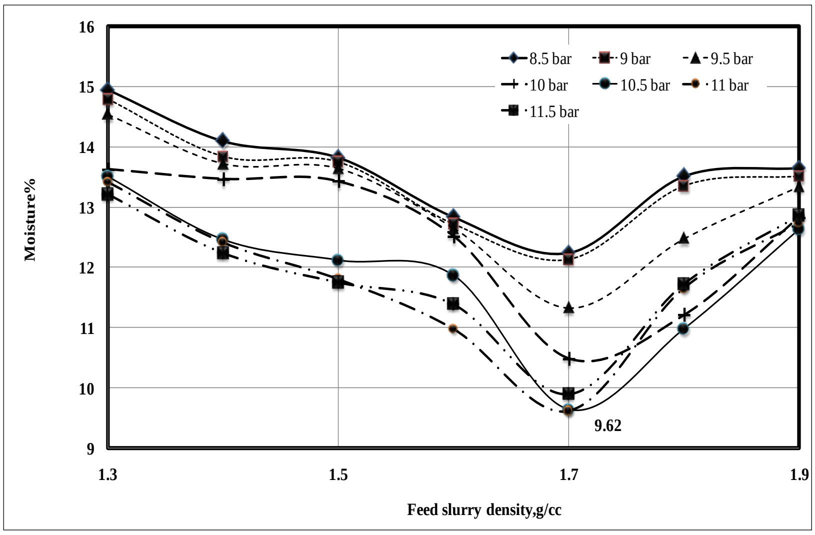

Figure 3 Effect of Feed density on the % moisture at different pressure levels

3.2. Effect of pressure

Figure 4 shows the statistical inference of the pressure variation in the VP-filter. It was found thatthe filter operates with an airpressure (bar) from 5.4 to 8.4 with a mean value of 6.9 Bar. The effect of air pressure on the % moisture is shown in the figure 5. From the figure 5 it is observed that, as the air pressure increases, the moisture decreased to minimum. The air blowing is required not only to to displace the residual Moisture also to the fill pore spaces, and prevent contact between the solids and drying air. The variation in the final cake Moisture attributes to variation in Air pressure. From the Figure 5 it is clearly indicates that, the 1.7 g/cc of pulp density reaches the minimum cake moisture of 9.5% at 10.5 bars of air pressure.

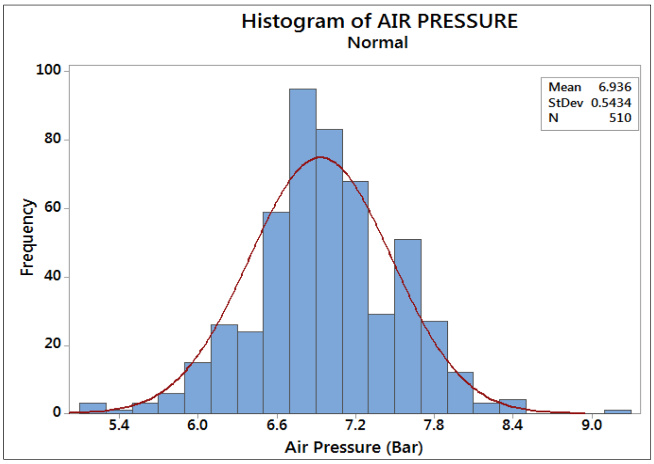

Figure 4 Air Pressure Variation in VPA

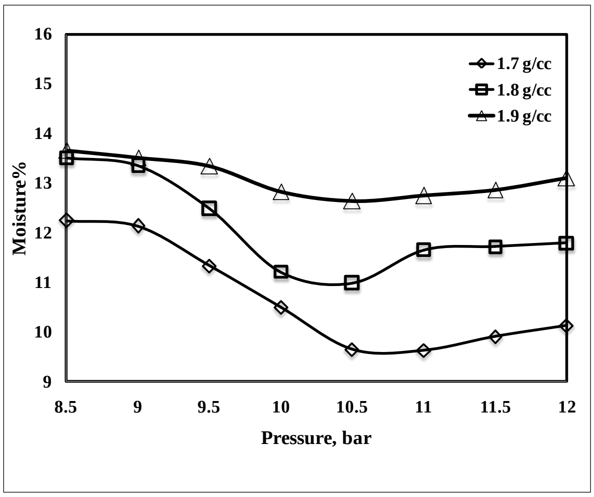

Figure 5 Effect of air pressure on the final cake moisture

3.3. Effect of Hold time

Air pressure duration (hold time) was varied from 1min to 5 min while other process variables were kept constant as 1.7 pulp density and 10.5 bar pressure was maintained. Figure 6 indicates that, as the hold time increases the final cake moisture dropped and stabilized at 4min which attributes to no change in the shear strains on the filter cake.

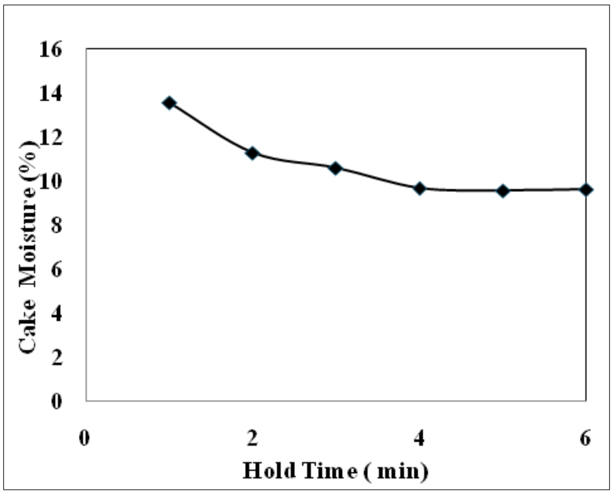

Figure 6 Air pressure duration (hold time)

3.4. Industrial Scale Studies

After analyzing the process data, the parameters like pulp density, air pressure and hold time are revisited at the industrial scale of VPA operations. It was observed that the air pressure (bar) to the filter varies between 5.4 and 8.4 bar, with a mean of 6.9 bar, as illustrated in Fig. 4. The variation in air pressure significantly impacts the final cake moisture. The air pressure found to be in the range of 6 to 7 bar, which is recorded as minimum. The consumption of drying air and the efficiency of cake blowing are influenced by earlier phases of the filtration cycle. A comprehensive analysis of the compressor discharge to the VPA has been conducted. Air blowing typically occurs between 1 - 4 minutes. For larger filters, a dedicated drying air receiver is essential, ideally equipped with an air supply and regulated air pressure. The optimal solution recommends a dedicated air compressor and receiver with adjustable pressure regulation and PID control of the airflow rate. To mitigate variations in air pressure, the control valve maintains the designated pressure, relieving any excess. As a result, airline pressure can be reliably maintained at >6.9 bar, ensuring quality output.

4. Conclusion

The implementation of Lean and Statistical tools was instrumental in identifying the root causes of these issues and developing effective strategies for their resolution. Three primary strategies were utilized: optimizing air consumption, and managing feed density using Poka-yoke techniques. By maintaining higher feed density successfully sustained moisture levels below 9.75%. The industrial VPA filter operation maintained through consistent feed density of over 2.10-2.15 gm/cc and air pressure greater than 7.2 bar. Furthermore, achieving an optimal feed density has enhanced feed filtration time and reduced overall cycle duration. Consistent feed density is crucial for ensuring cake moisture levels in the VPA. Ultimately, the study yields a impressive final results, reducing moisture from 10.06% to below 9.75%.

Compliance with ethical standards

Acknowledgments

The authors sincerely thank JSW Steel Limited, Vijayanagar Works, and Karnataka for allowing them to publish this paper.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] J. Smitha, C. Sheridana, L. van Dyka, S. Naikb, N. Plintc, H.D.G. Turrerd “Optimal ceramic filtration operating conditions for an iron-ore concentrate” Minerals Engineering 115 (2018) 1–3.

[2] B. P. Singh & L. Besra (1997) The Effect of Flocculants and Surfactants on the Filtration Dewatering of Iron Ore Fines, Separation Science and Technology, 32:13, 2201-2219, DOI: 10.1080/01496399708000764.

[3] M. Dash, R.K. Dwari*, S.K. Biswal, P.S.R. Reddy, P. Chattopadhyay, B.K. Mishra “Studies on the effect of flocculent adsorption on the dewatering of iron ore Tailings” Chemical Engineering Journal 173 (2011) 318– 325

[4] I. Townsend “Automatic pressure filtration in mining and metallurgy” Minerals Engineering 16 (2003) 165–173

[5] Gorres, G., Hindstrom, R., 2007. Some Experiences with Modern Dewatering Technologies in Fine Iron Ore Application. Perth WA, 20–22 August

[6] Pirkonen, P., Grönroos, J., Heikkinen, J., Ekberg, B., 2010. Ultrasound Assisted Cleaning of Ceramic Capillary Filter. Ultrason. Sonochem. pp. 1060–1065

[7] Salmimies, R., Kallas, J., Ekberg, B., Görres, G., Andreassen, J.P., Häkkinen, A., Beck, R., 2013. The scaling and regeneration of ceramic filter medium used in the dewatering of magnetite concentrate. Int. J. Miner. Process. 119, 21–26.

[8] Larox Corporation, 2007. Larox Ceramic Filters Brochure.

[9] Mota, M., Teixeira, J.A., Bowen, W.R., Welshin, A., 2003. Interference of coarse and fine particles of different shape in mixed porous beds and filter cakes. Miner. Eng. 16, 135–144.

[10] Wakeman, R., 2007. The influence of particle properties on filtration. Sep. Purif. Technol. 58, 234–241.

[11] Yu, J.-F., Fu, J., Cheng, H., Cui, Z., 2017. Recyclinf of rare earth particle by mini-hydrocyclones. Waste Manage. 61, 362–371.

[12] Anlauf, H., Sorrentino, J.A., 2004. The influence of particle collective characteristics on cake filtration results. Chem. Eng. Technol. 27 (10), 1080–1084.

[13] Rushton, A., Ward, W.S., Holdich, R.G., 2000. Solid-Liquid Filtration and Separation Technology, second ed. Wiley-VCH, Weinheim.

[14] Hogg, R., 2000. Flocculation and dewatering. Int. J. Miner. Process. 58, 223–236.