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Rheological Portrayal of Zinc Ore and Iron Ore Minerals

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Abstract
In the present investigation rheological conduct and portrayal of minerals are researched by utilizing Anton PaarRheolabQCrheometer to create broad rheological information. Two kinds of minerals viz. iron oreand zinc ore were taken for examination. The molecule size dispersion, pH, Scanning Electron Microscopy (SEM) investigation, Energy Dispersive Spectroscopy (EDS) and so on was examined utilizing different seat scale test with standard method. The rheology of mineral suspension with the variety of solids focus, temperature, and portion of coarse particles are performed. The rheological information demonstrates that upto 30% strong focus, mineral suspension demonstrates Newtonian conduct and past this shows non-Newtonian conduct. The rheological examination of the finner particulate of mineral suspension of iron metal and zinc mineral slurry is additionally done with the option of coarser particulate. It is seen that thickness of both mineral suspension are improved. The temperature impact on the rheological properties of mineral suspension likewise considered. The rheological information acquired was utilized to assess the weight drop of mineral metal slurry moving through straight pipe. It is discovered that for mineral slurry coursing through pipeline the weight drop increments with increment in speed and strong fixation.

Keywords: *Iron ore, Zinc ore, Rheology, Pressure drop, Ph.*

I. INTRODUCTION

Mining is considered as an undertaking of mankind conceded farming. The two enterprises considered as fundamental or essential ventures of the antiquated human progress. In spite of the fact that, on the off chance that we think about angling, blundering and farming as one section, acquiring and preparing of oil and gas with mining comparatively, at that point horticulture and mining are the essential source to satisfy all the fundamental needs of over a significant time span progress. From ancient time to exhibit, mining industry assumes significant job in the progression of human presence (Madigan1981). The term digging here is utilized for the extraction of normally happening mineral issues, for example, solids, (metals for example iron, aluminum, zinc, coal and so forth.) fluids, (petrochemical items, for example, fuel) and gases (gaseous petrol and so forth.) from the world's outside layer or intensely bodies for utilitarian purposes. The mining history is fascinating and move parallel with the history. Likewise, numerous significant social times and progressions are aligned with it and considered by numerous minerals or their subsidiaries as period preceding 4000 B.C.E perceived as Stone Age, period around 4000 to

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5000 B.C.E known as the Bronze Age, the time from 1500 B.C.E to 1780 B.C.E beginning time of human advancement called Iron Age, the time of iron derivate from 1780 to 1945 distinguished as Steel Age and Nuclear Age the time after the World War-II for example from 1945 to till now. Different mileposts of mankind's history, for example, voyage of Macro Polo's to China and Vasco da Gama's undertakings of India just as Africa, the revelation of New World by Columbus and the cutting edge blast toward gold that lead to the foundation of California, Australia, Alaska, South and North America were achieved with mineral giving a significant motivating force (Rickard 1932). Some other surprising and invigorating realities about the historical backdrop of mining and metallurgical industry likewise announced in the chronicled records of Gregory (1980), Raymond (1984). Mining industry assumes an essential job in each part of advancement it might be social, monetary and mechanical improvement. The expansion in populace and headway in innovation is additionally expanding the requests of crude material for industry which results in increment of mining activity. Presently a-days, mining industry contributes nearly in each field, for example, farming, transportation, development, vitality, wellbeing and so on.

Iron-mineral

Minerals are separated from the world's covering and from overwhelming rocks. More often than not, minerals are established in the structure diverse synthetic mixes in nature which is commonly known as metal. The earth covering contains almost 5% of iron normally and it is one of the most bounteous components in earth's outside which is being utilized broadly from 6000 years roughly. Likewise, iron is a structure square of modern upset as it is one of the least expensive and most grounded metals. Australia, Brazil, India and China are the biggest makers of the iron-metal in globe. Magnetite and Hematite are the most extravagant wellspring of iron anyway the extraction of iron from carbonates and sulfide metals isn't prudent. In India, hematite metal is found in Madhya Pradesh, Jamshedpur, Madras, Mysore, Noamondi, and so forth though magnetite is found in Mysore, Salem and Trichinopoly. Siderite is found in Raniganj (West Bengal).

Minerals are separated from the world's hull and from substantial rocks. Essentially, minerals are established as various synthetic mixes which is called metal. Tailings are the materials left after the extraction of important parts from the mineral. Mine tailings are generally created in slurry structure, which is the blend of water and mineral particles. The store was initially a metal before encountering a transformative occasion. 1 billion years prior, the high-grade transformative occasion is estimated to happen. There are a couple of sulfides and oxides present inside the mineral. Gahnite and rutile are the most extravagant wellspring of zinc metal. Tailings comprise of ground shake and procedure effluents that are produced in mine preparing plant. To remove the ideal item from the mine metal mechanical and concoction procedure are utilized and the lingering abandoned is known as tailings. The extraction procedure is rarely 100% proficient. At that point the uneconomic metals, minerals and procedure water are released as slurry to the capacity region which is known as Tailings storeroom (TSF).

Rheology

Liquid is a substance which experiences limitless distortion when power is applied on it. Rheology characterized as the investigation of development of issue, by and large in watery state, or as 'delicate strong' for example strong that experiences plastic stream affected by sensible power and stayed disfigured under certain condition (Morrison, 2001; Antony N. Beris, 2014). As it were, it is characterized as investigation of liquid conduct affected by applied

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power. Notwithstanding, on liquid just ordinary compressible and shear pressure can be applied while in rheology by and large investigation of liquid conduct is done affected by applied shear pressure. Typically two plate model is utilized to examine the conduct of liquid.

Different rheological models

Rheology depicts the patterns of non-Newtonian liquid by deciding the parameters required to create relationship among the distortion rate and shear pressure. The state of bend mirrors the classification of the stream. So as to decide the different parameters, the distinctive rheological models are utilized. The significantly utilized rheological models are recorded in Table 1.1. Two parameter rheological models are broadly used to think about the liquid stream conduct. As Bingham model is utilized to ponder the stream conduct of oil penetrating liquid and various sort muds though Power law is utilized examination the rheology of delicate strong, for example, coal and debris slurry. Casson model is utilized for visco-plastic liquids which have wide application to display the progression of blood. Thus, Herschel-Bulkley is utilized to ponder the rheology of slurry shaped by hard solids, for example, iron-metal however all of previously mentioned models have been discovered a decent estimation for different fields like rheology of nourishment item and polymer and so on.

II. LITERATURE REVIEW

A ton of research has been finished by numerous specialists on the rheology of the slurry suspensions, which set establishment for the present examination. A few factors that contribute in modifying the rheological conduct of mineral slurry has been explored by analysts and an ideal worth that advances a monetary slurry transport with an obvious thickness in a specific shear rate range has been found. Yavuz et al. (1998) examine impact of molecule size on the rheology of lignite - water slurry. The acquired example of lignite was sieved into six diverse molecule sizes: <45, 45 - 53, 53 - 63, 63 - 75, 75 - 90, 90 - 125 μm. Rheology tests were performed at strong grouping of 60% by weight at room temperature (for example 20°C). They depicts that the better particles had high consistency esteem which isn't reasonable for the transportation of slurry at higher fixation. Anyway with the mixing of courser molecule (90-125 μm), consistency of lignite slurry was improved. Ghantaet al. (2002) study the impact of molecule size dissemination, focus and surface properties by taking coal and copper metal slurry. They found that thickness of coal slurry suspension is decreased with expanding molecule size of coal, while if there should arise an occurrence of copper metal as molecule size builds consistency. They additionally saw that rheology of fine particulate slurry suspension improved with the option of coarse molecule of debris. He et al. (2004) played out an outline about the test studies led by past specialists on rheology of ultrafine pounding of modern minerals. They condensed crafted by past scientists used to demonstrating rheological conduct of slurries and the strategies for the portrayal of the suspension. The semi-observational model including slurry rheology, solids focus, and molecule size and slurry temperature was depicted. They revealed that the various parameters, for example, molecule size, strong focus and circulation, molecule shape temperature and pH influences the rheology of the slurry arranged by ultrafine granulating of modern minerals. Yang and Aldrich (2005) performed experimentation within the sight of attractive field on watery suspension of magnetite mineral molecule size of 75 □ m to research the stream conduct. They revealed that non-charged slurry above 30% strong fixation by weight display Bingham plastic conduct while when the slurry suspension presented to outer attractive field of 41×10-4 T, the stream conduct can be depicted by Herschel-Bulkley with stream record (n) run from 0.38 to 0.9. Yuchi et al. (2005) played out an

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investigation on multivariate relapse examination of sixteen examples coals secured from different mines of China with various positions of coal fluctuate between lignite to anthracite to discover the relationships between's eighteen distinct parameters from forty coal properties. They found that the carbon substance and grindability record of coal demonstrates positive connection with the slurryability while substance of dampness present in air at harmony and surface zone found by mercury porosimeter brings about negative effect. The rheological conduct of coal water slurry related emphatically with debris content, solvent particles, and volume of pore analyzed by Mercury porosimeter while zeta potential properties of surface of the coal impacts adversely on the rheological conduct of coal water slurry.

Roy and Das (2008) considered the impact of geochemical and mineralogical attributes on beneficiation procedure of poor quality iron metal example obtained from Bellary-Hospet part, India. They found that the significant gangue components are goethite, magnetite and limonite present in modest quantity. Notwithstanding, the Electron minute examinations uncovered that the size of gibbsite grains changing from 10 to 50 microns and related with the iron stage. The geochemistry information show unfavorable connection of Fe2O3 with silica and alumina. They expressed that if the molecule size of gangue material is excessively fine as look at iron oxide then attractive division strategy is ideal yet on the off chance that the size gangue material and mineral particles are too fine buoyancy when all is said in done and buoyancy in segment specifically circumstance is by all accounts increasingly compelling. Senapati et al. (2009) examined the rheological conduct of lime-water slurry at various strong fixation (by volume), molecule size and slurry temperature. They announced that the shear pressure is an immediate capacity of shear rate and carries on as practically Newtonian liquid for the strong focus beneath 30% by weight past which slurry was exceptionally pesudoplastic in nature. They likewise expressed that consistency of limestone mineral slurry diminishes with temperature and the change can be clarified by Arrhenius condition as far as required initiation vitality. Zhou et al. (2010) played out a test study on concentrated suspension of coal water slurry to research the rheological conduct. They arranged slurry from Datlong coal utilizing Haakerheometer and played out a relapse examination on trial information to fit distinctive rheological models. They found that the fluid suspension coal-water at strong centralization of 60 and 70% (by weight) show pseudoplastic conduct. Additionally, the trial information saw as well fitted with two variable rheological model Herschel-Bulkley. Agudo and Navarro (2010) inspected the stream and the morphological attributes of lime putties procured after pressure driven treatment and thought about various morphological parameters and stream conduct. They found that conduct of hard consumed lime and lime putty is non-Newtonian and liquid is rheopectic in nature. Improved reheological conduct was accomplished after hydro-treatment of the hard consumed lime though lime putty become progressively receptive after the treatment because of littler molecule size and huge surface region. Deosarkar and Sathe (2012) examined hypothetical models to research the effect of different variables utilized for anticipating consistency of magnetite-water suspension. Models were fitted to exploratory information of rheology of magnetite metal up to strong centralization of 30%. Slurry tests were set up by utilizing distinctive molecule size of strong, for example, 53, 52.3, 58.4 and 74.8 □ m. The rheogram information to foresee viable thickness of the slurry was best fitted to Liu's model among every one of the six models tried for the expectation. Likewise, the forecast done by utilizing ANN model between the slurry parameters and powerful thickness were discovered all the more near the trial information.

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G. Vieira and E. C. Peres (2012) contemplated the impact twenty distinct added substances on the rheological conduct of concentrate iron-metal water slurry. They revealed that slurry display pesudoplastic conduct and stream conduct can be clarified by Herschel-Bulkley and Bingham model. They found at the measurements 300 g/t: polyacrylic acids (DPW 410, DPW 510, and DPW 610), citrus extract, and sodium hexametaphosphate advanced decrease of the liquid consistency record and the plastic thickness. Though, further increment of measurement to 600 g/t and 900 g/t didn't bring about huge change in the motion bends. Vieira and Peres (2013) researched the impact of regrinding of iron-mineral focus on scattering and rheological qualities of slurry. The regrinding tests were performed under various pH esteem for example 7.3, 8.5 and 10.0 of scattering with the expansion of lime at centralization of 300 g/t. The level of the slurry scattering increments as pH shift from 7.3 to 10.0, however the estimations of yield pressure and obvious thickness saw to be lower, and the particular vitality utilization decreased by 17.4%.

PHYSICAL AND CHEMICAL CHARACTERISTICS

Ph of slurry

Molecule size appropriation is strategy to compute the decent variety present in the size of the particles in an example. The decent variety in molecule size of tests was examined with the assistance of standard mechanical sifter shaker.Table 4.1 portray the insight regarding the level of better present in scope of molecule size. The example is sieved for 30 minutes through arrangement of strainers of size 355, 250, 150, 106 and 53 µm. The heaviness of the particles held on each strainer secured cautiously, determined and communicated in rates. Tests were dried in stove at 105^{O}C for 30 minutes to guarantee that there was no dampness in the example. In S-1, about 52.8% particles were seen as under 53 µm. Roughly 40.8, 4.1, 3.2 and 0.1% were lie in the scope of 53-75, 75-106, 106-150,150-250 and 250-355 µm separately. Anyway in second example S-2 almost 26.4% particles have size under 53 µm. While 26, 39.5, 6.3 and 1.8% particles lie in the scope of 53-75, 75-106, 106-150,150-250 and 250-355 µm individually.

Table Error! No text of specified style in document.**.1** Particle size distribution

Sieve size (micro-meter)	Mesh Size (milli-meter)	Fraction (gm)		Commulative weight %(under)		Commulative weight %(Over)	
		S-1	S-2	S-1	S-2	S-1	S-2
<53	0.053	52.8	26.4	52.8	26.4	45.4	71.8
53-75	0.075	40.5	26	93.3	52.4	7.4	47.6
75-106	0.106	3.1	39.5	96.4	91.9	2.4	5.1
106-150	0.15	3.2	6.3	99.6	98.2	0.1	1.8
150-250	0.25	0.4	1.8	100	100	0	0

Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS)

SEM and EDS are regularly used to examine the morphological trademark and for the quantative

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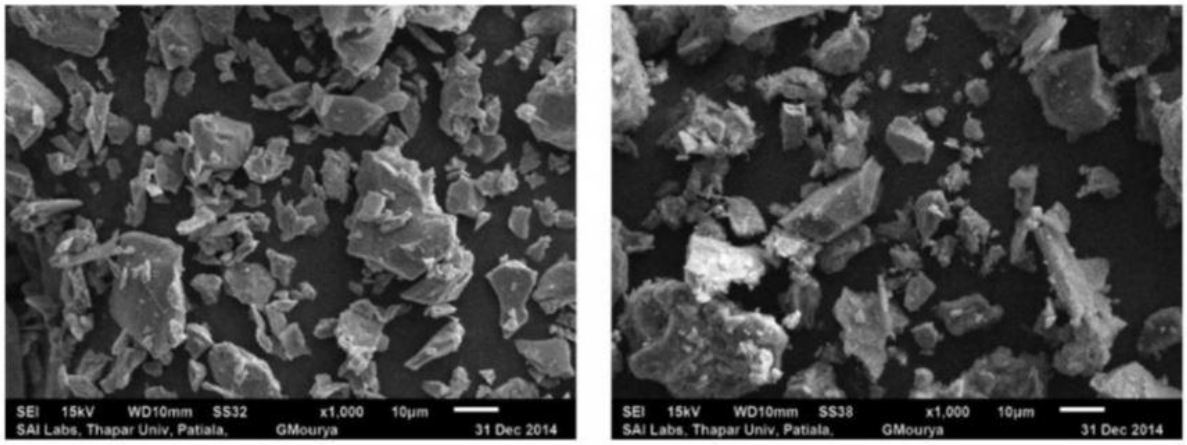
investigation to decide the components present in example. In SEM investigation more noteworthy goals shallow pictures are created due to limit electron shaft which result in an unmistakable 3-D appearance which is helpful in surface examination of the example. The checking electron micrographs of test S-1 and S-2 are appeared in Figure 1 and Figure 2. From figure it was seen that the molecule of iron-mineral were crystalline strands and granular in nature. The white rankle spots in the figure were might be because of the mine fire. The dull regions in the micrographs were generally Fe2O3 while the splendid part of tests was Ti and Si. Titanium was seen in the consequences of compound investigation as slag consideration which may expand the Titanium content in the examples.

The range investigation in EDS gave the insight concerning the different components present in the example. The subtleties of essential creation of tests are classified in Table 2. In range pinnacles were watched consequent to the different components of test. In test S-1 the weight level of Oxygen was seen 21.03% and iron 73.5%. Different components, for example, calcium (Ca), silicon (Si) and aluminum (Al) were available in little extent. Likewise from the range of test S-2 it was seen that the weight level of iron was 65.2% and weight level of oxygen was seen as 28.8%. Additionally EDS examination give insights regarding the different mixes present in test, for example, in test S-1 the compound level of SiO2, TiO2, and FeO was found around 4.37%, 2.52% and 90.81% separately. Anyway in test S-2 the compound rate was found of SiO2, TiO2, and FeO around 17.40%, 3.43% and 76.57%.



S-I S-II

Figure 2: SEM Image of the samples

Table Error! No text of specified style in document.**.2** Elemental compositions of sample S-1 and S-2

Elements		Fe	Si	Ti	Ca	Al
Sample	S-1	73.66	2.26	0.67	0.41	0.58
	S-2	71.2	1.18	0.13	0.25	0.75

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Table Error! No text of specified style in document..**3** Compounds detected in samples

Compounds		FeO	SiO_2	TiO_2	CaO	Al_2O_3
Sample	S-1	91.66	3.61	0.42	0.14	3.25
	S-2	82.57	9.67	4.47	0.68	2.88

IMPACT OF STRONG FOCUS AND TEMPERATURE ON RHEOLOGY OF IRON ORE AND ZINC ORE SLURRY

From figure 3, it is seen that focus have overwhelming impact on the rheological conduct of slurry suspension. Rheogram of test S-I, demonstrates a direct connection between shear pressure and shear rate upto 30% fixation which demonstrates that blend is of Newtonian nature while above 30% focus shear diminishing beginnings which shows Pseudoplastic nature.

Rheogram of test S-I at 25°C appeared in figure 3 shows that up to the shear pace of 150 s-1,rheogram demonstrates straight connection. As the shear rate builds hole between bends increments quickly. The shear pressure estimation of the example slurry increments from 7.5 Pa, 15.10 Pa, 23.6 Pa and 32.35 with the convergence of 30, 40, 50 and 60% by weight individually at the temperature of 25°C. The reduction in the shear pressure can be credited to the expansion in the consistency of the slurry suspension, decreased the obstruction of shear. When in the suspension bigger quantities of strong particles are present, high estimation of beginning shear pressure is required to begin the shearing procedure. With builds the temperature, decline the quantity of strong particles and surface territory per unit volume of the slurry suspension and thus shear pressure get diminished.

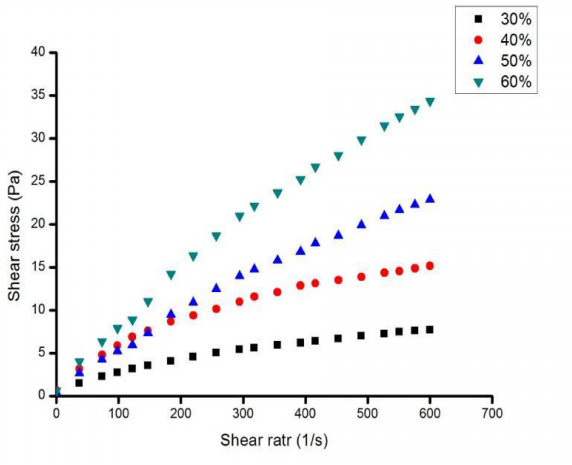

Figure 3.Effect of solid concentration for zinc ore (%weight) at 25^0 C.

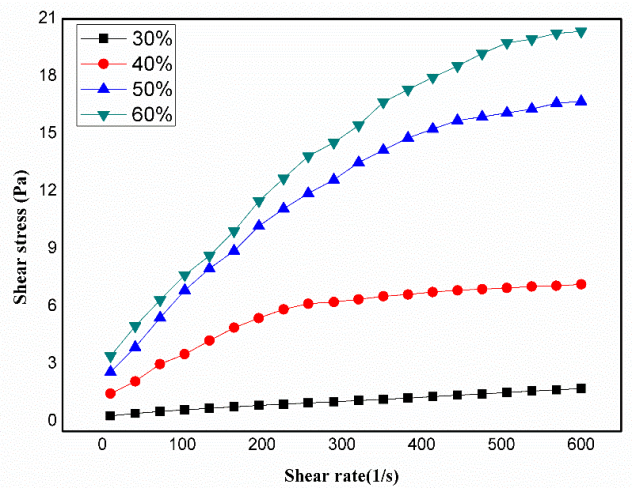

Figure 4.Effect of solid concentration for ire ore (%weight) at 25^0 C.

The rheological tests were performed at various strong focuses differing from 30-60% (by weight). The shear rate is differed from 0-600 s-1 to quantify the evident consistency of slurry suspension. The variety of shear worry with shear for test is appeared in Figure 4. From rheogram of

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iron-water suspension, it very well may be said that the stream conduct of iron-water suspension was exceptionally impacted by variety strong fixation, it was seen that the shear pressure is fluctuating directly w.r.t shear rate at 30% focus. Further increment in strong fixation above 30%, the stream attributes of slurry moved toward the non-Newtonian stream conduct. From investigation it was seen that slurry shows Pseudoplastic stream conduct for strong fixation changing from 40 to 60%. Rheology results delineate that shear pressure is likewise a capacity shear rate. At first high shear pressure is required to start the shearing as at first increasingly number of particles was very still which means high inactivity and required more power.

HEAD LOSS CALCULATION

Prediction of weight drop qualities of zinc metal water slurry

The constrained drop was additionally anticipated for the progression of zinc metal water slurry. The figuring for weight drop was resolved based on Non-Newtonian model. The strong fixation was differed in the scope of 30-60% (by weight). The thickness of the slurry at various strong fixations was controlled by the condition as given beneath.

$$\rho_m = \frac{100}{\left(C_W/\rho_s\right) + \left[\left(100 - C_W/\rho_l\right)\right]}$$

The power law was utilized to decide the consistency parameter (K) and stream conduct list (n). Reynolds number was determined by the accompanying articulation.

$$\mathrm{Re} = \frac{8D^n V^{2-n}\rho_m}{K}\left\{\frac{n}{2+6n}\right\}^n$$

The stream was thought to be laminar and the rubbing component was determined as.

$$f = \frac{16}{\mathrm{Re}}$$

The stream speed for the progression of slurry was fluctuated in the scope of 0.5-2 m/s. The weight drop was determined by Fanning condition as given beneath.

$$h = \frac{2fV^2\rho_m}{gD\rho_w}$$

The breadth of the flat pipe was taken as 100 mm. Figure 5 demonstrates the variety in weight drop with stream speed at various strong fixations. From the outcomes it was seen that the estimations of head misfortune was expanded as the stream speed was expanded. The weight drop was likewise an element of strong focus. As the strong focus was expanded from 30-40, 40-50 and 50-60% the weight drop is expanded by 81.69, 30.58 and 55.65% for stream speed of 2 m/s.

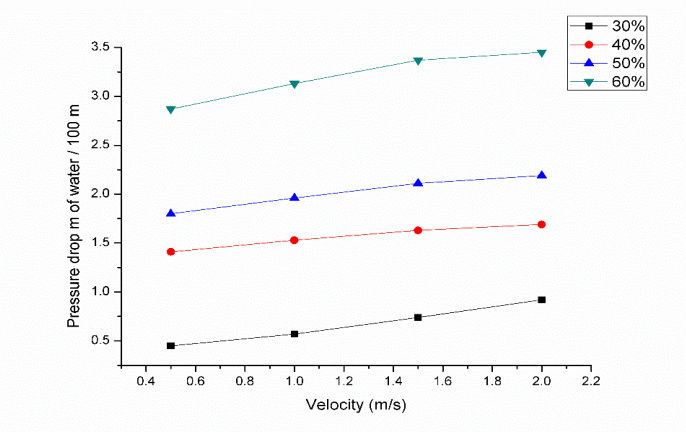

Figure 5.Variation of pressure drop for zinc ore with flow velocity at different solid concentrations.

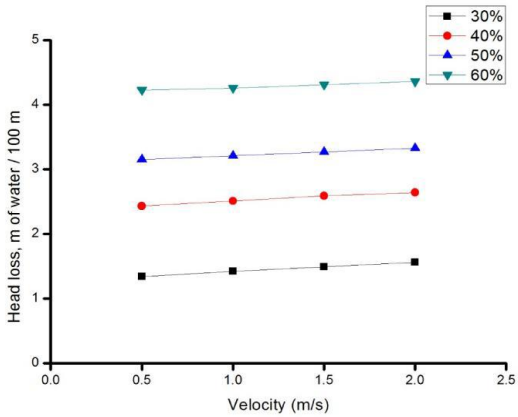

Figure 6. Variation of pressure drop for Iron ore with flow velocity at different solid concentrations.

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III. CONCLUSION

Present examination was completed to research stream and rheological qualities of zinc metal water slurry suspension. The weight drop was additionally anticipated from the fanning condition. The strong fixation was shifted in the scope of 30-60% (by weight). The pipe width and stream speed range was taken as 100 mm and 0.5-2 m/s.

- The slurry suspension shows Newtonian conduct just up to 30% strong fixation and after that it carries on like non-Newtonian in nature.
- Pressure drop was expanded with stream speed and strong focus. As the strong focus was expanded from 30-40, 40-50 and 50-60% the weight drop is expanded by 82.69, 22.58 and 55.53% for stream speed of 2 m/s.
- With increment in the focus, both evident thickness and shear pressure increments while with the expansion in temperature, both obvious thickness and shear pressure diminishes.

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