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Report

Design and Development of a 0.012 m^3 Froth Flotation Machine from Locally Sourced Materials

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Abstract: The desire to design and develop machine with high versatile method of physically separating mineral particles based on differences in the ability of air bubbles to selectively adhere to specific mineral surfaces in mineral/water slurry using indigenous materials is constantly evolving to meet specific requirements of specific industrial plant. Therefore, the aim of this study was to design and construct a 0.012 m^3 capacity laboratory froth flotation machine using locally sourced materials with the view to promoting indigenous technology in Nigeria. The construction was based on parameters established from literatures. The design was done using Auto-Cad version 7 software. The machine was built of different components which are corrosion resistant, easy to access and can be assembled and disassembled when the need arises. The machine was constructed such that its height can be adjusted to suite flotation characteristics of different materials. The machine was of height 1.5 m and designed to operate at batch condition. A flotation tank of capacity 0.012 m^3 holds the pulverized pulp mixture for flotation operation. The flotation tank was equipped with regulated speed agitator shaft and stirrer assembly to condition the pulverized pulp mixture. Regulated air flow from a 0.02 m^3/min compressor was also applied to the mixture in the cell for effective hydrophobicity and hydrophilicity.

Keywords: Design, Construction, Froth Flotation, Pulverize Pulp, Hydrophobicity

1. Introduction

Froth flotation is a highly versatile method of physically separating mineral particles based on differences in the ability of air bubbles to selectively adhere to specific mineral surfaces in mineral/water slurry [6, 11]. This beneficiation process involves the addition of chemical to slurry in order to render the surfaces of the particles hydrophilic and stay in the liquid phase completely wetted, while air bubbles are attached to the hydrophobic materials to form froth on top of the pulp which is removed [7]. This froth increases in height as more air bubbles are attached to the hydrophobic materials [10, 12]. Froth can only overflow at the vessel lip, the centre of the vessel becomes a large stagnant zone of froth which does not report to the concentrate [12].

Flotation machine design is constantly evolving to meet specific requirements of specific industrial plant [1]. Recent trend has been to increase the size of flotation machine in order to process more minerals and lower the cost of processing [7, 14]. This development has led to the challenges of design, development and operation of different flotation machines with different capacities, ranging from 0.03 to 1000 m^3 [2, 7].

Many of the novel flotation techniques, including the conventional cells, developed since 1980's were aimed at improving methods of contacting air bubbles and treating mineral particles in the collection zone [9, 5]. The collection zone achieves a separation between the valuable and non-valuable minerals based on the bubble-particle attachment process, which takes place below the collection zone (froth zone interface). During this process, a portion of the non-valuable minerals is carried from the collection zone into the froth zone with the mineral-bubble aggregates due to hydraulic entrainment [8].

The froth flotation process has been listed among the top ten inventions of the twentieth century with the first commercial installation occurring in 1906 [4, 12, 13]. Materials concentrated using froth flotation include those containing copper, lead, zinc, gold, platinum, iron, molybdenum, tin, phosphate, talc, rutile, kaoline, fluorspar, coal and many others [3, 15, 16].

This project was aimed at designing and fabricating a froth flotation machine for the mineral industries from indigenous materials and promoting indigenous technology in a developing nation like Nigeria.

2. Materials and Methods

2.1. Materials

All materials used in this project were locally sourced and fabricated. They include: steels, fabricated 5-way pulleys, rubber pulley belts, 0.55 Kw electric motor, 0.02 m^3/min air compressor, rubber hose, brass valve, welding machine and electrical accessories.

2.2. Methods

This laboratory flotation machine was designed and constructed according to literatures. Autocad version 7 software was used to draw the machine, its details and dimensions. The machine had several parts which were easily assembled and disassembled. These parts include belt housing, electric motor, power switch, aeration valve, agitator shaft and its housing, agitator shaft and sample base height adjustment handles, agitator assembly, flotation cell with lip, base and air compressor.

2.2.1. Belt Housing

The belt housing was made of 0.5 m long, 0.538 m wide, and 0.059 m high which houses the three pulleys (5-way each) and the belt that linked one of the pulley to the electric motor, and the other to the air compressor (0.02 m^3/min) and the last to the agitator shaft. These pulleys had 0.026 m, 0.036 m, 0.043 m, 0.048 m and 0.056 m diameters in each of the 5-way to enable the regulation of the speed of the compressor and the agitator. Provision was also made for the adjustment of this speed with adjustment valves. Figure 1 gives details of the belt housing.

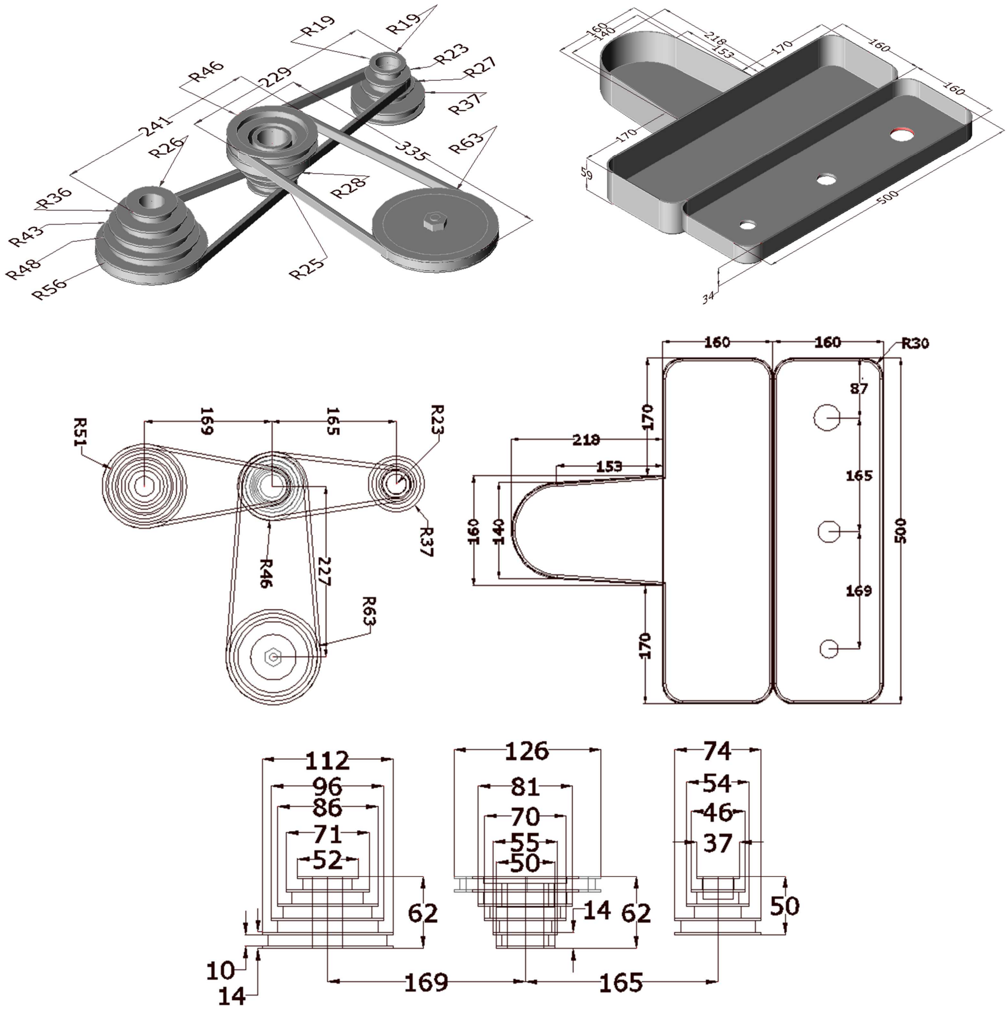


Figure 1. *Details of the belt housing.*

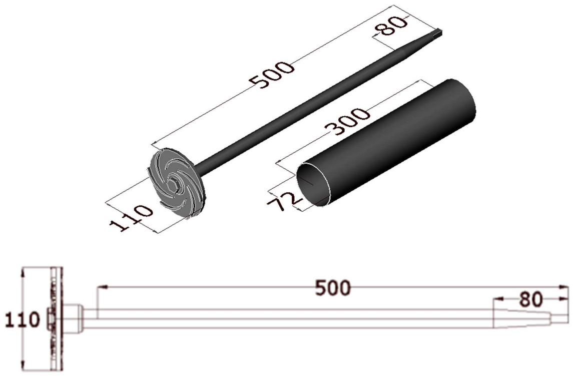


Figure 2. Agitator shaft and housing.

2.2.2. Agitator Shaft and Housing

The agitator shaft which was made of stainless steel to avoid rust, had dimension of 0.5 m long and 0.04 m diameter which was attached to the belt housing via one of the pulleys and covered with a stainless cylinder of 0.3 m long and 0.07 m in diameter. The agitator conditions the pulverized pulp mixture in the cell at regulated speed to enhance even hydrophobic and hydrophilic action. Figure 2 presents the agitator shaft and the housing.

2.2.3. Agitator Shaft and Cell Base Height Adjustment Handles

These adjustment handles were attached to the agitator shaft around the belt housing compartment to adjust the shaft down and up the flotation cell, while the other adjustment handle was attached to the base where the flotation cell is placed to either take the cell up or down. Figure 3 presents the agitator shaft and cell base adjustment and their handles.

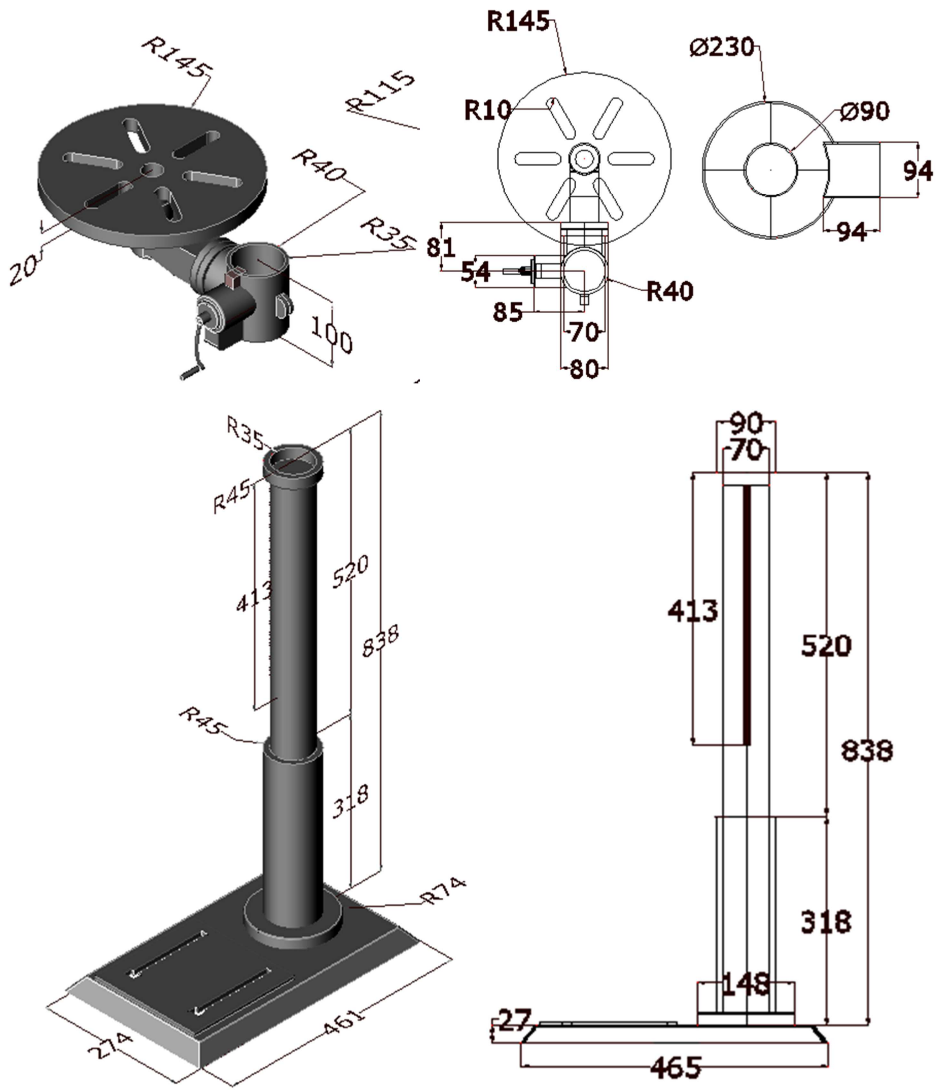


Figure 3. Agitator shaft and cell base adjustment handles.

2.2.4. Agitator Assembly

This assembly consists of the stirrer which is attached to the agitator shaft at the bottom. This stirrer is 0.11 m in diameter and it does the actual stirring whenever the agitator rotates. It is made of stainless steel to avoid corrosion and can be disassembled from the shaft.

2.2.5. Flotation Cell

The flotation cell is made of stainless steel to prevent rust. It is 12 m^3 in capacity and holds the pulverized pulp mixture during froth flotation operation. It was constructed with a flotation cell lip for froth collection. This cell is usually placed on the adjustable base. Figure 4 presents the flotation cell.

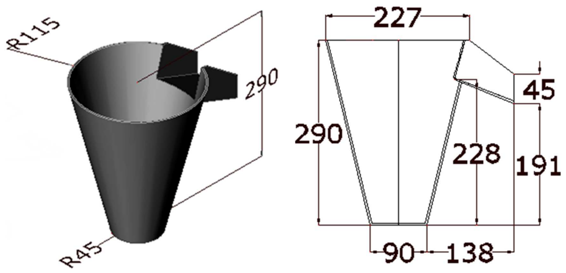


Figure 4. *Flotation cell.*

2.2.6. Electric Motor

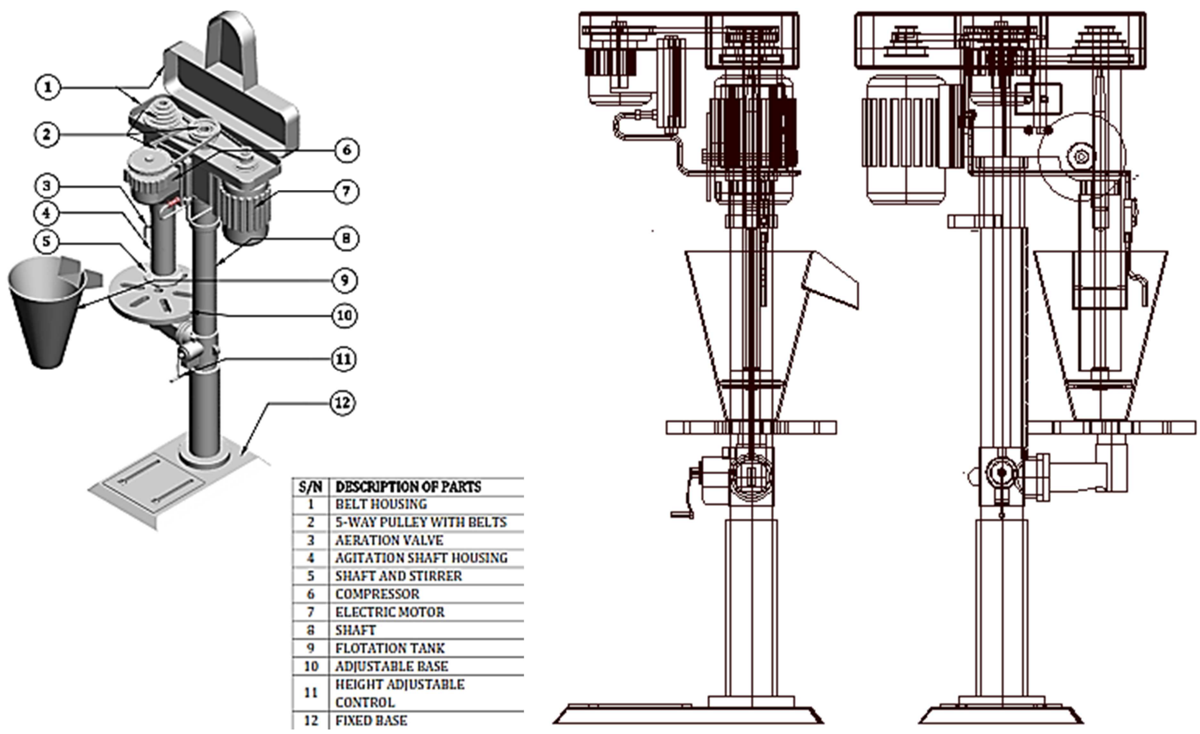
The 0.55 Kw electric motor was attached to the belt housing and connected to drive a pulley at fixed speed of 1200 rpm. This pulley was connected to two other pulleys to drive the compressor and the agitator shaft whose speed were regulated. The electric motor was connected to power control buttons to either put on or put off the power source.

2.2.7. Air Compressor

The air compressor which compresses 0.02 m^3/min was attached to the belt housing to supply compressed atmospheric air through a hose into the pulverized pulp mixture. The amount of air that enters the cell from the compressor is regulated with a brass valve.

3. Discussion of Results

The constructed flotation machine is presented in Figure 5.



S/N	DESCRIPTION OF PARTS
1	BELT HOUSING
2	5-WAY PULLEY WITH BELTS
3	AERATION VALVE
4	AGITATION SHAFT HOUSING
5	SHAFT AND STIRRER
6	COMPRESSOR
7	ELECTRIC MOTOR
8	SHAFT
9	FLOTATION TANK
10	ADJUSTABLE BASE
11	HEIGHT ADJUSTABLE CONTROL
12	FIXED BASE

Figure 5. *Complete constructed flotation machine.*

To prepare the pulverized pulp mixture, an electric mixer may be employed as conditioning machine. After conditioning the mixture with all reagents which are required, the pulp is feed into the steel flotation cell to the required level. Meanwhile, the air valve is closed and the machine powered off. The cell is placed on the base and adjusted upward simultaneously with the agitator shaft until it reaches a level some millimeter above the bottom of the cell to create room for smooth agitation and enough depth of foam at the top of the cell. The air valve is then opened to have a constant suspension level in the cell. As soon as these are done, the flotation machine is then powered on. To control the operation, deliberate alterations of various parameters are necessary and have great impact on the performance of the machine. For instance, the air flow rate may need to be adjusted. After every operation, the entire unit must be cleaned to avoid chocking. Unlike the stainless steel materials used in this flotation machine, most of the developed flotation columns in literature had their cells, stirrers and agitation shafts made of materials which could react with the pulp slurry and possibly corrode [1]. A 0.02 m^3/min air compressor which is cheaper than the common porous pipe bubble generators used in literature was incorporated into this flotation machine to generate air bubbles [1]. This flotation machine can accommodate different sizes of cells because of the introduction of a cell adjustable base which are not common to other flotation machine.

4. Conclusion

Based on the results of this study, the following conclusions were made:

Relevant information on the working mechanism and operational principle of a laboratory froth flotation machine have been well stated.

The machine can be used by both skilled and unskilled persons.

The machine is cheaper when compared to the cost of similar capacity in the market.

Corrosion resistant materials were used in the construction of the froth flotation machine.

All the materials used were locally sourced and fabricated.

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Conflicts of Interest

The authors declare that they have no competing interests.

Authors Contributions

Conceptualization, Francis, Asokogene Oluwadayo and Okafor Michael; methodology, Francis, Asokogene Oluwadayo; software, Francis, Asokogene Oluwadayo; validation, Francis, Asokogene Oluwadayo, Okafor Michael and Oboh Anthony; writing—original draft preparation, Francis, Asokogene Oluwadayo; supervision, Francis, Asokogene Oluwadayo; project administration, Oboh Anthony; funding acquisition, Oboh Anthony. All authors have read and agreed to the published version of the manuscript.

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