

Fluidized Bed Opposed Jet Mill System for Processing Inorganic Materials.

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Abstract. A jet mill system was built aiming to give values for processing inorganic materials, to be used for different industry. The milling housing of the system is composed of; milling chamber, compressed air nozzles which deliver compressed air in the milling chamber to accelerate sample particles. The classifier wheel is composed of two concentric pieces welded together under argon and coupled to a AC Motor, 0 - 9000 rpm, 2 kW, with AC frequencies convertor. The performances of this jet mill system were tried on five cheap locally available materials, viz. white sand, glass, iron oxide, black carbon and alum. It is possible to get particle sizes of less than 1 μm with narrow distribution of particle sizes.

Key words: Fluidized jet mill; inorganic material processing; air nozzle; classifier wheel.

1. Introduction:

Various industries demands fine particles such as paper, paint, plastic, pharmaceuticals, ceramics, cosmetics, foods and fine chemicals. Thus, the assembling business is setting an extremely stringent particular for these mineral particles incorporating better particles with closer control of mean molecule size or width and cut-off of the molecule size circulation [1-6]. Jet mills commonly used to produce particles between 1 μm and 10 μm and are widely used for these industrial requirements. They have the ability to give micron particles, narrow size distribution, low level of contamination, low wear rate, low noise, and their ability to grind heat sensitive materials [8-9]. Other advantages may include regular particle surface and high-purity. Studies on jet mills focus on the influence of different structure and operating parameters on the grinded product. Among these parameters is the upper and lower limits of the pressure inside milling chamber and at the cyclone as shown by Liu *et al.* [10]. Many models were develop [11-13], which were based on generalizing dimensional analysis such as that given by Rumpf [14], who mentioned successfully many cases based on single impact results carried out in an air-jet mill.

The main aim of this work is to build a prototype fluidized bed opposed jet mill system that can give good physical value for in processing inorganic industrial materials. The design of this system will focus on the precise nozzle position control, a critical parameter for efficient grinding, as well as particle size control if direct control of the produced material is important. The classifier design should



provide high classification efficiency, and hence significantly increases a grinding capacity of the system.

2. Materials and methods:

2.1 Jet mill system:

Schematic layout of the main parts of the manufactured dimension is shown in Figure-1. Components of the milling housing consisted of; the milling chamber(1), classifying wheel, Figure-3 (2), air stream outlet to the cyclone (3), classifying wheel motor (4), nozzles for compressed air (5), and sample feeding inlet (6). Oil free air compressor type (The Screw type Compressor, OZEN, Turkey at 8.4 - 13 bar, and the option of dry air is working well) was used to supply compressed air to the housing chamber through four nozzles equally distributed around the chamber. New designed classifier was shown in Figure-3, was made of stainless steel with 30 horizontal slots. The maximum speed design speed of classifier wheel is 9000 rpm while the operation speed 6500rpm. The classifier work with different speed controlled by motor voltage controller type. The design of the cyclone separator and the bag filter cyclone was based on the equation given in the literature [15-16]. The aim was to capture particle of about 1 μm in diameter, and strain the in the collection can 1. The cyclone was designed on the following particle size distribution: 0 - 2 μm = 40 %, 2 - 5 μm = 40 %, and 5 - 10 μm = 20 %.

All the components of the system were made of stainless steel and assembled on the bench viz. the optimums O-rings of all the flanges were fitted. The connections between the different part of the jet mill component with stainless steel piping and air hoses were performed. Manual pressure gauges were fitted with the milling chamber, cyclone and the filter bag cyclone. The measuring and electronic control devices were installed in their preprepared position.

a) Method:

The Jet mill was operated on five samples (500 g) available in the Iraqi market, as an example of giving a value to ordinary material that has the possibility to be used for different man use. Iraqi white sand, ground glass obtained from beverages bottles, alum used in cosmetics, iron oxide for casting purposes, and black carbon used in rubber formulation. The general procedure used for operating this jet-mill includes cleaning the jet mill system by running a quantity of 250 g of the sample to be used, and then 500 g of the sample was jet milled and collected. Different amount of the recovered sample was collected in the cyclone collection can.

3. Results and Discussion:

The design of the milling chamber given by Xue-dong *et al.* [9] was mainly considered to obtain best particle sizing with some improvements. The design of this system intends to introduce many variables controls, among them the pressure of the milling chamber, through

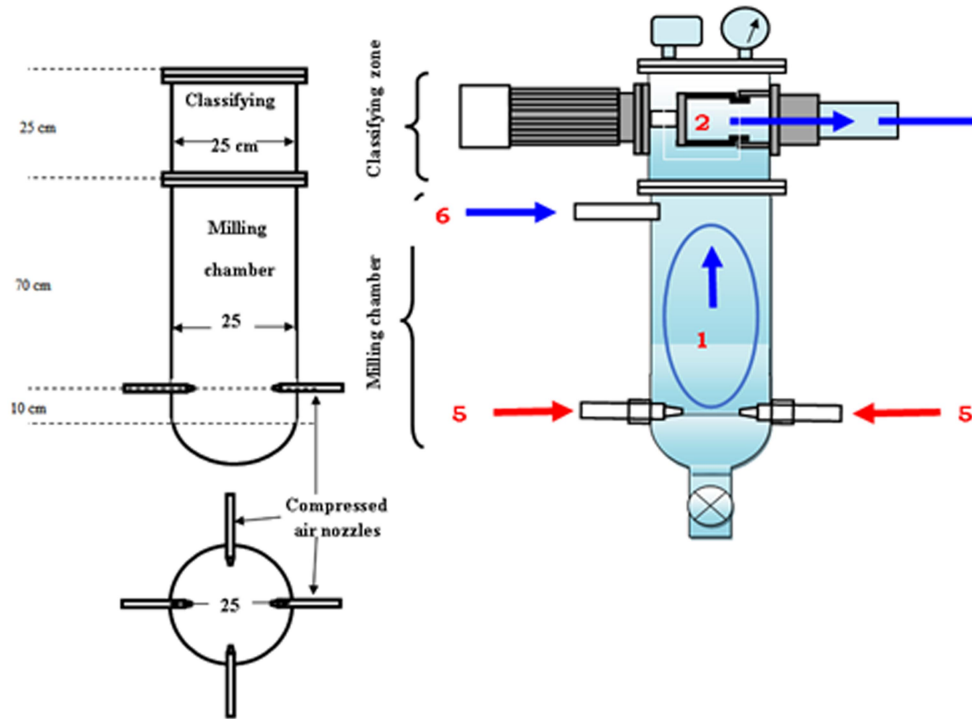


Figure 1. Components of the milling housing; (1) the milling chamber, (2) classifying wheel, (3) air stream outlet to the cyclone, (4) classifying wheel motor, (5) nozzles for compressed air, and (6) sample feeding inlet.

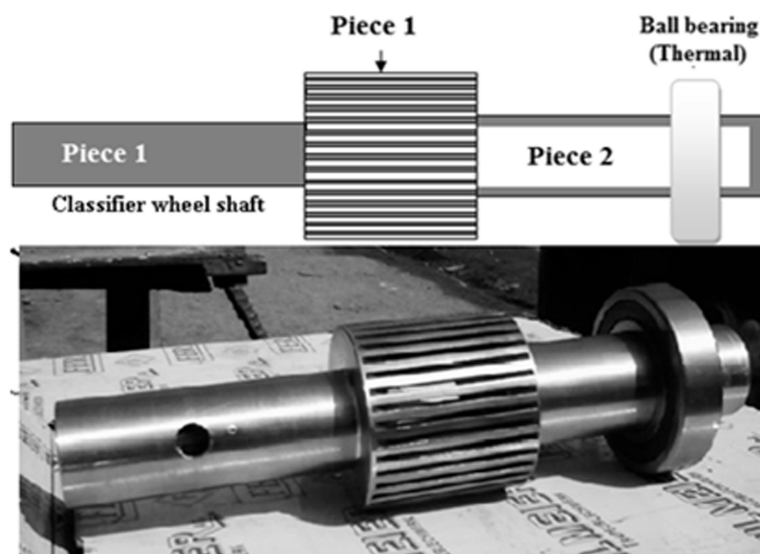


Figure-2: The final shape of the two piece classifying wheel of ~ 1.2 kg weight, the two pieces was welded under argon.

the use of a gate butterfly valve controlled by pneumatic gauge. The picture and the schematic illustration of the classifying wheel was presented in figure-2. It is made of stainless steel, and composed of two concentric pieces welded together under argon. The shaft of the first piece end contain a hole to fit the shaft of classifying motor, while the other piece is a cylinder that lead the compressed air to the cyclone. The wheel cylinder is mounted on a protected thermal ball bearing, such a way that its weight will be distributed between the motor shaft and the ball bearing, the weight of the two pieces is ~ 1.2 kg weight. The design of the cyclone is a traditional high efficiency type, suitable for jet milling purposes according to the literature [15-16]. The filter bag cyclone is supplied to this system as a precaution to protect the environment from the submicron particles on human health. After assembling the different part of the Jet mill system, the controllers of the different part were tested, among them was the classifier wheel, and a speed of 6500 rpm was achieved.

Samples were analyzed by using three technique to evaluate the jet mill performance at a classifier speed of 6000 rpm, and compressor supplied pressure of 8 -10 bar, full speed of the feeder (50 rpm). Analyses technique includes: optical microscopic imaging, particle seizer analysis, and SPM (Scanning Probe microscope). Samples were analyzed by using three technique to evaluate the jet mill performance at a classifier speed of 6500 rpm, and compressor supplied pressure of 8 -10 bar, full speed of the feeder (50 rpm), and the results of the analyses of these samples were presented in table-1, and figures-3.

The results of the light microscopy were not presented excluded because this technique is not useful for such study. From the analysis charts obtained for of the jet-milled samples: glass, Iraqi white sand, iron oxide, black carbon and alum, the following general conclusion can be withdrawn as presented in table-1: The average diameter of the jet-milled sample by using this technique is less than $1.0\text{ }\mu\text{m}$ diameter. The value obtained for Diameter Max and Average Diameter are very close in value. The particle size distribution as obtained by CSPM technique for the tested samples is less than $1.0\text{ }\mu\text{m}$ diameter. This is better result than that reported by other workers, who get $2.9\text{ }\mu\text{m}$ of alumina compared to planetary ball milling ($30.2\text{ }\mu\text{m}$) [16-17], and $\sim 25\text{ }\mu\text{m}$ of metallurgical samples [18].

The products of this Jet mill system can find wide use in industry. Iraqi white sand, ground glass obtained from beverages bottles, alum can find use in cosmetics, iron oxide for casting purposes, and black carbon used in rubber formulation. Future work to improve the function of Fluidized Bed Opposed Jet Mill System can include: studying various variable parameters that can positively affect the milling process. Among these variables is the milling housing pressure. The design of milling housing of this system is capable to reach an amount of up to 50 kg. Scaling up this system to reach 25 - 50 can be made, keeping in mind that some part of this jet system has to be enlarged for amount over 50 kg. Among these parts are the sample feeder, feeder motor, collection can 1, and the height of the bench. The large size of the milling chamber brings the possibility for adding auxiliary techniques that can cause more particle sizing of the sought materials, among them: Laser beam, ultrasonic probe, microwave beam, and IR radiation.

4. Conclusion:

The performances of this jet mill system were tried on processing five cheap materials, viz. white sand, glass, iron oxide, black carbon and alum. The analysis of the products showed that this jet-mill has the capability of milling these inorganic materials to a particle sizes of $1\text{ }\mu\text{m}$ with narrow distribution of particle sizes. The normal breadth of the plane processed specimen by utilizing this strategy is under $1.0\text{ }\mu\text{m}$ distance across, the width max, the normal measurement are shut in worth, and the molecule size dispersion is under $1.0\text{ }\mu\text{m}$ breadth.

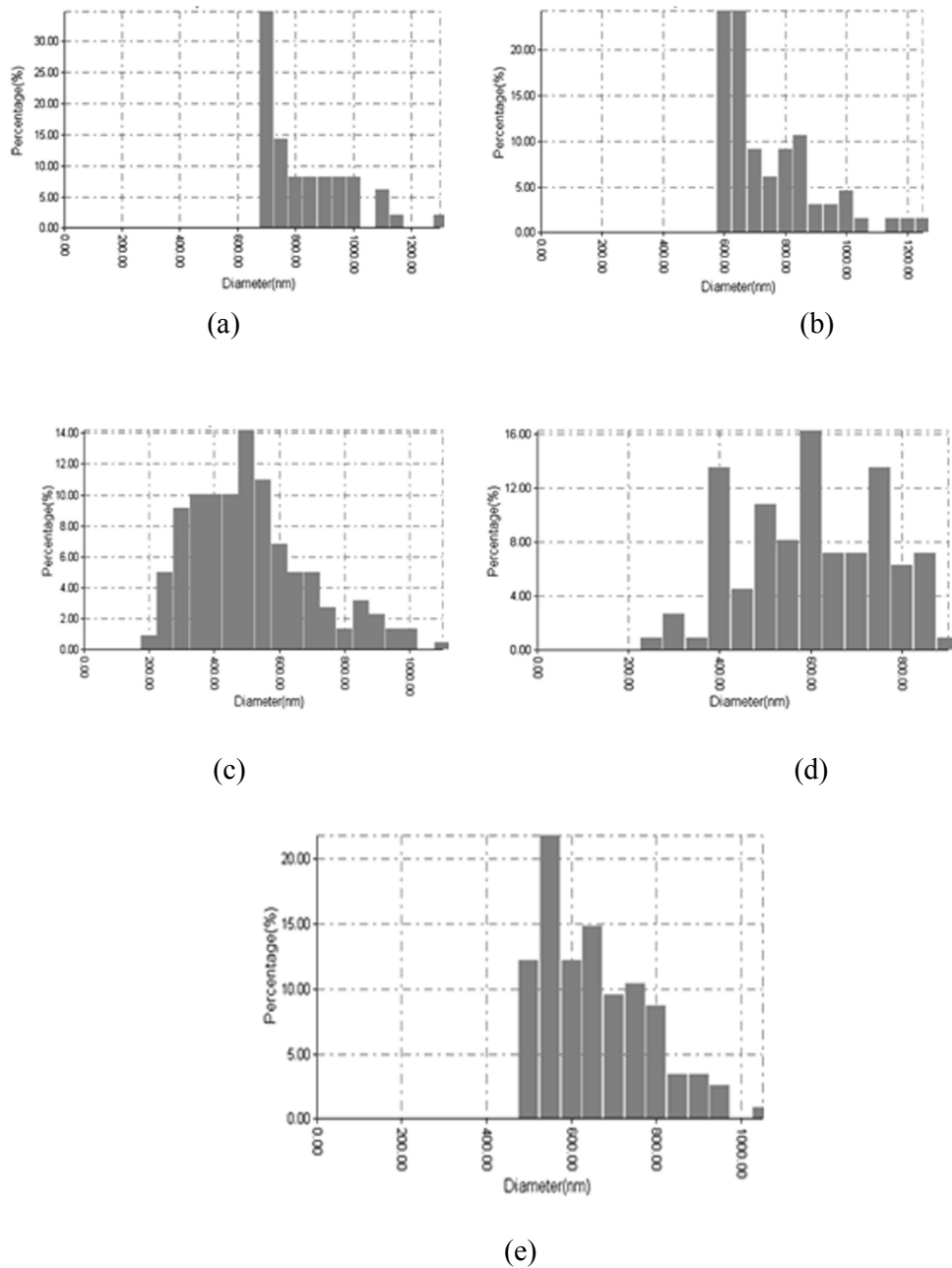


Figure 3. The garrulity cumulating distribution chart of jet-milled (a) white sand, (b) glass, (c) iron oxide Fe_2O_3 , (d) carbon black, and (e) alum by Shimadzu SALD 2101 particle seizer.

Table 1. The results obtained by using two analytical techniques (including; Diameter Max, Mean Diameter, and Diameter rang of jet-milled samples: glass, white sand, iron oxide, black carbon and alum.

Material	Particle seizer (μm)			SPM (μm)		
	Diameter Max	Average Diameter	Diameter Rang	Diameter Max	Average Diameter	Diameter rang
Glass	0.840	0.682	2.930 - 0.450	0.634	0.717	0.60 - 1.25
Iraqi white sand	0.365	1.304	0.160 - 5.480	0.812	0.70	0.70 - 1.30
Alum	0.682	0.608	0.450 - 0.840	0.650	0.634	0.500 - 1.050
Iron oxide	-	-	-	0.488	0.450	0.200 - 1.100
Black carbon	-	-	-	0.582	0.600	0.90 - 1.25

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6. References:

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