Effect of Variations Throat Length on Ejector Performance

by Sattar Yunus

Effect of Variations Throat Length on Ejector Performance

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Abstract. In the present work, experimental investigations have been carried out on ejectors with throat length variation, the changes in throat length variation in the ejector was affect the vacuum pressure produced, of the three variations of throat length tested it , where the length of each throat is 10 cm, 20 cm and 30 cm with throat diameter that same is 2 cm and the diameter of the vacuum cylinder ie 30 cm. The results is the highest vacuum pressure value is in the experiment using a throat length of 30 cm with a vacuum pressure of 87.5 kPa. while the lowest vacuum pressure using a throat length of 10 cm with a vacuum pressure of 90.5 kPa.

Keywords**:** Ejector, Throat Length, Vacuum Pressure, Performance

I. INTRODUCTION

Historically, several different types of devices have been given the generic name "ejector" simply because they rely upon the induction of a quantity of secondary fluid from a lower to a higher pressure into a duct by some form of interaction with a primary stream fluid in the duct [1].

The main function of the ejector is to entrain the maximum secondary flow at any given primary operating condition and to compress the entrained mass within the ejector to the required discharge condition [2]. The higher the secondary flow, the larger is the energy saving potential of the system. Therefore, the secondary to the primary mass flow rate ratio, *Ws/WP* can be assumed as large as required if adequate pumping can be achieved in the ejector. Therefore, a good understanding of the ejector entrainment capability is critical in its design and operation.

Ejectors have simple geometry and no moving parts. Their operation does not require electrical or mechanical shaft energy input. This greatly reduces equipment mass and increases reliability. Ejectors have found wide use in power plant, aerospace, propulsion etc [3]. Ejectors are simple pieces of equipment. Nevertheless, many of their possible services are overlooked. They often are used to pump gases and vapors from a system to create a vacuum. However, they can be used for a great number of other pumping situations [4], [5].

Jet ejectors have been successfully used for polluted gas cleaning application over last many decades due to their capability of handling gas containing pollutants such as vapor, gaseous, and solid/liquid aerosols up to 0.1 μm size. However they have inherent disadvantage of high pressure drop across the system which results in high fan/pump operating cost. But this disadvantage is compensated by their significantly less capital and maintenance costs compared to other wet scrubbers with comparable collection efficiencies [6].

A jet ejector when used as a scrubber is considered to have given optimum performance when its desired scrubbing efficiency is achieved at minimum pressure drop [7]. [8]. [9]. Models to predict pressure drop and scrubbing efficiency are required for optimization of performance of jet ejector. Pressure drop and scrubbing efficiency are complex functions of gas velocity, liquid-to-gas ratio, ejector geometry (shape and number of nozzles, area ratio, throat diameter, throat length, projection ratio, angle of divergence and convergence), operating and suction pressure, properties of gas and liquid (temperature, concentration, diffusivity, viscosity, surface tension, etc.), reactivity of fluids, variation in composition of fluids, etc.[10], [11], [12].

Ejectors are flow induction devices employed for the generation of a vacuum for compressing a fluid [13], Figure 1 shows a straight throat ejector. High pressure motive fluid enters a converging diverging nozzle and is accelerated to a supersonic Mach number. The pressure at section NE is below that of the entrained fluid at its inlet. Consequently, the entrained fluid is drawn into the ejector. The motive and entrained fluids mix between sections NE and U and the uniform mixture is diffused to reach the discharge pressure.

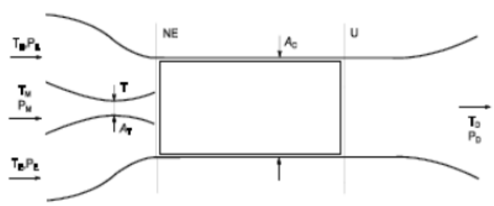

Figure 1. Schematic diagram of a straight throat ejector

Ejectors are devices used to induce a secondary fluid by momentum and energy transfer from a high velocity primary jet. Ejectors can be operated with incompressible fluids (liquids), and in this application are normally referred to as jet pumps or eductors. On the other hand when ejectors are operated with compressible fluids (gases and vapors) the terms ejector and injector are generally employed. A major difference between the two, besides the working fluid states, is the supersonic, choked flow nozzle of the gas ejector system. The supersonic approach allows a greater conversion of primary fluid energy to secondary fluid pressure head increase. However, this occurs with the penalty of considerable thermodynamic complexity in the mixing and diffusion sections.

The ejector configuration consists mainly of four parts, primary nozzle, entrance (suction) section, mixing section, and diffuser. In the ejector, the kinetic energy of the primary fluid is used to create a low pressure in the suction chamber by entraining the secondary fluid stream. The mixing of the two fluid streams occurs inthe mixing chamber of the ejector, and the resultant mixture is compressed downstream out of the diffuser [2]. The system is inferior in efficiency compared to a fan [14]. However, its advantages lie in its simplicity, ease of operation and rugged construction, having no moving parts and requiring less maintenance, has a long life and sustains its efficiency even when handling corrosive or dusty fluid streams.

In this study, conducted variation of throat length change three times, where the length of each throat is 10 cm, 20 cm and 30 cm with throat diameter of 2 cm and the diameter of the vacuum cylinder ie 30 cm and vacuum presssure will be observed.

II. METHODS

A. Tes Stand and Instrumentation.

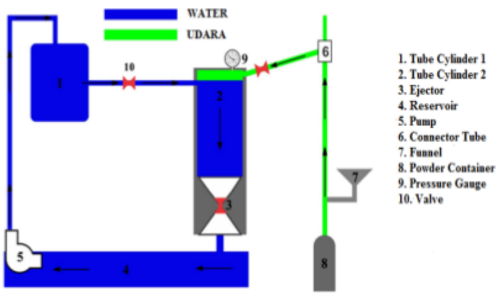

Figure 2. Test Stand and Instrumentation

B. Testing Method

Tests on the installation system that has been made then the test method will be done as follows:

- Comparative analytical methods: Analyze the tests with the rules of physical rules and fluid mechanics standard then compare the measurement results with theoretical calculations.
- Descriptive method: Observing a change caused by treatment on an object or system that can produce a conclusion.

C. Experimental Procedure

The test procedures that will be carried out are as follows:

- Connecting equipment installation system with electric power.
- Operating the pump machine (5) to fill the reservoir 4).
- Opening the valve (10) and valve (11) and closing the valve (3) until cylinder (2) can be fully charged.
- Put in the sawdust ± 60 grams in powder container (7).
- Close the valve (10) and valve (11) after the cylinder (2) is fully charged.
- Measure cylinder pressure (2) measured at pressure gauge (9) with open valve (3).
- Measuring of the initial water level of the powder container (4).
- Run the ejector by opening valve (3) and valve (11).
- Record the time until the water on the cylinder (2) runs out.
- Record the amount of sawdust sucked and unsuccessful to into the predictor glass (6).
- Record of the level water in reservoir (4).
- Change the throat ejector variation (3).
- Turns off the test equipment.

III. RESULT AND DISCUSSION

In this study conducted variation of throat length change three times, where the length of each throat is 10 cm, 20 cm and 30 cm with throat diameter of 2 cm and the diameter of the vacuum cylinder ie 30 cm. Based on the Figure 3, it shows the highest vacuum pressure value is in the experiment using a throat length of 30 cm with a vacuum pressure of 87.5 kPa. while the lowest vacuum pressure using a throat length of 10 cm with a vacuum pressure of 90.5 kPa. The throat diameter used is 2 cm. When the length of the throat is getting longer then the compressive strength of the top of the ejector will increasingly be converted to a flow velocity which will result in greater vacuum pressure.

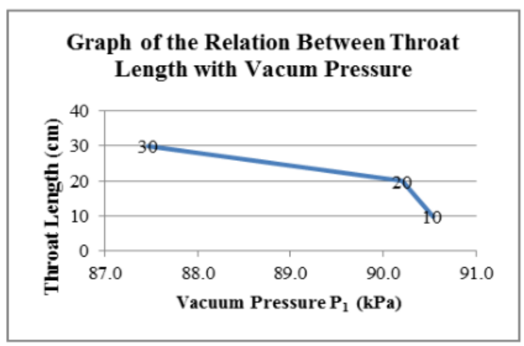

Figure 3. Graph of the Relation Between Throat Length With Vacuum Pressure.

Based on the graph below (Figure 4), shows that at the highest vacuum pressure value of 87.5 kPa then the flow velocity will be bigger that is equal to 0,021 m/s. while for the lowest vacuum pressure of 90.5 kPa, the flow rate is smaller at 0,018 m / s. The greater the flow rate the vacuum pressure will increase.

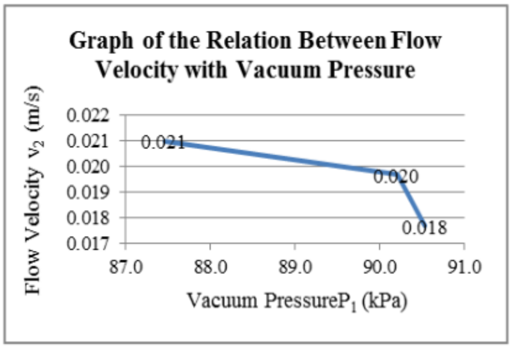

Figure 4. Graph of the Relation Between Flow Velocity with Vacuum Pressure.

Vacuum pressure is also affected by the throat diameter of the ejector, when the experimental, the ejector valve is opened as many as ½. The vacuum pressure of the ejector is very small and there is not sawdust is sucked upward towards the ejector, we assume that when the diameter is added then the discharge will get bigger so V_2 will also get bigger.

Based on the graph below (Figure 5), shows that at the highest vacuum pressure value of 87.5 kPa it will be more and more sawdust is sucked up to 32.2 grams, while for the lowest vacuum pressure of 90.5 kPa, the sawdust sucked will be less that is equal to 15.6 grams. The vacuum pressure created makes the sawdust sucked into the ejector, but sawdust does not entirely into the ejector, this is due to the lack of vacuum pressure created, and the pipe diameter to the ejector is too small with the size of observation glass rather large making the sawdust obstructed for entry into the ejector.

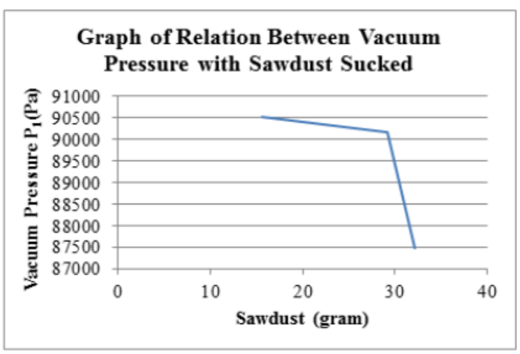

Figure 5. Graph of the Relation Between Vacuum Pressure With Sawdust Sucked.

IV. CONCLUSIONS

By passing the fluid (water) from the cylinder to the ejector, then there will be a vacuum pressure on the cylinder, resulting from fluid flow and changes in cross-sectional area of the cylinder to the ejector, changes in throat length variation in the ejector will affect the vacuum pressure produced, of the three variations of throat length tested it can be concluded that the longer the throat on the ejector the greater the vacuum pressure produced, But the resulting vacuum pressure is not continuous because at the time of charging water to the cylinder the pressure will go up (not vacuum), but when the water from the cylinder re-flowed through the ejector it will re-create vacuum pressure, From a one-time testing process 2/3 of time is used for water filling to the cylinder and vacuum pressure appears only at 1/3 of the test time, where from 1/3 the time the particles on the exhaust gas in this case sawdust that can be sucked into the ejector is only ½ of the sawdust tested on the sewer, even then with the maximum pressure ejector 87.5 kPa, that is with throat length 30 cm.

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