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by Rusdi Nur
The influence of Throat Length and Vacuum Pressure on The Air Pollutant Filtration Using Ejector

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Abstract. Environmental pollution can be caused by natural events or human activities, which can threaten living creatures including humans in the future. This phenomenon is caused by the emission of particles or other chemical compounds that are not present in the natural component so that it exceeds the permitted amount. In this paper, a construction design with vacuum pollution control system is used, so that it can find enough pressure to eliminate the exhaust gas using sawdust and pipes as a funnel simulation in the industry. This research uses the ejector system in filtering air mixed with sawdust. The results showed that the highest vacuum pressure value of 87.5kPa then the more the sawdust will be inhaled up to 32.2 grams while for the lowest vacuum pressure of 90.5 kPa, the sawdust inhaled will be less that is equal to 15.6 grams.

INTRODUCTION

The impact of the uncontrolled industrial activity on the environment can lead to healthy ecosystems, which affecting human well-being, availability of natural resources and sustainable economic viability. Hazardous industrial waste can cause pollution that damages human health, some species will become extinct, and contribute to global warming and the depletion of the ozone layer. Air pollution is defined as the entry into the air composition of air, so the air does not correspond to its natural composition. This phenomenon is caused by the entry of particles or chemical composition into the air, where natural air should not contain chemical composition in the atmosphere (1). The cause of air pollution is generally influenced by two factors, namely internal and external factors. Internal factors are naturally occurring factors such as dust flying through the wind, dust released by volcanic eruptions and the process of decomposing organic waste. While external factors can be interpreted as a result of human activities such as burning fossil fuels, dust (powder) from the results of industrial activities, and the use of chemicals sprayed in the air (2). Air pollution was defined as the inclusion of living things, substances, energies or other components into the environment, and or the changing of the environmental order by human activities or by natural processes, so that the quality of the environment decreases to a certain extent that causes the environment to malfunction in accordance with its designation (3). In this respect, pollution is also defined as the emergence of one or more physical, chemical, or biological substances in the atmosphere. Some of them may be harmful to humans or damage the health and lives
of others, interfere with the aesthetics and comfort, and destroying property or the environment, or generally cause health problems in humans (4). According to the Tenth Report of the Commission on Environmental Pollution, Pollution generally defined as the introduction by humans into the environment of substances or responsible energy to cause harm to human health, endangering living resources and ecological systems, structural damage or improper use of the environment (5).

The process of reducing air pollution can be done by using a mechanism on the pressure difference between two fluid streams in opposite directions in different spaces. This mechanism will change the direction and velocity characteristics significantly. The construction design using the above mechanism is expected that the compressible fluid flow rate (particle vapor, dust, and particles) will reverse in such a way as a result of larger incompressible fluid momentum force mechanisms. In order to obtain a high enough incompressible (water) momentum fluid momentum mechanism, a geometric construction of the ejector was varied in order to obtain optimum results (6).

The type parameter based on the quality of ambient air standards and regulated in Government Regulation No. 41 of 1992, namely particulates with diameters less than 10 μm (PM10), particulate matter with diameter less than 2.5 μm (PM2.5), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), ozone (O₃), hydrocarbon (HC) (7)(8). Air is also the atmosphere that is around the earth and its function is very important for life in this world. In the air, The oxygen (O₂) is used for breathing, carbon dioxide (CO₂) for photosynthesis by leaf chlorophyll and ozone (O₃) to withstand ultraviolet rays. The environment according to Law No. 23 of 1997 is defined as the unity of space and all materials, power and living creatures including humans and perpetrators that affect the viability of life and welfare of humans and other living creatures. The environment is a source of raw materials, energy, food, water, clean air and land that is useful for human life. The mechanism of entry of foreign elements into the air can occur with various forms and processes such as:

- Photochemical fog shaped like orange-brown smoke but has a fairly heavy mass like fog usually occurs over industrial areas and busy highways.
- The photochemical haze that occurs as a result of the reaction of nitrite compounds and some of the volatile organic compounds present in the air.
- Vehicle exhaust gases and industries containing NO₂, CO and unburned hydrocarbons (primary pollutants), and also NO₂ and SO₂ in the form of smog (secondary pollutants).

This paper aims to determine the effect of throat length and vacuum pressure on the sawdust filtration process using ejector equipment.

**EXPERIMENTAL METHOD**

**Materials and Equipment**

The testing material used was sawdust as pollutant materials. The equipment used was the compressor, water pump, reservoir, the ejector system, the manometer of fluid pressure as instrumentation tool.

![FIGURE 1. The equipment of compressor (a), water pump (b), ejector system, (d) PVC Pipe](image-url)
Experimental Method

The experimental method was performed as follows:
1. Install all devices with a drive mechanism to drain the fluid in all areas to be operated.
2. Supply the installation equipment system with electric power and operate the pumping machine to fill the tubs, energy cylinders, and ejector in full while conducting a descriptive survey.
3. Activate all instruments (measuring instruments) and record the value of the reading.

The experimental setup was controlling the air pollution using ejector system as shown in Figure 2.

![Figure 2](image1.jpg)

**FIGURE 2.** The equipment of air pollutant without running (a) and with running (b)

RESULTS AND DISCUSSION

The research was using vacuum cylinder diameter 30 cm and throat with diameter 2 cm. This study was also conducted variation of throat length that i.e. 10 cm, 20 cm and 30cm. The result of experimental was obtained as follows:

<table>
<thead>
<tr>
<th>Ejector Pressure (bar)</th>
<th>Powder inserted (gram)</th>
<th>Powder of not-inhaled ejector (gram)</th>
<th>Powder of inhaled ejector (gram)</th>
<th>Ejector Diameter</th>
<th>Initial Height (mm)</th>
<th>Last Height (mm)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.860</td>
<td>70.8</td>
<td>49.9</td>
<td>20.9</td>
<td>10</td>
<td>2</td>
<td>90</td>
<td>43.59</td>
</tr>
<tr>
<td>0.870</td>
<td>67.8</td>
<td>33.0</td>
<td>34.8</td>
<td>10</td>
<td>2</td>
<td>54</td>
<td>134</td>
</tr>
<tr>
<td>0.890</td>
<td>63.0</td>
<td>31.3</td>
<td>31.7</td>
<td>10</td>
<td>2</td>
<td>52</td>
<td>133</td>
</tr>
</tbody>
</table>
TABLE 2. The Result data using 2nd Ejector for length of 20 cm

<table>
<thead>
<tr>
<th>Ejector Pressure (bar)</th>
<th>Powder inserted (gram)</th>
<th>Powder of non-inhaled ejector (gram)</th>
<th>Powder of inhaled ejector (gram)</th>
<th>Ejector Diameter ( A_1 ) (cm)</th>
<th>( A_2 ) (cm)</th>
<th>Initial height (mm)</th>
<th>Last height (mm)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.863</td>
<td>68.8</td>
<td>46.7</td>
<td>21.4</td>
<td>20</td>
<td>2</td>
<td>90</td>
<td>169</td>
<td>43.59</td>
</tr>
<tr>
<td>0.885</td>
<td>67.0</td>
<td>34.1</td>
<td>32.9</td>
<td>20</td>
<td>2</td>
<td>54</td>
<td>134</td>
<td>46.66</td>
</tr>
<tr>
<td>0.900</td>
<td>64.2</td>
<td>33.3</td>
<td>30.7</td>
<td>20</td>
<td>2</td>
<td>52</td>
<td>133</td>
<td>43.59</td>
</tr>
</tbody>
</table>

TABLE 3. The Result data using 3rd Ejector for length of 30 cm

<table>
<thead>
<tr>
<th>Ejector Pressure (bar)</th>
<th>Powder inserted (gram)</th>
<th>Powder of non-inhaled ejector (gram)</th>
<th>Powder of inhaled ejector (gram)</th>
<th>Ejector Diameter ( A_1 ) (cm)</th>
<th>( A_2 ) (cm)</th>
<th>Initial height (mm)</th>
<th>Last height (mm)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.880</td>
<td>65.5</td>
<td>31.7</td>
<td>33.8</td>
<td>30</td>
<td>2</td>
<td>51</td>
<td>132</td>
<td>41.5</td>
</tr>
<tr>
<td>0.890</td>
<td>65.7</td>
<td>30.3</td>
<td>35.4</td>
<td>30</td>
<td>2</td>
<td>51</td>
<td>129</td>
<td>42</td>
</tr>
<tr>
<td>0.905</td>
<td>62.0</td>
<td>29.7</td>
<td>32.3</td>
<td>30</td>
<td>2</td>
<td>51</td>
<td>132</td>
<td>43</td>
</tr>
</tbody>
</table>

From the result data as shown in tables 1, 2, and 3, it can be described the relationship between the variable throat length and the vacuum pressure as shown in Fig. 3. As well as, the relationship between the vacuum pressures with inhaled sawdust can be described as in Figure 4. Investigation of ejector was studied on hydraulic transport (9).

**FIGURE 3.** Graph of throat length and vacuum pressure

In Figure 3, it shows that the highest vacuum pressure of 87.5 kPa was obtained by using a throat length of 30 cm, while the lowest vacuum pressure of 90.5 kPa was obtained using a throat length of 10 cm. The throat diameter used was 2 cm. The testing with the size of the throat longer, then the compressive strength of the top of the ejector will be increasingly converted into flow velocity resulting in greater vacuum pressure. Another investigation has studied the effect of nozzle throat length on the resolution of a low-pressure impact (10).
FIGURE 4. Graph of vacuum pressure and sawdust

Based on Figure 4, it shows that the highest vacuum pressure value of 87.0 kPa will be inhaled the sawdust till 35.4 grams. While for the lower vacuum pressure of 90.5 kPa can be inhaled the sawdust to 31.7 grams. The vacuum pressure created will make the sawdust inhaled into the ejector. The researcher has investigated the influence of vacuum pressure and activation condition on pore development through filtering the Chinese fir sawdust (11). For other responses, the power demand can be determined. The power demand was investigated through operating the compressor unit and the pump water unit for filtering the air pollutant. Determining the power demand was performed on turning process of aluminum alloy (12)(13)(14).

CONCLUSION

It can be concluded as follows:

- Constructively, the pressure pollution control systems can determine the pressure sufficient to eliminate the exhaust gas by using sawdust and PVC pipe as a chimney simulation in the industry.

- The highest vacuum pressure value was obtained in the experiment using a throat length of 30 cm with a vacuum pressure of 87.5 kPa. While the lowest vacuum pressure was obtained by using a throat length of 10 cm with a vacuum pressure of 90.5 kPa. It shows that the longer the throat the greater the vacuum pressure is produced. The use of compressor pressure less than the vacuum ejector pressure will make the sawdust on the PVC pipe able to be inhaled into the ejector.

- The highest vacuum pressure (87.5 kPa) can inhale sawdust up to a maximum of 32.2 grams, and the lowest vacuum pressure of 90.5 kPa will be inhaled 15.6 grams.
ACKNOWLEDGMENT

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