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# ANALYTICAL STUDY OF THE EFFECT OF INLET ANGLE VARIATION ON HYDRAM PUMP EFFICIENCY

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**ABSTRACT**

Hydram pump is a solution to overcome the problem of water demand, especially for highland areas. Hydram pumps can be used for rice field areas because they do not require an electric energy source. Operating parameters at the hydram pump greatly affect the efficiency of the hydram pump. In practice in the field, altitude is not difficult to obtain, especially for mountainous areas. However, for some highland areas, often to get a certain height must be with a large elevation distance hydram pump to water sources. In this research, a change in the angle of inlet variation will be conducted on the efficiency that occurs. So that this research can be a benchmark for determining the distance of a hydram pump to a water source. The highest water discharge that can be generated from a 1 in size PVC hydram pump, 2.75 m inlet height, 5 m outlet height is 1.5 x $10^{-5}$ $m^3/s$. while the lowest water discharge in the test carried out is 0 $m^3/s$ at the number of pendants 1 and the pump inlet angle is 45°. The inlet angle greatly affects the resulting flow rate. The inlet angle of 30° results in a higher water flow rate of $1.44 \times 10^{-5}$ $m^3/s$ at the number of pendulum 2 compared to the 45° inlet angle which only gets $9.44 \times 10^{-6}$ $m^3/s$ even up to 0 $m^3/s$ at the number of pendulum 1.

**Keywords:** *hydram pump; inlet angle; hydram pump efficiency.*

## 1. INTRODUCTION

The need for water for irrigating rice fields in the Majalengka area is quite large, this can be seen in the data from the BPS Majalengka Regency which shows 2,318 Ha. This shows that the need for water for irrigating rice fields is quite high [1,2].

The Majalengka area has highlands and lowlands. During the rainy season, irrigation for rice fields is not a problem. During the dry season, it cannot be denied that the fulfillment of water needs for rice fields is very limited, especially for lowland areas. For highland areas, too, because not all rice fields have access to water sources from rivers [3-8].

Hydram pump is a solution to solve the problem of water needs, especially for highland areas. The hydram pump can be used for rice fields because the pump does not require a source of electrical energy [9,10].

Made Suarda et al. tested the hydram pump by making changes to the air tube used. The results of this study, it was found that the head back pressure in the delivery pipe decreased from 103.87 m without using an air tube to 37.85 m with an air tube. Furthermore, in the pipe head, the pressure due to the water hammer increased from 0.29 m without using an air tube to 2.9 m using an air tube. So that the installation of an air tube can significantly increase the efficiency of the hydram pump from 0.72% without a tube to 19.45% with an air tube [11].

The operating parameters of the hydram pump greatly affect the efficiency of the hydram pump. In practice in the field, altitude is not difficult to obtain, especially for mountainous areas. However, for some highland areas, it is often necessary to obtain a certain height with a large elevation distance from the hydram pump to the water source. This research will study the changes in the variation of the inlet angle on the efficiency that occurs. So that with this research, can be a benchmark reference for determining the distance of the hydram pump to the water source.

## 2. METHODS

The steps in this research are as follows:

**Identification of problems**

Identification of the problem in this study, namely the inlet angle factor of the hydram pump, the volume of water in the reservoir, the number of the pendulum.

**Study Literature**

A literature study is carried out by studying books, scientific journals, and previous theses that are in accordance with the research topic, to obtain basic theories that can be used as references to strengthen arguments.

**Field observation**

Researchers collected data by making direct observations of the components to be examined on the hydram pump**.**

**Testing Process**

Performing tests by changing the hydram pump inlet angle and water volume to increase the efficiency of the hydram pump.

**Analysis of Test Result Data**

Analyze experimental data. Perform data comparison analysis results to see the efficiency that occurs due to changes made.

**Conclusion**

Drawing conclusions is made to conclude the results of the research process using a factorial design $2^3$ by optimizing by changing the inlet angle of the hydram pump and the volume of the water in this reservoir can affect the efficiency of the hydram pump.

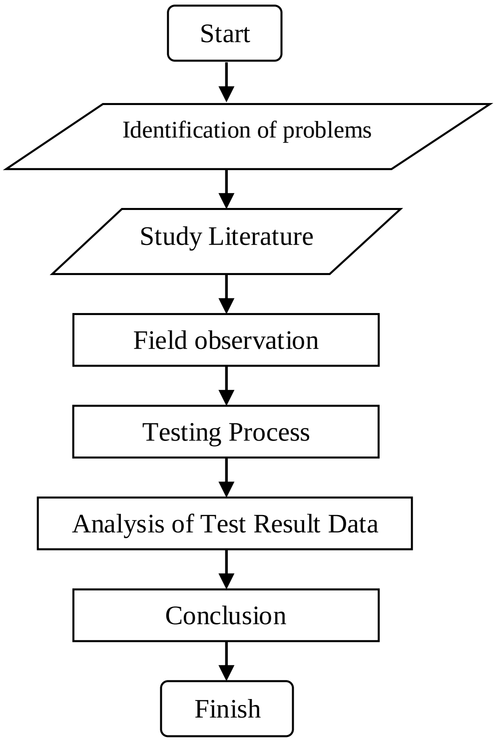


**Figure 1.** Research Methodology

## 3. RESULTS AND DISCUSSION

### 3.1. Design Experiment

Experimental designs are determined in advance to determine what variables affect the efficiency of the hydram pump and allow for a study.

### 3.2. Research Variables

There are several research variables that can affect the efficiency of the hydram pump. In this study, it will be divided into 2 variables, namely fixed variables and variable variables.

**a. Fixed Variable**

Fixed variables in this study are variables that are made fixed without changes at each test. Some of the variables that are made fixed in this study are:

- Inlet hydram : 1 in
- Outlet hydram : ¾ in
- Diameter of the hydram tube : 3 in
- Hydram pipe diameter : 1 in

- Number of the pendulum : 2
- Height of hydram inlet : 1.75 m
- Hydram outlet angle : 45°

**b. Not fixed Variable**

The variable that is not fixed in this study is the variable that will be tested in the study. Some of the variables tested are as follows in figure 2.

**Figure 2.** Hydram Pump

- Hydram inlet angle : 30° dan 45°
- Water reservoir volume : 30 L dan 15 L
- Number of pendulum : 1 dan 2

### 3.3. Hydram Pump Testing

The testing process in this study uses the $2^3$ factorial design method. This method uses 3 test variables with 2 levels for each variable. Table 1 shows the variables to be tested.

**Table 1.** Test Variable

| Variable | Level | |
|---|---|---|
| | + | - |
| Tandon Volume | 1 | ½ |
| Hydram Inlet Angle | 45 | 30 |
| Number of pendulum | 2 | 1 |

Testing is done referring to table 2.

**Table 2.** Experiment Design Factorial Design $2^3$

| Tandon Volume | | Hydram Inlet Angle | | Number of pendulum | |
|---|---|---|---|---|---|
| + | 1 | + | 45 | + | 2 |
| + | 1 | + | 45 | - | 1 |
| + | 1 | - | 30 | + | 2 |
| + | 1 | - | 30 | - | 1 |
| - | ½ | + | 45 | + | 2 |
| - | ½ | + | 45 | - | 1 |
| - | ½ | - | 30 | + | 2 |
| - | ½ | - | 30 | - | 1 |

In the testing process, first, prepare some needs in testing. Among them: Measuring length, Measuring bucket, Stopwatch, and Bevel Protractor.

The steps in the testing carried out are as follows:

- Before doing the test, first, make sure there are no leaks in the hydram pump and its equipment.
- Make sure the water source does not contain garbage or other things.
- Install the hydram inlet pipe according to the test table. (30° or 45°).
- 4. Place the hydram pump on the ground level, there is no slope on the hydram pump. Check using a water pass.
- Attach the pendulum of the hydram pump to be used. (1 or 2).
- Close the hydram input tap.
- 7. Put water in the reservoir according to the test table (1 or ½). And always keep it at the desired volume.
- Open the hydram input faucet.
- If the pendulum does not operate immediately, give a shock to the pendulum being used. Until the pendulum can operate and pump water.
- Take measurements on the flow of water that comes out of the hydram outlet.

In the implementation of the test, for hydram pumps that use pendulum 1 using a discharge measurement using a volume of 0.00023 $m^3$ and using pendulum 2 using a volume of 0.00045 $m^3$.

### 3.4. Data Processing

The experimental data above is quite varied, with the Yates algorithm the data is processed to determine which variable has the most influence. In the following way in table 3 and 4.

**Table 3.** Factorial Design Hydram Pump Testing $2^3$

| Tandon Volume | | Hydram Inlet Angle | | Number of pendulum | | Time | | | Discharge ($m^3/s$) | | | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 | 2 | 3 | 1 | 2 | 3 | |
| + | 1 | + | 45 | + | 2 | 56’ | 47’ | 42’ | 8,04E-06 | 9,57E-06 | 1,07E-05 | 9.44E-06 |
| + | 1 | + | 45 | - | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| + | 1 | - | 30 | + | 2 | 30’ | 34’ | 30 | 1,50E-05 | 1,32E-05 | 1,50E-05 | 1.44E-05 |
| + | 1 | - | 30 | - | 1 | 1”17’ | 1”4’ | 42’ | 2,99E-06 | 3,59E-06 | 5,48E-06 | 4.02E-06 |
| - | ½ | + | 45 | + | 2 | 1”7’ | 51’ | 58’ | 6,72E-06 | 8,82E-06 | 7,76E-06 | 7.77E-06 |
| - | ½ | + | 45 | - | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| - | ½ | - | 30 | + | 2 | 36’ | 37’ | 45’ | 1,25E-05 | 1,22E-05 | 1,00E-05 | 1.16E-05 |
| - | ½ | - | 30 | - | 1 | 42’ | 50’ | 1”1’ | 5,48E-06 | 4,60E-06 | 3,77E-06 | 4.62E-06 |

**Table 4.** Data Processing Using Yates Algorithm

| Discharge ($m^3/s$) | | | Velocity (m/s) | | | Average | I | II | III | Div | | Information |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 1 | 2 | 3 | | | | | | | |
| 8,04E-06 | 9,57E-06 | 1,07E-05 | 0,0473 | 0,0563 | 0,0630 | 0,0555 | 0,05554 | 0,16395 | 0,30475 | 8 | 0,03809 | Average |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,10842 | 0,1408 | 0,20317 | 4 | 0,05079 | Volume |
| 1,50E-05 | 1,32E-05 | 1,50E-05 | 0,0882 | 0,0779 | 0,0882 | 0,0848 | 0,04568 | 0,11667 | -0,1023 | 4 | -0,0256 | Hydram Inlet Angle |
| 2,99E-06 | 3,59E-06 | 5,48E-06 | 0,0176 | 0,0211 | 0,0322 | 0,0236 | 0,09512 | 0,0865 | -0,0007 | 4 | -0,0002 | Volume - Hydram Inlet Angle |
| 6,72E-06 | 8,82E-06 | 7,76E-06 | 0,0395 | 0,052 | 0,0456 | 0,0457 | 0,05554 | -0,0529 | 0,02316 | 4 | 0,00579 | Number of pendulum |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,06113 | -0,0494 | 0,03017 | 4 | 0,00754 | Tandon Volume - Number of pendulum |
| 1,25E-05 | 1,22E-05 | 1,00E-05 | 0,0735 | 0,0715 | 0,0588 | 0,0680 | 0,04568 | -0,0056 | -0,0034 | 4 | -0,0009 | Hydram Inlet Angle - Number of pendulum |
| 5,48E-06 | 4,60E-06 | 3,77E-06 | 0,0322 | 0,0271 | 0,0222 | 0,0272 | 0,04081 | 0,00487 | -0,0105 | 4 | -0,0026 | Tandon Volume - Hydram Inlet Angle - Number of pendulum |

From the results of the Yates algorithm in table 4, there are several conclusions, including:

Average: 0.03809 m/s; The mean distance resulting from the whole experiment was 0.03809 m/s. This means that the average flow velocity obtained at the time of testing is 0.03809 m/s. Tandon Volume: 0.05079 m/s; If you change the volume from 0.5 reservoirs to 1 reservoir, there will be an increase in water flow velocity of 0.05079 m/s. Inlet Angle: -0.0256 m/s; if changing the inlet angle from 30° to 45°, there will be a reduction in water flow velocity of 0.0256 m/s. The number of pendants: 0.00579 m/s; if you change the number of pendants from 1 to 2, there will be an increase in the speed of the water flow of 0.00579 m/s. So it can be concluded, that there are 2 most influential variables of the 3 variables that have been tested. Namely the Tandon Volume and Hydram Inlet Angle.

## 4. CONCLUSION

The conclusion that can be drawn from the research that has been done is: The highest water discharge that can be generated from a 1 in size PVC hydram pump, 2.75 m inlet height, 5 m outlet height is 1.5 x 10-5 $m^3/s$. while the lowest water discharge in the test carried out is 0 $m^3/s$ at the number of pendants 1 and the pump inlet angle is 45°. The inlet angle greatly affects the resulting flow rate. The inlet angle of 30° results in a higher water flow rate of $1.44x10^{-5}$ $m^3/s$ at the number of pendulum 2 compared to the 45° inlet angle which only gets $9.44x10^{-6}$ $m^3/s$ even up to 0 $m^3/s$ at the number of pendulum 1.

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