

# A Cooling Tower Design System for a Friction Machine

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For the manufacture of cooling tower system in the friction machine to keep running smoothly then from it made this design system so that this system will be able to reuse the remaining water disposal. The working principle of the friction machine is the temperature and friction of the brake lining sample to reach the temperature target for testing. To stabilize the temperature on the machine, cooling or water stabilizer is required which only rely on PDAM water, which is accommodated at a central tandon. For processed water will experience a reduction in the amount of water discharge due to evaporation due to the hot engine, and to be able to know the shortage of water is given additional form of automatic buoy connected to the central tandon. This design system uses a calculation with a mathematical scale using the basic physical law is the principle of Bernoulli equation. The creation of cooling flow system designed only in the form of Analysis of System Design and merely the theory of analysis obtained through observation, observation, and previous data retrieval on the Friction machine. Water used in the flow system both before and after modification comes from the PDAM. In the previous engine design of the cooling flow system, when water is dead or late will interfere with the process. Therefore, the Cooling Tower system was created to keep the Friction engine running. The treated water after the cooling flow system is repaired will continue to rotate according to the system being created, therefore the hot Friction engine results in reduced water due to evaporation, so as to provide enhancements in the form of automatic buoys connected to the central tanks to fill the deficiencies.

**Key words:** *Friction Machine, System Design and Law of Physics.*

## Introduction

System design can be analysed. Knowing principles and techniques will optimize working systems as comprised of humans, machines, materials, work equipment and the best work environment. This will enable to the system to work effectively and efficiently, and integrate it into the basics of physics, as applied laws functioning optimally and improving the quality of data sources and their accuracy (Blanchard, Fabrycky and Fabrycky, 1990).

Due to the rapid development of technology and intellectuals in Indonesia, system design can evaluate a problem, describe how a case happened, and base the design on an analysis and evaluation of the subject matter.

System design is in the form of principles and techniques of working systems. It consists of people, machines, materials, and tools and work environment. For the system to work effectively and efficiently, it is combined with the basic physical science of applied laws (Wignjosubroto, 2000).

To know whether a system is working properly, logic and mathematics are used, obtained through the idea in picture scheme or Kaizen of system improvement by looking at the problems and constraints (Faisal, 2013).

Numerical scale calculations are then added to form a detailed plan idea (Adrianto, 2010).

*Friction Testing Machine.* The machine tests a brake canvass specimen formed and adjusted on a test machine. A solenoid and PDAM water are used directly as a coolant, as well as a blower to suck some of the steam out and work to keep the temperature stable (Kho, 2015).

The cooling tower system is in the form of a simple cycle (Tipler, 1998). Water flows into a machine using a solenoid according to a computerized demand program. Water is discharged through a pipe that is not connected to the sewer, yet connected to a tank outside the engine room called the lower tank (Awwaluddin, Santosa and Suwardiyono, 2013). Water that is processed as a coolant will continue to expand and decrease the amount of mass until finally the lower tank will recede diminish little by little. A float valve in the lower tank serves as an automatic tool when the water discharge at the tank is lowered and receded so that the buoy will hang and open the valve on the central transponder tube, to fill the deficiency to the

extent that is adjusted, in proportion to the amount that comes out (Bueche and Hecht, 2006; Ezeanyej Clement, 2016).

From here, the water in the lower tank will be pulled upward using a water pump to the upper tank, from the lower tank and with the help of the surrounding air blast and the distance of the pipe with the upper lobe of the tube with the pipe connected to the lower windpipe as the water cooling simple after processing with hot friction machine (Nirmalan and Hylton, 1989).

## Literature and Method

### *Definition of Friction*

Friction is the force, in the direction opposite to a body or a tendency of moving objects, which appear when two objects come into contact. It need not be solid, but also can be liquid or gas. In this friction machine the object is solid with two frictional forces; static and kinetic. The amount depends on the magnitude of the normal force (N) and the friction surface hardness (friction coefficient =  $\mu$ ) (Bueche and Hecht, 2006; Kragelsky and Alisin, 2016).

$$A = -b_0 \frac{\vec{v}}{|\vec{v}|} - b_1 v \frac{\vec{v}}{|\vec{v}|} - b_1 v^2 \frac{\vec{v}}{|\vec{v}|} \quad (1)$$

Equation (1) shows where the first term is the frictional force known as the static and kinetic force. The second and third terms are the friction forces on the objects in the fluid.

### *Friction Testing Machine*

The machine is designed to determine the friction and the power used by materials wearing upon the contact at each end. The stank contains materials with rotation round disk on the fixed speed (RPM) or at a constant variable, which is driven by 2.67 HP (Horse Power). It is capable of rotating at 0 to 2950 rpm. The diameter of the disk is in accordance with the request.

A piezoelectric sensor is used as a frictional measuring meter ( $\mu$ ) on the disk connected by a computer screen to a Program Logic Controller (PLC) system which can rotate up to 650°C. Normal load, speed rotation and trajectory diameter may vary. The load used on this machine is 12.5Kg. Load, friction force, temperature and roll are displayed digitally on a computer screen.

The friction machine aims to know the rise and fall of the friction coefficient ( $\mu$ ), the average weight reduction (gr) as a percentage, and average power consumption or Wear Rate ( $10^{-7} \text{cm}^3/\text{Nm}$ ) at any temperature. From the function, the durability of a brake lining,

loss rate or loss weight and brake lining thickness is to a 300°C temperature limit. Because the average temperature limit in the testing of brake pads that have been mass produced is only 300°C, while the temperature is 350°C, is testing on brake lining is Trial or Sampling Break Lining.

The canvass sample is 25 x 25 mm, placed on the end of a continuous rubbing stank after the load lever weighs 12.5 kg lowered and initiate the engine spin. So the weight measurement is formulated in the following percent loss percentage:

$$W = \frac{W_0 - W_i}{W_0} \times 100 \% \text{ or } \frac{\text{initial wight after process}}{\text{initial weight}} \times 100 \% \quad (2)$$

Source: Internal Company Data.

Shown in equation (2) is the With Total Loss (W), the wear rate ( $10^{-7} \text{ cm}^3/\text{N.m}$ ) and friction coefficients (C). Each increase of 50°C will show the quality of braking and brake pad retention. Brake lining is good if it has a friction coefficient ( $\mu \geq 30$ ) and wear rate ( $10^{-7} \text{ cm}^3/\text{N.m} \leq 40$ ), known from computerized readings on the screen through friction sensors connected to PLCs. Total loss will follow and show the quantity of the density of brake lining products, to determine the extent of brake lining spoilage.

### ***Equation of Continuity***

When a fluid flows in a pipeline with a cross section and has a flow velocity, the flow rate of the fluid flow can be determined by the equation:

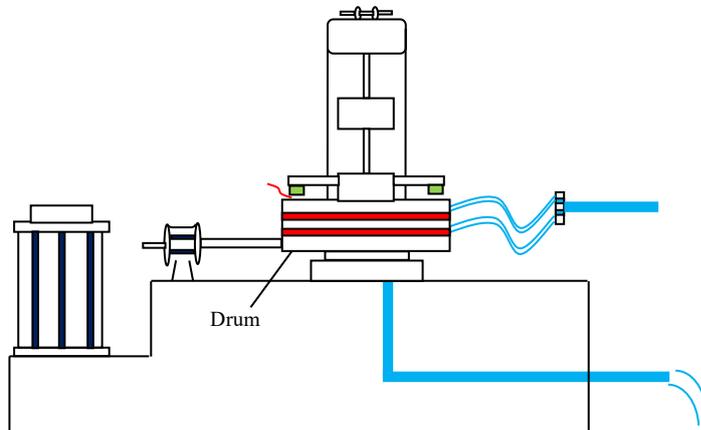
$$Q = A V \quad (3)$$

Shown in equation (3) is the fluid flow in a different pipe. If  $A_1$  is the cross-sectional area at point 1, with  $V_1$  velocity, then in  $t$  seconds the particles at point 1 will move as far as  $V_1 t$ , and the passing volume of the  $A_1$  will equal  $A_1 V_1 t$ . The volume of fluid passing through the cross section  $A_2$  per time is  $A_2 V_2$ .

### ***Circulation of Irrigation Machine Friction***

The working principle of the friction machine rests on the temperature and friction of the brake lining sample, to reach the temperature target for testing. To stabilize the temperature on the machine, a cooling or water stabilizer is required which only rely on PDAM water. That water is accommodated at a central tank, not only for friction machines but for toilets and company production needs.

**Picture 1 .Previous Friction Flow Scheme Image**



Based on the picture (1), above. The water flows through the central connecting pipeline which has a length of 21.5 meters and diameter of 1". The resulting water discharge is 42 litres/minute Then water flows into the pipe where a solenoid is connected and waiting for panel commands from thermocouple. This works according to temperature requested. When the process shows the temperature exceeds the limit or range  $> 5^{\circ}\text{C}$ , then the solenoid command is done.

The solenoid will provide water pressure of 0,2 Mpa through a plastic pipe. when the temperature drops or stabilizes, the solenoid work stops. The heater will give a heat effect to reach the target of disk temperature according to the process phase. When the temperature is suitable it will automatically turn off. When the temperature falls it will turn on until the determined temperature is back.

Water sprayed by the solenoid will be temporarily stored on the drum disk until it exits through the 3" diameter drain pipe to the sewer with average water yield process  $\geq 75$  L.

### ***Components of Friction Machine***

The friction machine consists of:

1. Heater
  - a. Cartridge Heater
  - b. Band, Nozzle Heater
  - c. Tubular Heater
2. Thermocouple Detector
3. Solenoid Steam Valve or Water Sprinkler

#### 4. Blower or Centrifuge F

##### *Relation of Bernoulli Principle and Flow System*

This is a relationship between pressure, flow rate and the height of the fluid to fix density. This equation states that the amounts of pressure, kinetic energy and potential energy per unit volume have the same value at each point along the flow. In pipes flowing from high to lower, the magnitude of the fluid flow is:

$$P_1 + \frac{1}{2} \rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g h_2 \quad (4)$$

The Bernoulli equation (4) is the basic equation of fluid dynamics, which corresponds to the pressure, flow velocity and altitude of a point along a straight line.

Force performed by force  $F_1$  is  $dW_1 = A_1 P_1 h_1$  while on the right side force  $dW_2 = -A_2 P_2 h_2$ . Thus, the total force is:

$$W_1 + W_2 = A_1 P_1 h_1 - A_2 P_2 h_2 = \frac{m}{\rho} \quad (5)$$

When the mass of the moving fluid is  $m$ , and the density of the fluid mass is  $\rho$ ,  $A_1 \rho_1 = A_2 \rho_2$  the equation (5) is :

$$W = (P_1 - P_2) \frac{m}{\rho}$$

The above equation represents the total effort made by the fluid when it is non-viscous, so there is no friction force; therefore the total work is an additional total mechanical energy in the massive fluid 'm'. The amount of total mechanical energy added is:

$$E = \left( \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2 \right) + (m g y_2 - m g y_1)$$

Then;

$$(P_1 - P_2) \frac{m}{\rho} = \left( \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2 \right) + (m g y_2 - m g y_1)$$

$$P_1 + \frac{1}{2} \rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g y_2$$

It is concluded that

$$P + \frac{1}{2} \rho v^2 + \rho g y = \text{Constant}$$

##### **Result & Discussion**

The method used in this study is a qualitative method of comparative analysis, i.e. comparative research in the form of schemes and drawings. This changes mindsets or ways of thinking, not only in the inventory side of a tool but also the innovations that make it



possible to improve the system in everyday life, in the form of concept insights to show efficiency and optimization.

### ***Comparison of Machine Friction Scheme***

Designing a new system is required to advance the previous system, because the design aims to give an overview of the system that will run. For this reason there is a comparison between the system owned by the predecessor, and the latest system.

### ***System Before Change***

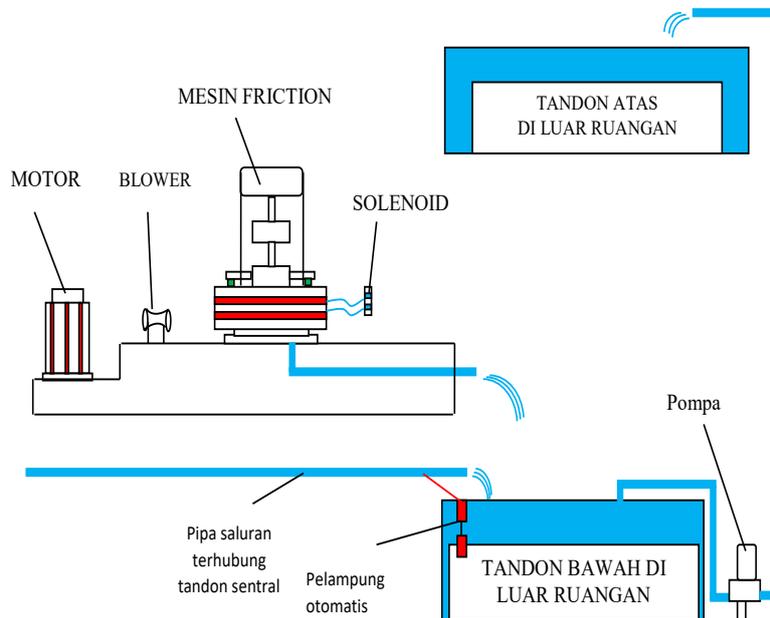
Previously, friction machines had a cooling system in the form of water connected directly to the central tank tube. The PDAM is off, the water in the central tank is empty and the machine cannot work or the process stops because there is no water as a cooler. Because the water does not undergo chemical changes, it can still be reused for further engine cooling.

Water flows through a pipeline connected to a central tank, with the help of a water pump located at the central tank to the solenoid, to be sprayed onto the Drum Friction section through a plastic tube. From the spraying, the heater will experience a decrease in temperature when that water evaporates due to heat and is then sucked by the Blower. Sprayed water in the Drum Friction section is temporarily accommodated, and then flows through the outlet pipe channel. This continuous process causes the central tank to lose  $\pm 75$  litres of water per process for 12 minutes.

### ***System after Change***

Changes are intended to improve the previous system. It relied solely on water in the central tank only as the fulfillment for coolant. That can lead to process failure and, most importantly, efficiency in water use.

**Picture 2.** Friction Flow Scheme after Changes



Based on the picture (2): seen in outline friction flow. Water that was previously connected to the central tandon was changed and connected with a reservoir above the room. The water will then pass through the solenoid. The steam vapor will be captured by the blower and temporarily stored in the drum friction section, for later discharge through the sewer pipe, then collected back to the lower tank outside the room with large discharges of water that came out. Next the water is pulled up to the tank at a height of several metres using the pump. Then the water will fall back through the solenoid connecting pipe according to the height and gravitational force of the pressing fluid mechanics. Keep in mind that when in the upper tank, the water automatically performs simple cooling, aided by the exposure or the above-mentioned airflow called cooling ponds.

Small portion of water heading towards the solenoid is used as a coolant with a spray will evaporate. Some will be wasted out into the sewer pipe. A small portion of the steam when it occurs continuously will cause receding at the outside lower tank, so that the discharge of incoming and outgoing water is unbalanced. That will cause the same thing as in the previous scheme. To avoid water subsidence at the lower tank, an automatic sensor is provided in the form of a buoy. Central tanks will provide water to fill some of the water that has been reduced when the buoy is dependent on the lower tank. This way, discharge or mass water enters the machine and exits on the friction machine.

The diameter of the solenoid outlet is  $(d) = 10.5 \text{ mm}$ . The width of the pipe hole (A) connected to the solenoid is  $\pi r^2 = 3.14 \times (5.25)^2 = 86.7 \text{ mm}^2$ . If water velocity to the tank is  $(v) 0.28 \text{ m/s}$ , for one process the machine takes  $(t)$ , which is 10 minutes or 600 seconds.

$$V_{fluida} = (86,7 \times 10^{-3}) \cdot 0,28 \cdot 600 = 14,6 \text{ Litre / process.}$$

In one experiment or one sampling testing there are several testing stages that are started from  $100^\circ\text{c}$  to  $300^\circ\text{c}$ , with an increase at each stage of  $50^\circ\text{c}$ .

$$V_{fluida} \text{ total} = 14,6 \times 5 = 73 \text{ liter} = 0,073 \text{ m}^3.$$

$$\text{Volume of tank} = 1,8 \times 1 \times 0,8 = 1,44 \text{ m}^3.$$

In the friction machine it is known that the length of the pipe distance from the central tank ( $h_{\text{tank pipe}}$ ) is 21, 5 meters, with the diameter of the pipe ( $A_{\text{tank pipe}}$ ) being 1 "(inchi) or about  $2,54 \times 10^{-2} \text{ meter}^2$ , and has the pressure contained in the central tank ( $P_{\text{tan sanyo}}$ ) of 1.6 bar or equivalent  $1,6 \times 10^5 \text{ N/m}^2$ .

The connection of the pipe to the solenoid ( $h_{\text{connection pipe}}$ ) is 45 cm or 0.45 meters, with the pipe diameter area ( $A_{\text{tank pipe}}$ ) that is  $\frac{1}{4}$ " (inchi) or about  $6,35 \times 10^{-3} \text{ meter}^2$ , and a pressure on the solenoid ( $P_{\text{solenoid}}$ ) of 0.2 Mpa or  $2 \times 10^5 \text{ N/m}^2$ .

There is a pressure on the solenoid ( $P_{\text{soleoide}}$ ) of 0.2 Mpa or, that is, at the speed of the pipe or tank  $v_{\text{pipe tandon}}$  and speed on the Solenoid or  $V_{\text{pipe solenoid}}$  is found with the following formula:

$$V = \sqrt{2 \cdot g \cdot h} \dots$$

Then the result of the V tank pipe and solenoid pipe is:

$$V_{\text{tank pipe}} = 20,5 \text{ m/sec}$$

$$V_{\text{solenoid pipe}} = 2,97 \text{ m/sec}$$

By the Bernoulli principle, the height and length of the pipe of the upper tank, adjusted to the capacity of the power, is equivalent to the pressure of the water pump at the central tank. The pressure (P) drop at the upper tank equals the pressure of the water pump at the central tank.

$$P_2 + \frac{1}{2} \rho v_2^2 + \rho g h_2 = P_1 + \frac{1}{2} \rho v_1^2 + \rho g h_1$$

$$\begin{aligned}1,6 \times 10^5 + \frac{1}{2}(1000 \cdot 2,97^2) + 1000 \cdot 9,8 \cdot h &= \\2 \times 10^5 + \frac{1}{2}(1000 \cdot 2,97^2) + 1000 \cdot 9,8 \cdot 0,45 & \\1,6 \times 10^5 + 4,41 + 9800 \cdot h &= \\2 \times 10^5 + 4,41 + 4410 & \\9800 \cdot h = 4 \times 10^4 + 4410 & \\h = 4,5 \text{ meters} &\end{aligned}$$

Thus, the tank should have a height of 4.5 metres, with an estimated range of  $\pm 5$  metres altitude to gain water pressure, in accordance with the pressure water pump owned by the central water pump.

## Conclusion

The conclusions of this study are as follows:

1. In the previous engine design of the cooling flow system, when the water is off or late, it will interfere with the process. Therefore, the Cooling Tower system was created to keep the friction engine running.
2. The treated water after the cooling flow system is repaired will continue to rotate according to the system being created. Therefore the hot friction engine results in reduced water due to evaporation, so as to provide enhancements in the form of automatic buoys connected to the central tanks to fill the deficiencies.
3. In the modified design system, Friction machines can use the physical laws of the Bernoulli Principles equation. Water discharge is around 14.6 litres in each process. The size of the tank to accommodate each process is  $1.44 \text{ m}^3$ . Meanwhile, to obtain a pressure approaching 1.6 bar, a 4.5 metre tank height is needed.

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