MINI STEAM GENERATOR

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Abstract - *This document presents the invasion of a mini steam generator that will be programmed by means of pressure, temperature and water level sensors. The mini generator will be portable, thus innovating the size since most boilers or industrial steam generators are large, and heavy. It has a digital controller that will control the sensors and will be shown in a digital screen. It is required an appropriate level of water so that the boiler continuously generates steam. The temperature that the water must contain when filling the boiler and the generator will reduce accidents due to poor control of temperature, level and pressure*.

Key Words: *Temperature, pressure, programming, generator, sensors.*

1. INTRODUCTION

Preventive maintenance is the act of performing regularly scheduled maintenance activities to help prevent unexpected failures in the future. In other words, it's about fixing things before they break. The benefits that maintenance gives us is the increase in the life of the assets, reduce maintenance, boost activity, reduce downtime in addition to reducing failures, preventing catastrophes and saving economy. In the industry, the figure for a steam generator to explode is 35949.0% due to poor maintenance and supervision of the level. (Machines, 2019).

The problem that regularly arises in steam generators is the poor supervision of water level and its installation, this causes explosions and therefore human and material losses. For this reason, it is proposed the implementation of temperature sensors, water level sensors, and pressure sensors besides this, they will be programed with Arduino in order to reduce the number of accidents due to poor supervision of steam generator.

The steam generator itself is a closed vessel that generates water vapor at pressures higher than atmospheric. The temperature of the liquid increases until it reaches the vaporization temperature and remains constant while the liquid becomes vapor, once the boiling temperature is reached, the operating pressure continues the heat supply and vaporization begins without temperature variation. The steam generator is made with a stainless steel tubular with a height of 50cm, a diameter of 33cm, an electrical resistance for heating, as well as a layer of fiberglass for protection, a sheet cap, with temperature and pressure meters.

2. METHODOLOGY

For the development of this project, a container was first manufactured with a 316 stainless steel schedule 20 tube with a length of 500mm and a diameter of 101.6mm. Therefore, the container has 2 lids on both sides with a plate of the same material with a thickness of 3mm, for that 316 welding of 1/8 in diameter was applied, which also allows the correct fusion of the materials, Figure 1.

Fig- 1 Container

3 3/8 connections were adopted, and 2 were placed in the lower part of the container for the water supply and to place the temperature sensors, likewise, 1 was installed in the upper part for the adaptation of the pressure sensor.

Therefore, 2 thermowells were placed for the adaptation of type K thermocouples in two different areas of the container to detect the temperature of the liquid, 2 stainless steel nipples 1, ¼" were also placed where they will be set the water level sensors to control the level from the inside. In any case, all these variables will be controlled semi-automatically by the ATMEGA 328P microcontroller, Figure 2.

Fig- 2 Placement of thermowells.

Likewise, for the steam outlet, an outlet was adapted at the top of the container. In the same way, it will be controlled by a metal ball valve that allows manual control of the steam outlet. However, it also has a check valve brass relief that opens at 1.23MPa for safety in case the internal pressure of the container is exceeded, Figure 3.

Fig- 3 Placement of relief valve.

Later tests were carried out to verify leaks inside the steam generator since there are parts that were welded. For this reason, it was decided to test the container in welding joints, so it was subjected to compressed air tests in addition to a water test was carried out to rule out leaks between the welded pieces, in such a way that the result was negative and no leak was found, later all the sensors were placed in their respective places to carry out said tests to verify that it did not exist any leak once the sensors are placed in their respective place.

In this way, to generate heat in the container, a 65W/in low-density cartridge-type tubular resistance with a diameter of 6.6mm and a length of 255mm was installed with a 120VAC power supply for 180°C (350 °F), Figure 4.

Fig-4 Placement of resistance**.**

It should be considered that it is very important to measure the temperature of the steam generator, which is why 2 type K thermocouples were used with their respective MAX6675 transmitter to make temperature measurements in a wide range from 0° to 1024°C so that their supply is from 3.3 - 5V, its working current is 50mA, the temperature range is from -200°C to 1024°C and its temperature resolution is 0.25°C; therefore, the 2 thermocouples will be programmed with the ATMEGA 328P microcontroller, Figure 5 and 6.

Fig- 5 Rod-type thermometer

Fig- 6 Type K thermocouple and MAX 6675 module.

To measure the pressure, an analog sensor HK3022 was used, which works at a range of 0 to 0.5MPa for constant pressure systems such as water, air, and oil. The sensor output has an analog voltage that varies linearly from 0.5V equivalent to 0MPa and 4.0V equivalent to 0.8MPa, for this reason, its analog outputs are compatible with the analog inputs (ADC) of the ATMEGA 328P microcontroller, Figure 7.

Figure 7 Analog pressure sensor**.**

In this way, to measure the water level from inside the steam generator, 2 stainless steel angle level sensors were used for the filling and emptying operation, is based on a magnetic Reed Switch type switch that is hermetically sealed inside the stem of our sensor and activated by moving the foam float that contains a permanent magnet so its voltage range is 0 – 250V, Max. 0.5 - 120VAC, Open circuit resistance 100 MO, Closed-circuit resistance 0.4 O, Power 10W, Operating temperature -30° ~ 125° C, Thread diameter 28 mm, Nut diameter 1/8´NPT, Figure 8.

Fig- 8 Switch-type water level sensor.

For filling the steam generator with water, a 12 V DC Mini electric water pump was used, with a power of 6W, operating current 0.5-0. 7A, Traffic: 1300mL/min 100ml, Lift 1.5m, life up to 2500H, water temperature is 5-40, outlet diameter: 6.72mm, size 98 x 35mm, so 6 meters of 6.72mm transparent hose was used to fill the steam generator, Figure 9 and 10.

Fig- 9 12V water pump.

Fig- 10 Hose

Once all the sensors were placed in their respective places, tests were carried out with the temperature sensors so that the steam generator was filled with water, later the resistance was connected to heat the water and be able to carry out the temperature tests and verify from ATMEGA 328P, so the result was positive since the 2 thermocouples marked their temperature, Figure 11.

Fig- 11 Test

In the same way, pressure tests were carried out, which were done with hot water, allowing it to reach a temperature of 90°C to generate steam pressure, so the pressure sensor marked the data in ATMEGA 328P so that a second test where the steam generator was emptied and compressed air was put inside the container so that the 2 forms the sensor marked its pressure.

To better understand the operation of the process, the following flow chart of the pressure sensor is shown (Figure 12) in which the functionality of the pressure sensor is represented, said sensor will collect the data of the pressure that is inside the generator, a once the sensor checks the measurement, the data will be sent to the ATMEGA 328P serial monitor where the data will be displayed. Said measurements will be repeated during the time that the steam generator is in operation.

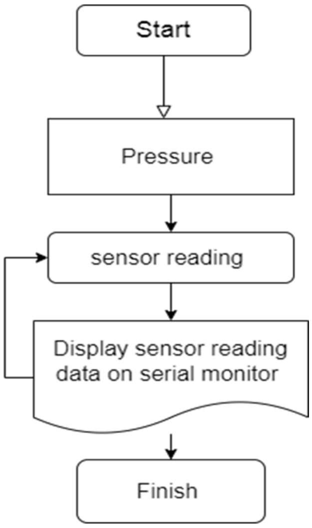

Fig- 12 Diagram of the operation of the pressure sensor.

The following diagram of the operation of the level sensor will be explained (Figure 13), its main function is to activate and deactivate the pump that supplies water to the generator. The aforementioned sensor has a similar function to a switch, therefore, when the container is at its maximum water level, the sensor will maintain the function of an NC switch, consequently, due to the production of steam, the water level will decrease. and the sensor will take the function of a NA switch.

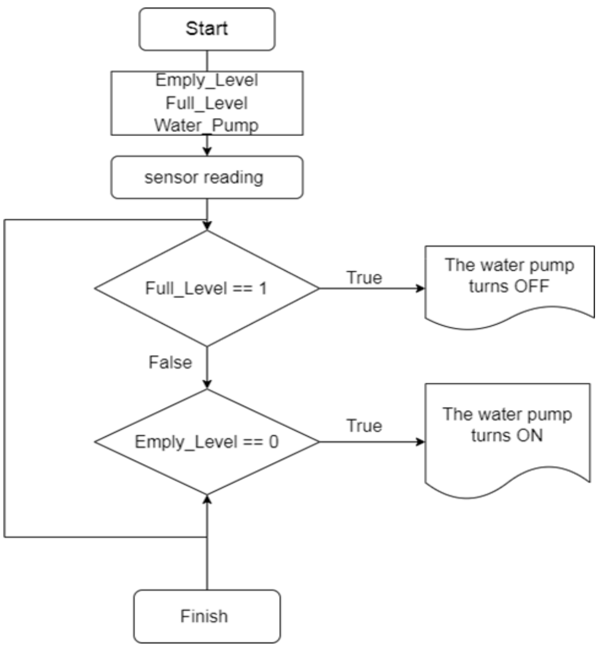

Fig- 13 Level sensor flow chart

So that the slack diagram of the temperature sensor will be explained (Figure 14), which represents the operation of the thermocouple. Its purpose is to keep the temperature in ATMEGA 328P monitored so that it will avoid any accidents and will allow it not to exceed the temperature at which it should be maintained.

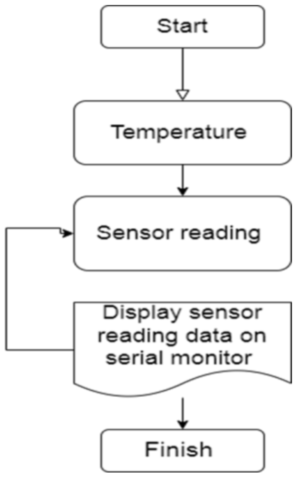

Figure 14 Temperature sensor flowchart

3. CONCLUSIONS

Based on this research, the efficiency of the steam generator depends on its design. The sensors and the water pump that feeds the generator were correctly installed. Through ATMEGA328P they will have pressure, temperature and level readings.

Filling tests were performed on the generator and it was observed that the level switches correctly deactivate the generator feed pump.

With the help of a display of the ATMEGA328P microcontroller, the readings are displayed that allow us to keep abreast of the internal temperature of the container**, so that** the water that enters the boiler through the pump will have a temperature of 40 ° C by means of the feed water preheating system, to have a constant evaporation. It is worth mentioning that the safety valve never opened due to some excess internal pressure. Thus, verifying that the pressure and temperature indicators implemented fulfilled their function. Some possible causes of failure would be that if you do not have water at a minimum temperature of 40 °C, a thermal shock can be caused, and the resistance would have a lower quality of life. If the steam generator reaches an overpressure, it can generate an explosion, and if the pump fails, it would run out of liquid and the generator would explode.

It is important to look for an ideal type of water that does not affect or damage the container because when the water gets very hot, it can generate scale that sticks to the water level sensors. Finally, the generator must contain a foil coating for greater personal safety.

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