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OTIMIZATION IN SYSTEM REFRIGERATION OF AUTOMOTIVE BATTERIES ON FORMATION PROCESS - A CASE STUDY

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Abstract. *One of the processes present in the manufacturing of automotive batteries is the formation process, where the batteries are activated through routines of electrical charges with gradual increases of electrical voltage. During this process, the batteries suffer internal reactions that release heat and increase temperatures around them, exposing the industrial plant to the risk of fire. To avoid this risk, some manufacturers use water bank refrigeration as a solution. These are structures where the batteries rest over baths of water while they are loaded. Because of the batteries' increasing temperature during the formation process, the challenge for manufacturers is to reduce the cost and long time of the process, making the control temperature an important factor to productivity. Another problem is the water loss in the process due to the cooling system used. Therefore, this study presents a solution applied in the formation process of battery industry to optimize both time and cost through a new water cooling system.*

Keywords: *battery, cooling system, formation process.*

1. INTRODUCTION

The automotive industry has grown in recent years, and to reach this demand, the battery industry has tried to keep pace, seeking to improve processes and expand facilities.

The manufacturing processes currently found in automotive battery production lines, according to DARDEN (2015), are the following: insertion set of plates; insertion of the fused terminals; filling acid; formation (initial battery charge); tests operational adjustments; cleaning label and finishing.

This proposal focuses on the process of formation, where batteries are electrically charged. During this process, the batteries suffer internal reactions that release heat and increase the temperature, exposing the industrial plant to the risk of fire (NAVSO, 1991). To avoid this risk, some manufacturers use water banks as a cooling solution, in which the battery structures rest in a water bath while they are loaded. The challenge for manufacturers is to reduce the cost and time, because the temperature of the batteries rises during this process, making temperature controls an important factor to productivity (SIEMENS, 2015). Another problem is the loss of water in the process due to the cooling system used. Therefore, this study presents a solution applied in the FORMATION PROCESS of battery industry to improve the time and cost by proposing a new water cooling system.

2. MATERIALS AND METHODS

In the case study, the water banks, in which the batteries rest while receiving the initial electrical connections, comprise 200 batteries on average. Fig.1 shows a water bank.

Figure 1: Bank for battery training

When the batteries are placed in the banks, the volume of water is on average 4m³. When the formation process begins, the volume increases over 2m³, covering about 100 mm.

In the case study, the water used for this procedure came from the industrial water system with cooling towers, the hot water tank, the cold water tank and the centrifugal pumps. At the beginning of the formation process, the water was 30°C. During the formation of this battery, bank water circulated in a closed system until the temperature rose by 12°C. At that moment, the bank water was exchanged for water at a temperature of 30°C, thereby decreasing the temperature.

The temperature measurement tests revealed that the water temperature rose by 3°C/h; thus, the heat dissipation of the batteries per bank was 21 kW.

The major problem with this type of system was the great variation in water temperature that made difficult the cooling of the battery, causing the formation process to last for more than 20 hours. Another drawback was the consumption of drinking water in the cooling towers, with average losses of 2.5 m³/h of water by evaporation. Because of these results, the goal of creating a new cooling system was to reduce water losses and increase productivity.

This new cooling system was applied to 64 banks with a new loading plan and new cooling system for the purpose of the formation process to last an average of 10 hours. Performing tests on one of the banks that already operated according to this procedure, with a more severe loading plan, it was found that the average water temperature rose 7°C/h, concluding that the thermal dissipation was approximately 50 kW .

A basic flow chart of the new battery banks (Fig.2) with some important data:

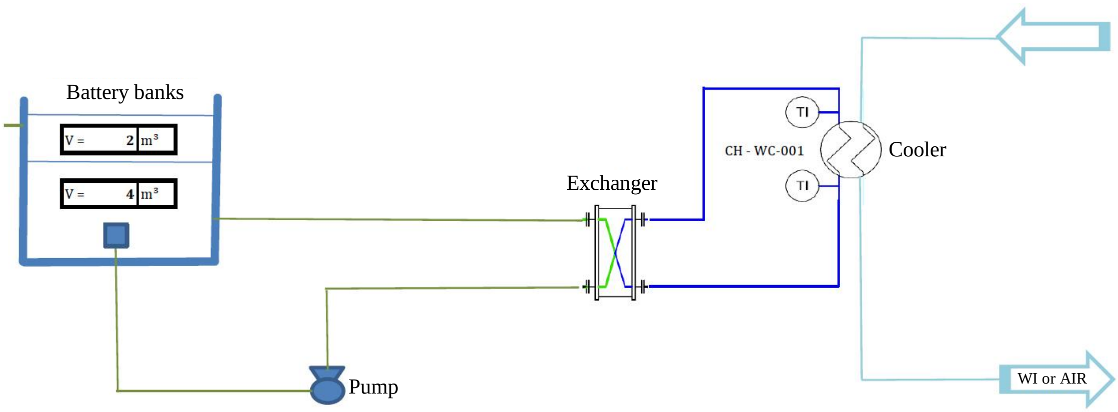

Figure 2: Flow chart refrigeration battery banks

- The heat load released by each bank is 50 kW.
- Total of 64 banks.
- Each new battery bank comes with a heat exchanger that adjusts the water temperature so that it stays between 26-30°C. NOTE: The temperature of the water returning to the banks cannot be less because it can prevent the chemical reactions of the battery.

Given this information in composing the new cooling system, a comparative analysis can be made between the cooler with condensation water and the cooler with condensation air, to meet these new conditions in the process of forming and cooling batteries.

The concepts of heat transfer used for calculate thermal work, flow rate and COP were extracted from the following references: ÇENGEL (2009) and INCROPERA (2006).

3. RESULTS AND DISCUSSION

Below, Table 1, with the initial costs, electrical consumption and water consumption, compares results system using a water cooler and an air cooler.

Table 1: Comparison between the water cooler x air cooler

	water cooler	air cooler
Thermal power cooler	**1035 [kW]**	
COLD WATER		
Temp.In [°C]	18.5	20.5
Temp.Out [°C]	14.8	16
Flow Rate [m³/h]	242.1	199.1
INDUSTRIAL WATER		
Temp.In [°C]	18.5	-
Temp.Out [°C]	14.8	-
Flow Rate [m³/h]	242.1	-
Evaporation loss in the Tower (TOTAL - 3 chillers) [m³/h]	7.26	-
OTHER INFORMATION		
Electric Motor [kW]	136	262
COP calculated	7.6	3.95
COP manufacturer	8.16	3.97
COSTS		
Unit Cost	US$270,000.00	US$200,000.00
Quantity	3	3
Initial Cost	US$810,000.00	US$600,000.00
Monthly cost of energy consumption	US$26,758.49	US$47,699.91
Water consumption (m³/month)	5,227	-
Monthly cost of water consumption (US$10,42/10 m³)	US$5,449.78	-

• It may be noted that the difference in cost of initial investment between the water cooler and air cooler is US$210.000,00.

• The cost of electricity in the air cooler is greater because its efficiency is less than the water cooler, and this difference is US$20,941.42 per month.

• However, water loss by evaporation on the water cooler system is 7.26 m³/h. This loss will be 5,227.2 cubic meters per month, equivalent to a monthly cost of approximately US$5,449.78/month, depending on the price of water per cubic meter in the plant location.

• Both of the two solutions (water cooler and air cooler) reduced the operating time of the formation process by half, according to tests carried out in the plant. This happened because these systems were built to a specific size to absorb the entire heat load that the batteries released during the process.

• In terms of initial cost and cost of water replacement, using the air cooler becomes more feasible.

4. CONCLUSIONS

An improvement study was done through using some parameter settings that would reduce operating time and cost of the formation process of automotive batteries, a process in which the batteries are charged electrically.

The modified parameter is the cooling system of the battery during charging. In order to maintain a more stable water temperature in the water banks, the proposed solutions were to use the water cooler and the air cooler. Both solutions cut in half the normal operating time. Each manufacturer selected the type of solution that was according to their internal requirements.

This study provides ideas to industries in the same sector that show that small changes in some parameters of their processes can bring significant productivity.

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