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Design and Implementation of an Electric Piston in the General Company for Rubber Industries

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ABSTRACT

The General Company for Rubber Industries produces tires, tubes of auto, rubber gaskets, rubber coupling, and enveloping some metal products such as steel rolls and rotation wheels. All rubber products above-mentioned are called secondary products. Due to the consumption of raw materials to produce the tire, the company stopped producing steam, which reflected negatively on the second- ary product, which led to the idea to find alternative solutions to heat the piston during the company stopping. As a result, this paper focuses on the design and manufacture of an electric piston to solve this problem. The idea of electric heating is heating the pisto n with electric heaters that connected to a control circuit to regulate and control the temperature. Heat conduction in this design may be ex- pected as being one-dimensional since via this design, heat conduction will be calculated in one direction and igno red the others. The findings demonstrate the efficiency of the manufactured piston in terms of profits and increase productivity. Comments on the ad- vantages and disadvantages of both pistons are also given in this paper.

KEYWORDS

Electric piston, Steam piston, Rubber industries, Productivity, Secondary products

INTRODUCTION

The General Company for Rubber Industries was founded in 1974. It is one of the specialized companies that producing tires in various sizes (large, medium and small) as well as agricultural tires. It had already managed to produce aircraft tires in best speci- fications in addition to the production of tanks lining rubber to resist acids and other rubber products [1]. The design capacity of the company around 300 thousand tires annually while the availa- ble capacity about 200 thousand tires. Their production is charac- terized by quality and durability that is subject to the tests of the Central Agency for Standardization and quality control. The com- pany is serious steps to obtain ISO certification through a contract with Specialized Institute for Engineering Industries [2], [3]. The control process of the product manufacture is by observing the phases of all the details of the production process begin from the preparation department which is the manufacturing of rubber Dough division, where the quality monitors in the preparation department to control of the manufacturing Dough rubber. In the formation department, parts of the multilateral tires are formed and the process control of manufacturing parts happened as usual. In the construction division, semi -finished parts are built that is formed in the formation department on special machines depend on size [4], [5]. Finally, the fixation department that contains sev- eral main divisions:

1. Division of paint and drilling where the tires are painted and drilled to be ready for compression.
2. Division of large and medium pistons where these pistons are connected with a feed network of hot water and steam from the boilers. The monitoring of operating conditions which are the temperature and pressure are the most im- portant duties of an observer of quality in the department of the fixation. The process of tire vulcanization in the pis- ton is based on temperature and pressure [6].

Vulcanization discovered by Charles Goodyear in 1839. Dur- ing the experiment, a mixture of rubber and sulfur has fallen on a hot stove. He found that the heat strengthens the mixture [7]. The process of compressing the tire inside the piston is con- trolled according to the following [8], [9]:

1. Monitoring the operational conditions of the piston tempera- ture and pressure.
2. Ensuring the work of a piston timer.
3. Ensuring the validity of the green tire for the compression without distortion due to the storage.
4. Placing the tire inside the piston in its proper position in the mold.
5. Putting the welded area in front of the eye to be observed during the compressing.
6. Giving the shaping process the size in a gradual manner.
7. Providing the required stopping for the piston according to the standards.
8. Completing the other stages of the piston, which are per- formed automatically in the piston such as closing the drains, opening the feeding valve, closing the exit valve and others.
9. Running the timer ... to know the time of the compressing.
10. After the end of the cycle of vulcanization and opening the piston which is carefully controlled by the operator then removing the tire from the mold.
11. The tire should be examined after its exit from the piston when it’s hot as a first inspection stage. The quality notes should be recorded with colored crayons to be sent to the other inspection stages.

DIVISION REPAIRS

This paper focuses on the current issue of stopping the com- pany to produce steam, which reflected negatively on the se c- ondary product of the company. The idea is to find alternative solutions to heat the piston during the company stopping. Con- sequently, this paper focuses on design and manufacture of an electric piston to solve this problem. The idea of electric heating is heating the piston with electric heaters that connected to a control circuit to regulate and controls the temperature. The rest of this article is organized as follows. S ection 2 is about related works. In S ection 3, research methodology is de- scribed. Results and discussion are explained in S ection 4. The conclusion is presented in Section 5.

RELATED WORKS

There are numerous studies conducted in different fields that depend on and considered heat conduction via a large plane wall such as the house wall, glass window with single pane, the end of a pressing iron metallic plate, steam tube of a cast -iron, a cylindrical nuclear fuel element, the wall of a spherical container, the wire of an electrical resistance, or tempered a spherical metallic ball. Heat conduction in these geometries and others may be expected as being one-dimensional since via these geometries, heat conduction will be calculated in one direction and ignored the others [10]. According to [11], a new space–time meshless technique is presented for resolving the reverse heat conduction problem. A mathematical approximation is gained using the heat equation Trefftz basis function. The Trefftz technique, which varies from conventional collocation approaches depend on a set of unstructured points in the place, is utilized in this research to collocate border points in the space–time coordinate system so that the primary and border conditions can together be treated as border conditions on the space–time area border. [12] present ed analytical formula with its presence theorem for reverse heat conduction problem solution of quasi-infinite bar, equal to the first kind of a Volterra integral equation, like fractional derivatives infinite series.

The mathematical technique is depending on some characteristics of function space M [0, T] regarding fractional integration and derivatives. [13] revisited the optimal shape issue of a single cooling fin via the equation of one-dimensional heat conduction with convection border conditions. Initially, the authors apply a method using optimality conditions depend on requiring stability of the optimization problem Lagrangian function. This produces an optimal condition basis for the generally touted fixed temperature incline condition. Furthermore, the prescribed thermal power root temperature is minimized, instead of maximizing the heat transfer degree for a fixed root temperature as earlier works. [14] addressed the technique of lines and its different the numerical technique of lines as a dependable avenue of one- dimensional numerical analysis unstable heat conduction in cylinders, walls, and spheres including surface convection interaction by a close fluid. The technique of lines converts the one- dimensional unstable heat conduction formula in the spatial and time parameters x, t to the first -order ordinary differential equations adjoint system in the time parameter t. [15] studied the heat conduction design including two isotropic material temperatures, which exolains, the change rate of interior energy caused by the heat flux movement form one intermediate to its complement with familiar Wentzell boundary conditions.

The authors study the one-dimensional Laplace operator spectrum on the section [0, 1] with familiar Wentzell boundary conditions. They observe the relative spectrum in heat conduction formula of one-dimensional including two temperatures, and create the re- solving set in the Cauchy-Wentzell issue with familiar Wentzell boundary conditions. According to [16], heat conduction issues are investigated from information entropy view. The temperature variation law with time in the lumped-heat-capacity scheme can be explained in the exponential distribution form. It is verified that exponential distribution is the key of a conditional great value issue with data entropy as an objective function. The common analysis technique of heat conduction issues from the information entropy view is pro- posed. Essential solution of heat conduction formula can be writ- ten in the normal distribution form, and normal distribution may be derived from the extreme entropy principle. In [17], a meshless numerical technique based upon radial basis function (RBF) is established to solve the linear heat transfer formula in one-dimensional areas by convection boundary conditions using heat source terms. This technique uses the temperature and the time as parameters and is evenly applicable to issues in various space dimensions. Thermal modeling has been enhanced, in which a diverse critical zone impacting the macroscopic portion thermal are involved in the powder bed, the conduction formula based on the porosity coupling through the phenomena of convection, using distribution modulization of the heat source as a boundary condition.

RESEARCH METHODOLOGY

Principles of design an electric piston

The working of the electric piston is depending on the principle of heating that results from the current passage and the resistance of these conductors to that current. When the conductor's re- sistance increases, the heat generated also increases. This is what happens in the heating in the electric piston, which is character- ized by high resistance. This heat will transmit to the rubber paste where the load currents try to distribute the temperature on the rubber paste equally, and when the temperature reaches the re- quired degree, the thermostat will separate the current from the heating element automatically. If the temperature decreases, the thermostat will sense this and connects the current to the heating element to compensate for that decrease; and so on the electric piston is done. We will explain the heat conduction in the base plate of an iron: Assume the base plate of a (1200 W) domestic iron which has a thickness (L) =0.5cm, thermal conductivity (k) =15 W/m·K, and base area (A) =300cm2 . The internal surface of the base plate is exposed to regular heat flow produced by the resistance heaters inside, and the external surface mislays heat to the environs by convection at T_∞=20°C, as shown in Fig. 1. Assuming the coeffi- cient of convection heat transfer (h=80 W/m2 ·K) and ignoring heat mislaying by radiation, gain an expression for the difference in the base plate temperature, and assess the temperatures at the internal and the external surfaces.

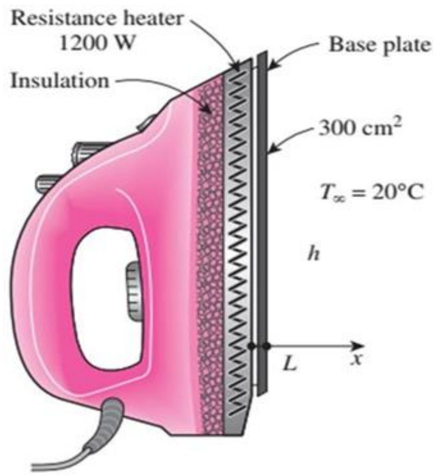

Figure 1. Heat conduction in the iron base plate.

The iron base plate is considered. The variation of the plate temperature and the surface temperatures are to be specified. We propose several assumptions:

1. Heat transfer is stable because there is no variation with time.
2. Heat transfer is unidimensional because the base plate su r- face area is huge compared to its thickness and on both sides, the thermal conditions are uniform.
3. Constant thermal conductivity.
4. No heat generation in the medium.
5. Neglect heat transfer by radiation.
6. The whole heat produced in the resistance wires is transferred to the iron base plate through its internal surface b e- cause the upper portion of the iron is well isolated.

The given thermal conductivity is to be k=15W/m·K

Analysis The internal surface of the base plate is exposed to uniform heat flow at a rate of

$$\dot{q_0} = \frac{\dot{Q}_0}{A_{base}} = \frac{1200\,W}{0.03\,m^2} = 40000\,{}^{W}/_{m^2} \tag{1}$$

The external side of the plate is exposed to the convection situation. By taking the normal direction related to the wall surface such as the x-direction with its source on the internal surface, the differential formula for this issue can be stated as Fig. 2:

$$\frac{d^2T}{dx^2} = 0 \tag{2}$$

Through the boundary conditions:

$$-k\frac{dT(0)}{dx} = \dot{q_0} = 40000\,{}^{W}/_{m^2} \tag{3}$$

$$-k\frac{dT(L)}{dx} = h[T(L) - T_\infty] \tag{4}$$

The common solution of the differential formula is again gained by two consecutive integrations to be:

$$\frac{dT}{dx} = C_1 \quad (5)$$

And:

$$T(x) = C_1x + C_2 \quad (6)$$

Where C_1 and C_2 are random constants. By applying the first boundary condition,

$$-k\frac{dT(0)}{dx} = \dot{q}_0 \rightarrow -kC_1 = \dot{q}_0 \rightarrow C_1 = -\frac{\dot{q}_0}{k} \quad (7)$$

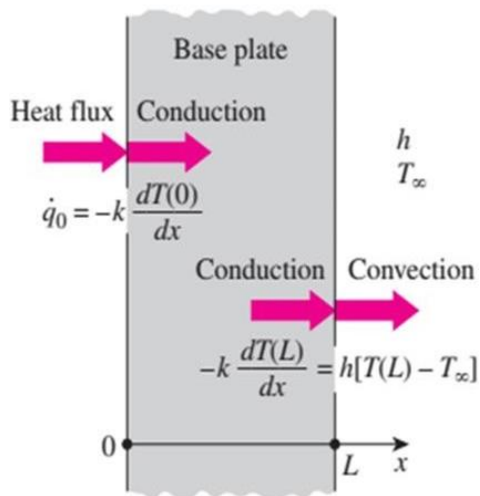

Figure 2. The boundary conditions on the iron base plate

Observing that $dT/dx=C_1$ and $T(L) = C_1L+C_2$, the application of the second boundary condition provides

$$-k\frac{dT(L)}{dx} = h[T(L) - T_\infty] \rightarrow -kC_1 = h[(C_1L + C_2) - T_\infty] \quad (8)$$

Replacing $C_1 = \dot{q}0/k$ and resolving for C_2, we get

$$C_2 = T_\infty + \frac{\dot{q}_0}{h} + \frac{\dot{q}_0}{k}L \quad (9)$$

Now replacing C_1 and C_2 into the common solution (6) provides

$$T(x) = T_\infty + \dot{q}_0\left(\frac{L-x}{k} + \frac{1}{h}\right) \quad (10)$$

This is the solution for the difference of the plate temperature. The temperatures at the internal and ex- ternal plate surfaces are determined by replacing x= 0 and x=L, respectively, into the equation (b):

$$T(0) = T_\infty + \dot{q}_0\left(\frac{L}{k} + \frac{1}{h}\right)$$

$$= 20^oC + \left(40000\,{}^{W}/_{m^2}\right)\left(\frac{0.005\ m}{15\,{}^{W}/_{m.K}} + \frac{1}{80^{W}/_{m^2.K}}\right) = 533^o\ \text{C}$$

and

$$T(L) = T_\infty + \dot{q}_0\left(0 + \frac{1}{h}\right) = 20^oC + \frac{40000\,{}^{W}/_{m^2}}{80\,{}^{W}/_{m^2.K}}$$

$$= 520^oC$$

From the abovementioned explanation we observe that the temperature of the internal base plate surface is 13°C higher than the external surface temperature when stable operating conditions are gotten. Moreover, observe that this heat transfer analysis permits us to calculate the sur- faces temperatures which we cannot even get. This in- stance proves how convection boundary conditions and the heat flow are applied to heat transfer issues.

Manufacturing of an electric piston

Each clamp is made of two iron plates with a thickness of 10 mm. The electric heater is placed between these two plates and is firmly anchored to ensure that the heater is connected to the entire surface of the plate. Each clamp is then connected to the electrical control system to transmit the electric current to the heater and control the temperature, as shown in Fig. (3 and 4). After the completion of the modification, we started the actual production. The first production was a rubber roller for Waist Factory for Textile and Knitting with 500 pieces, as well as the production of coupling Rubber for Dewaniyah textile factory and the production of rubber parts for the company such as the oil resistant Heptane pump. The results were identical to the steam piston. . Fig. (5 and 6) illustrates the method of manufacturing electric clamp.

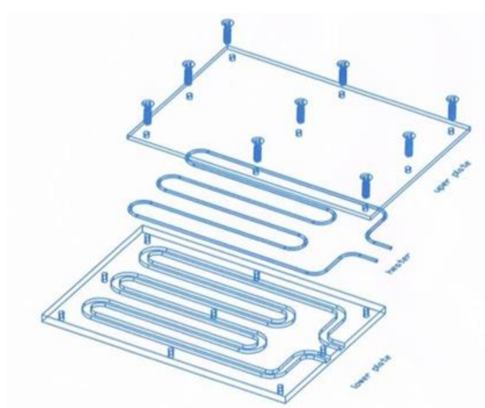

Figure 3. The method of manufacturing each clamp of an electric piston.

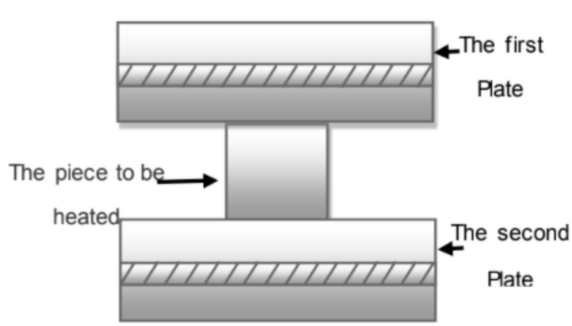

Figure 4. The electric piston

Figure 5. The electric piston

Figure 6. The method of manufacturing each clamp of the electric piston

RESULTS AND DISCUSSION

The first production was for the Wasit textile factory in the total amount (5000000 million Iraqi dinars) five million dinars, and the research revenues during the past years (500 million Iraqi dinars) five hundred million dinars until 1/8/2020. The research costs amounted to (600000 Iraqi dinars) six hundred thousand dinars. The advantage of the electric piston is the easy control the temperature through (THERMOCOUPLE) and (DIGITAL CONTROLLER). The sensor type is (PT100) was selected for high-temperature sensitivity, where the temperature control (SET) is established and when the temperature of the heater reaches the temperature required through the sensor, the controller interrupts the current from the heater and thus the temperature is easily con- trolled. It also needs a low operating current of up to 20 Amperes and therefore it can be operated on a small generator. The steam piston is controlled by a mechanical valve operated by air pressure and controls the amount of vapor entering the piston and thus controls the temperature.

CONCLUSIONS

This paper focuses on a design and an implementation of an electric piston to solve the problem of stopping producing steam in the company and stopping the steam piston. The idea of electric heating is heating the piston with electric heaters that connected to a control circuit to regulate and controls the temperature. The results prove the efficiency of the manufactured piston in term of incomes and increase productivity. The advantage of the electric piston is the easy control the tem- perature through (THERMOCOUP LE) and (DIGITAL CONTROLLER).

The electric piston is better than the steam piston because the steam piston contains the following disadvantages:

1. The condition of the presence of air. Thus, any delay with air compressors, we cannot control the amount of steam.
2. The possibility of leakage of steam.
3. Mechanical valve needs to be maintained periodically.

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