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DEVELOPMENT OF INDUCTION HEATING FURNACE USED IN GASKET CURING FOR INCREASING ENERGY EFFICIENCY IN TINPLATE PACKAGING INDUSTRY

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Abstract

Tinplate packagings produced in packaging industry are generally composed of three parts. These are bottom gate, casing and top gate. Gasket is used where bottom and top gates join up with the casing. The gasket used need to be cured at a certain temperature in order to provide a complete seal. In tinplate packaging industry, furnaces used in this process are generally operated at temperatures nearly between 70 to 90 ^{o}C and maximum production rate of 160-170 part/min. Besides, each of these furnaces consumes 10 kW/h energy. It is observed that this embodied gasket is not cured appropriately regarding international quality standards. A gasket curing furnace with induction heating has been developed and it is observed that it reaches the desired temperature value relatively fast and provides more gate passing rate (approximately 800 part/min) compared to available furnaces with approximately 3 kW/h energy consumption. In this study, the working principle of this newly developed furnace and the energy efficiency and savings obtained by this application is examined.
Keywords: Induction System, Energy efficiency, Gasket Curing Furnace.

1. Introduction

Currently, in packaging industry gaskets are used at top and bottom gates of tinplate can in order to provide sealing. Gaskets dispensed to gates require to be cured at a certain temperature. Furnaces already used in tinplate packaging industry consume 10 kW/h energy. Besides, these furnaces must be kept at a certain temperature depending on the gate production rate which increases the total energy consumption.

There are gasket curing furnaces behind each of the gate production presses depending on gate passing rate. Accordingly, it is possible to pass gates produced by three gate press on a single furnace. Available furnaces used in gasket curing are gas furnaces that give rise to sealing problems in the product. Therefore, use of induction heating furnace for the curing process is evaluated for a process enhancement.

Induction heating systems have the leading benefits such as relatively low energy consumption, fast heating rate and good reproducibility. The fundamentals of induction heating rely on electromagnetic energy transmission. Precisely, energy is transferred from a coil through which an alternating current is circulating. Due to the Foucault law, there exists induced currents in the conductive part and by means of joule effect workpiece is heated. Induction heating processes are used at relatively high frequencies when heating should be performed very locally near surface [1]. In this study, the working principle of induction heating furnace used in gasket curing and the resulting energy savings and efficiency are illustrated with the top gate production of Ø52 tinplate aerosol can.

2. Working principle of available furnace used in gasket curing process

The working principle of furnaces used in tinplate can packaging production can be summarized as: Gates are produced with several processes and undergo curling process. After the curling process gaskets are made by the machine and fed to gasket curing furnaces. In this furnace system, gates move inside a metal slot in an overall helical system. This furnace has two separate partition at each sides and hot air is blown by means of two fans through the gates where the gaskets placed so that the gaskets are cured. Interior walls of the furnace are coated with glass wool and generally glass wool is covered with aluminum plate for more aesthetic

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appearance. Gas furnaces are used in curing process of the gaskets dispensed to the gates. Each of these furnaces operates at temperatures between 70 to 90 ^{o}C. However, temperature at the penetrating gate surface is approximately 50 ^{o}C and gates are removed from the furnace within 50 seconds. When the maximum operation temperatures and gate removal time of these furnaces are also considered, it is observed that these values cause gate gaskets to be dehumidified merely, they could not be cured adequately. This situation gives rise to sealing problems during product assembly. Moreover, a certain time is needed for these furnaces to reach the desired temperature levels and the desired temperature level should be maintained whether or not gate passing occurs in order to ensure the required production rate. This also increase the cost. One of the furnaces used in the process is shown in Figure 1.

Figure 1. One of The Furnaces Used In The Process

3. The working principle of induction heating furnace used in gasket curing

Induction heating furnace used in gasket curing provide three times faster curing compared with available furnaces. When the operation temperature is set to 140 ^{o}C regarding the quality standards curing time for a gasket is determined to have taken 10 seconds. Newly developed gasket curing furnace with induction heating reaches the desired temperature value when it senses the metal so that the energy consumption is reduced to 3 kW/h. This furnace consists of gate intake system, induction system, a glass bell, fans, electrical resistance system and a water cooling unit. Gates passes through the glass bell. Fans enable dehumification of gates. Power input of the furnace is 3 kW and output frequency is in 30-50 kHz range. Operation voltage is 380 Volt (AC)/3 phase. Water cooling system that will run in conjunction with the induction system has a cooling capacity of 3.5 kW and hermetic compressor power input is 1.5 kW. Water cooling unit running in the system supply not only fixing the temperature but also protecting the induction coil from overheating. Induction heating furnace has some specialties like: uninterrupted and off-position operation, short and open circuit prevention, digital resonance tracking, capability of testing itself, notification of failure and warnings, capability of heating each part homogeneously and equally, temperature reading and fixing, consuming non-reactive energy, capability to sense the part with a sensor, capability to fix the part temperature when desired temperature is reached. A schematic representation of an induction heating furnace used in gasket curing process is shown in Figure 2.

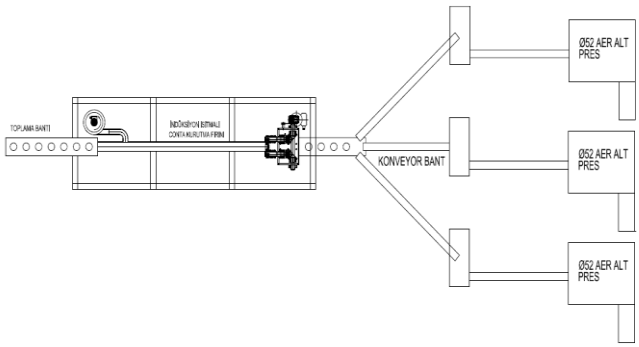

Figure 2. Schematic Representation of an Induction Heating Furnace Used in Gasket Curing Process

The working principle of induction heating furnace used in gasket curing can be summarized as follows: The top and bottom gates of tinplate cans are produced in related presses after several operations and are fed on a conveyor band to the machine which the gaskets are made. Gasket dispersion is made around the gates with a

nozzle system. Thereafter, gates coming from six presses conjugate in a single line on conveyor band and are transmitted to the gasket curing furnace.
Gates move swiftly in the furnace and gaskets are cured. At the outlet of the furnace, gates are dehumidified by means of a fan. The picture of these furnaces is shown in Figure 3.

Figure 3. The Picture of These Furnaces

4. Advantages of gasket curing furnace with induction heating over current curing furnaces

The advantages of gasket curing furnace with induction heating over available furnaces are given as follows:

-Obtaining the Required Temperatures for the Gasket Curing Process:
Induction systems can provide heating at different temperatures up to 1500 ^{o}C by adjusting the electrical current. Available furnaces operate at temperatures between 70-90 ^{o}C and gaskets that are placed at gates cannot be cured according to desired quality procedures. A relatively fast curing has been supplied by the development of induction heating furnace for the gasket curing process.

- Increasing Production Rate:
There is at least one available furnace behind each press depending on the gate production rate. Each of the furnaces operates at production rate of 140 part/min. Induction heating furnace has a operation rate of 6 times of available furnaces, thereby gates leaving six presses pass from a single induction heating furnace.

- Increasing Energy Efficiency of Production Line:
A single furnace is used instead of 6 furnaces and this results saving in production line.

- Decreasing Amount of Energy Used:
Energy consumption in the curing process is reduced from 60 kW/h to 3 kW/h owing to the use of induction heating furnace used in gasket curing. Thus, 95 % energy saving is obtained. Likewise, this furnace reaches the desired temperature relatively fast and operates only when gate passing occur by means of a sensor. In this way, energy saving

- Gates Completes Curing Process at Desired Temperature for Manual Packaging:
Furthermore, parts leaving induction heating furnace are collected manually. However, they can't be packed at high temperatures. When this is taken into consideration, a cooling unit is integrated to the outlet of induction heating furnace.

5. Results and Discussions

Furnaces currently used in tinplate can packaging industry operate at nearly 70 ^{o}C and consume 10 kW/h energy. When we consider production of aerosol can gates, there are six presses and behind each press there is a furnace used in gasket curing. Therefore, total energy consumption of furnaces will be 60 kW/h. Furthermore, available furnaces operate depending on the press production rate which has a maximum capacity of 140 part/min. Induction heating furnace has a capacity which perform total part quantity leaving six presses. Gate passing rate conveniently fulfill 840 part/min production rate, hence use of single induction heating furnace instead of using six curing furnace reduce the energy consumption from 60 kW/h to 3 kW/h. The total annual energy saving resulting from this enhancement is approximately 499.320 kW/h in aerosol

can gate production. From cost point of view, for the aerosol bottom gate production 69.904,80 TL saving has been assessed.

6. Conclusion

In this study, the working principle of induction heating furnace used in gasket curing and advantages provided by these furnaces compared with available furnaces are presented along with energy saving gained in the case of use. Newly developed system has provided approximately 95 % energy saving for the process and has made a major contribution to energy efficiency.
In virtue of these types of enhancements in the processes, the problems encountered in electrical energy production and usage in our country will be precluded. Besides, the investments, to meet the increasing electrical energy demand which is more than 10 % every year, will be lowered adequately.

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