Design and Manufacturing of Conveyorized Infrared Oven: A Review

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ABSTRACT: *This project deals with the designing and manufacturing of a table-top conveyorised IR (infrared) oven. The furnace works on the principle of infrared radiation propagated with the help of medium wave IR tubes. The method of heat transfer which is primarily through radiation which is governed by Stefan Boltzmann's law, Wien's law, and Planck's distribution law. Radiation heat transfer is caused as a result of vibrational and rotational movements of molecules, atoms and electrons. The energy is transported by electromagnetic waves (photons). Radiation requires no medium for propagation and therefore can take place in vacuum. The benefits of infrared (IR) heating includes short heat-up times, good temperature control, and energy efficiency. Significantly higher heating rates and better temperature control is achievable than in a conventional convection furnace. Since heating is on a demand basis, reduced energy consumption is a major advantage along with the shorter production time. We are going to construct a model to improve efficiency of this heating system.*

Key Words: *Efficiency, Infrared radiation, Planck's Distribution Law, Stefan Boltzmann's Law, Temperature control, Wien's Law.*

INTRODUCTION:

Infrared radiation (IR), sometimes referred to simply as infrared, is a region of the electromagnetic radiation spectrum where wavelength ranges from about 700 nanometers(nm) to 1 millimeter(mm). Infrared waves are longer in wavelength compared to those of visible light, but shorter than those of radio waves. Correspondingly, their frequencies are higher than those of microwaves, but lower than those of visible light, ranging from about 300 GHz to 400 THz. Conveyorised ovens are energy efficient ovens which are widely used in overhead conveyors. The ovens can be made in such a way that they support the conveyor track which can be made inside a heating chamber and thus help in containing the heat and fumes within. Infrared ovens are being widely used in various applications like paint finishing, powder coating, plastic moulding, ink drying, automobile, audio accessories, stationery etc. Types of emitters are reflector heat lamp, quartz tube and ceramic emitter. Rapid heating of the product is achieved and low energy cost as the heat is targeted to the required surface. In our project we intend to use infrared heating. The heating process is sustained through medium wave infrared tubes. At a wavelength of 3-5 micrometres of the infrared lamp the heating effect starts. The given wavelength offers the following advantages over convection heating:

1. 90 % energy is transmitted as infrared
2. Instant, accurately controllable radiant heat
3. Easy installation
4. High efficiency, low energy costs

A real fabrication model is to analyse IR heating system, the capacity of the oven is 4-6 KW. From the furnace the temperature is sensed by thermocouple, which is based on the Seeback's principle. The infrared heating has the potential to be used for solutionizing of metal forging with benefits of reduced energy consumption, increased productivity and improved microstructure and mechanical properties, other applications include reduction of moisture content in various objects.

The furnace is placed on a conveyor which is controllable through a ECU unit. The speed of the conveyor can be varied between 0.8-15 metres per minute. Conveyor is based of Teflon mesh type as it can withstand high temperature.

FURNACE SPECIFICATIONS:

1. Max temperature: 200°C.
2. Furnace cube material: Mild steel, powder- coated
3. Insulation material: Rockwool.
4. Inner cube material: Stainless steel, powder coated.
5. Dimensions: 400x600x400 mm

ADVANTAGES OVER OTHER METHODS OF HEATING AND DRYING:

1. Quicker heating and surface drying compared to other conventional heating methods.
2. Free of fire hazards as no spark/flames are used to heating the product.
3. Heat provided to the product is easier to control with the help of electronic components unlike in the case of convection or conduction heating.
4. IR energy distribution is consistent and uniform providing better product quality than conventional heating
5. High energy efficiency is achieved as IR energy is transferred from IR emitters by radiation to product surface without requiring any heating medium
6. High intensity of IR heat can reduce the required processing time.
7. High degree of automation allows precise control of process parameters
8. Compact design and different types of IR emitters permit a space-saving
9. Low maintenance cost because of more electrical components.

INFRARED HEATER SPECIFICATIONS:

1. Number of lamps: 2-3
2. Heating type: infrared radiation
3. Input power: 4-6 KW
4. Wavelength of heater: medium wave
5. Max temperature: 1000°C

COMPONENTS USED:

1. Furnace cube
2. Insulator material
3. Furnace door
4. Infrared lamps
5. Lamp holders
6. External paint
7. HVAC fan/blower
8. Thermocouple
9. Conveyor system
10. 3-phase motor
11. Gear box

LITERATURE SURVEY:

Vinod K. Sikka, Craig A. Blue; Evan Keith Ohriner observed in this paper [7] the relation of heat treatment of materials, and more particularly the use of infrared radiation in such heat treatment. More specifically, they stated the current invention which relates to the use of very high heat fluxes and heating rates to selectively treat an object. They stated various methods of rapidly and efficiently heating a layer of an object and also to provide a method of achieving such heating with little or no temperature effect on the remaining layers or portion of the object.

These and other objectives and advantages were met by providing a process for heat treating an object having a surface section and a base section by the steps of directing infrared radiation toward the surface section at a power density of at least 250 kW/m to rapidly heat the surface at a rate of at least 100° C per minute and shielding the base section from the infrared radiation, the rapid heat causing the surface section to undergo a physical, chemical, or phase change to change a characteristic of the surface section while not changing that characteristic in the base section. The surface section may form the shield for the base section, and the method can be used on monolithic, laminar, or composite objects.

Fayrd R. Cook [6] observed that a conveyorised oven for heating products comprises of:

A cavity having a first continuous access opening and a second continuous access opening.

A convection heating source including a heating element, a blower, and a plenum in communication with the cavity and it providing heated air to the cavity

An upper radiant energy heating source in communication with the cavity, the upper radiant energy heating source including an infrared light source and at least one reflector providing radiant energy to the cavity.

A lower radiant energy heating source in communication with the cavity, the lower radiant energy heating source providing radiant energy to the cavity.

A conveyor system for transporting products through the first continuous access opening, the cavity, and the second continuous access opening at a rate of speed sufficient to allow the food products to be heated.

Kurt Roth, John Dieckmann and James Brodrick observed in this journal paper [4] that infrared radiant heaters can be used to replace unit heater where they can use electricity to produce heat. Various tests were carried out and the tests found that, after adjusting for the outdoor temperatures over the test periods, the radiant infrared heaters consumed about half the energy to heat the same space as the unit heaters.

They also found that radiant infrared heaters also have several positive attributes compared to unit heaters. The radiant infrared heater does a better job of heating in the exposed areas. Essentially, the radiant heater element and the surfaces heated by the radiant heater continue to heat objects in the room even after the thermal energy in the air has dissipated.

The efficiency of the heater can be increased if placed in a circular orientation. It is oriented in a straight line at the moment.

Douglas Canfield and Frank Lu in their article 'Mystery out of Infrared Heating' stated on various aspects related to infrared heating like when to use infrared and convection heating ,compatibility of parts with IR, IR in solvent and hazardous environment.

It also explains the different loop process control systems which work in the IR that is, open and closed loop system.

Sanjay B. Pawar and V.M. Pratape in their research paper [1] stated that the energy loss in convective air drying is found to be very large in chemical and allied food industries. Air, the drying medium, needs to be heated using air heaters, which generally have low thermal efficiency. On the contrary, as the infrared radiation is recognized as surface heater, it can be very suitable for drying of food materials whose drying is generally carried out in thin slices. Moreover, use of infrared heaters in other dryers is very beneficial to lower the drying time without significantly affecting the quality of the final products. Lowering the drying time can increase the productivity and decrease the cost of operation practically.

Chao Ding and Ragab Khir researchers, in their research paper [2] and experiments have proven that IR heating has immense potential to be utilized as a sustainable, environment friendly technology for achieving almost instantaneously high drying rate, high quality of milling and sensory quality, disinfection of freshly harvested rough rice. IR heating can also be used as an efficient stabilization method to improve the storage ability of rough and brown rice. From their research we can observe that infrared is suitable and more appropriate for curing food products as it does not cause any changes in the quality of the food but instead increases the storage life of the food product to be stored in the industry by getting rid of the moisture content which facilitates the habitation of microbial organisms.And infrared rays is especially useful in drying hygroscopic products which the most food product are, as the heat produced in the food products due to the infrared sources last for a longer time compared to the other conventional heating methods.

R. Ramaswamy in his research paper [9] stated that IR heating iis the most promising means to be used in both small- and large-scale food processing plants. This technology has a lot of potential in various applications because of its inherent advantages, such as controlled, rapid heating and precise targeted application. In addition to surface heating of foods and dehydration of agricultural products, IR radiation could conveniently be used for decontamination and disinfection of food and food-contact surfaces.

In recent years there has been a lot of attention given towards novel technologies because of the constant demand from consumers for quality products that are safe to eat. Convenience of usage of IR and availability of its resource gives IR heating a head start in terms of being adopted in the commercial market. Furthermore, the technique can easily be integrated into any in-line processing system.Due to wide variation in the surface characteristics of foods, it is clear that the equipment used(lamp, waveguide, power, etc.) and process parameters (time, power of exposure, distance of application, etc.) need to be optimized for the specific application.

Lingamallu Jagan Mohan Rao and Kulathooran Ramalakshmi in their research paper [10] stated that microwave radiation (MW) whose wavelength is in the range of 1mm to 1m lies between IR and radiofrequency (RF) and is known as dielectric radiation. Material which exposed to MW is heated due to dipolar rotation and ionic polarization. Hence, material which contain a polar substance such as water is heated faster with microwaves. The typical domestic Microwave oven has a frequency of 2450 MHz. The applications of MW in food processing are blanching, drying, pasteurization, baking, etc. Compared to standard microwave technology, higher frequencies such as 24,150MHz are also used for industrial applications with respect to special physical/ engineering advantages.

OUTCOMES AND FUTURE SCOPE:

Infrared heating can yield very high percentage of heating efficiency with minimal energy input. We can also achieve localised or globalised heating depending upon the requirement.The integration of IR with other matured processing operations such as blanching, dehydration, freeze-dehydration, thawing, roasting, baking, cooking has been shown to open up new processing options. Combinations of IR heating with microwave heating and other common conductive and convective modes of heating have been gaining momentum because of increased energy throughput.

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