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Modular Electromagnetic Levitator Furnace

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Abstract**—***In this paper we are going to melt the metals by the process of electromagnetic levitation which is a well-known technique used to avoid the risk of contamination by crucible material as in conventional induction heating system. A requirement to achieve a stable levitation melting of the metallic load at a fixed equilibrium position. To place a metallic object into a time-varying magnetic field generated by an induction coil induces eddy currents in the object. The interaction between the induced eddy current and the applied field generates electromagnetic force that can be used to levitate the object. It is found that the process stability is affected not only by the coil geometry but also by the power supply design simulation of a simple series resonant converter as the power supply showed instabilities caused by a phase delay between the sphere moment and the current envelope of the converter.*

Keywords—Furnace, levitation.

I. INTRODUCTION

The basic of induction heating principle have been understood and applied to manufacturing since the 1900s. During 1900s, the technology developed for a fast, reliable process to harden metal engine parts, led to a rediscovery of induction technology.

Since almost all electric processes create heat, it is easy to understand that electro heat appears early in science. The heat generated through energy-conversion processes, however, usually goes hand in hand with energy losses. If on the other hand, the transformation of electric energy into thermal energy is a desired action, the electro heat produced can be used for many technical processes. One of the most intelligent techniques is the induction heating of electrically conductive materials. It comprises a wide field of applications in metal-casting industry because of its benefits. At present time induction heating and melting processes are commonly used all over the world. The progress in electro heat became possible only after the discovery of the dynamo-electric principle and the availability of technically usable dynamo-machines in the second half of the nineteenth century. At that time, the development of induction melting started, followed later by the high- frequency heating of metallic bodies for hot-forming and heat-treating. An absence of powerful high frequency (HF) sources caused a big delay in the practical implementation of the initial ideas to use high frequency for heating.

II. PRINCIPLE

The principle of induction heating is mainly based on two well-known physical phenomena:

2.1 Electromagnetic Induction

$$E = -d\Phi/dt \quad \text{…. (1)}$$

E: Voltage (V)

Ø: magnetic flux (Wb)

t: time (s)

2.2 Joule Effect

P = R*I 2 Watts …. (2)

III. POWER FORMULA

For Billet

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For a solid circular billet;

$$P_w = (N \cdot I \cdot K_c)^2 \cdot \frac{\pi \cdot d \cdot \rho}{\delta \cdot L} \cdot Q_{rod} \quad \text{.... (3)}$$

For Rectangular Slab

For a rectangular slab;

$$P_w = (N \cdot I \cdot K_c)^2 \cdot \frac{2 \cdot W \cdot \rho}{\delta \cdot L} \cdot Q_{slab} \quad \text{. (4)}$$

Efficiency of electrical energy

The efficiency of conversion,

$$\eta_c = 100 \Big/ \left[1 + \frac{1}{K_a K_c^2} \cdot \frac{S_c}{S_w} \cdot \sqrt{\frac{\rho_c}{\rho_w \mu_w}} \cdot \frac{1}{Q}\right] \quad \text{.... (5)}$$

IV. WORKING

The single phase AC supply of 230V, 50Hz is feed to the project. Further there are MCB connected of 32 Amps and fuse of 25amps protection purpose. There an isolation transformer used so isolation of input circuit with the output circuit. Isolation transformer is 5KVA rating. It's 1:1 transformer which handles current up to 25 amps.

Further the rectifier circuit is used for conversion of supply from AC to DC. The full bridge rectifier is used for conversion purpose. CLC filter is used for getting ripple free DC. Voltage at the output of this is about 206 V.

The 206V DC is then feed to the inverter circuit. The inverter circuit is a single phase bridge inverter with PWM technique consists of IGBTs. The output frequency is about 200 V AC at 1 KHz frequency.

This AC voltage at high frequency is feed to the Induction coil which is hollow copper coil. The load to be melt are aluminum, tin and lead.

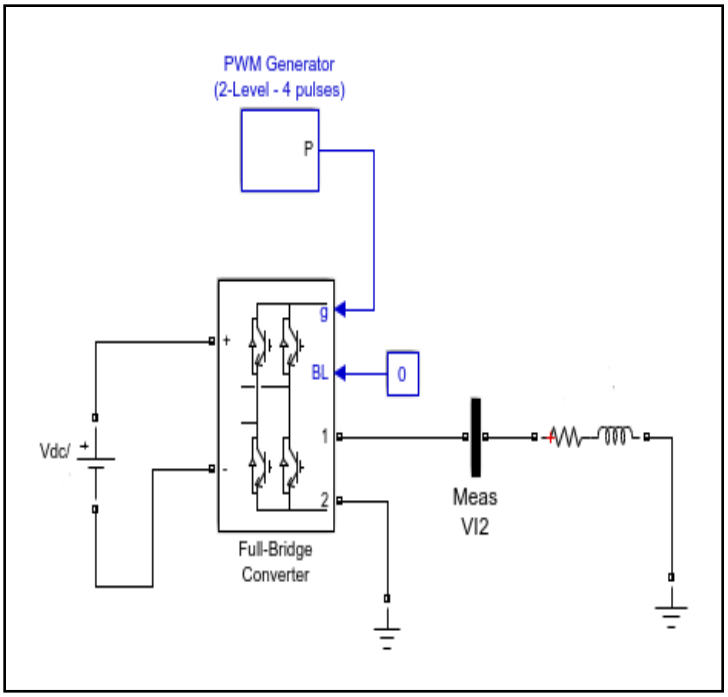

Fig. 1 Inverter circuit.

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V. ADVANTAGE AND FUTURE SCOPE

Environment Friendly, No Green house gas, fast heating and clean heating.

VI. APPLICATION

Used in industry for furnace and used to laboratory experiment to see liquid metals properties. It can be used for making high purity alloys for variety of applications.

VII. RESULT

The given specimen has been melted using our modular electromagnetic levitator furnace.

VIII. CONCLUSION

In this project we have both experimentally and numerically showed the process of electric melting in a clean and simple manner. The basic different types of electric heating methods are Resistance melting, Electric Arc melting and the Induction melting. In this project we are using induction heating technique for the purpose of melting of metal in a microgravity of space. The basic principle of the Induction heating is given by the Faraday's Laws of electromagnetic Induction which states that whenever a conductor is placed in a varying magnetic field electromagnetic force are induced which is called induced electromagnetic force, if the conductor circuit is closed current are also induced which is called induced current. The Induced current generated is circulating in nature and are referred to as Eddy Currents. The definition of Eddy current is called Foucault currents are loops of electrical current induced within conductors by a changing magnetic field in the conductor due to Faraday's laws of Induction. This circulating currents due to collision with the atoms of the metal release heat in the form of I2R loss. In our project we use this I2R loss for our benefit and use for the purpose of metal melting. The calculation of the magnetic force on the metal is done with the help of the Lorentz force. The Levitation part is achieved with the help of special property of magnetic field which is known as Magnetic levitation. The scientific definition of magnetic levitation is 'Magnetic levitation, maglev, or magnetic suspension is a method by which an object is suspended with no support other than magnetic fields'. In our project we achieved this magnetic levitation with the help off the shape of our coil which is Helical in shape. The Helical shape resembles changing diameter of the coil as we proceed towards lower side. According to Biot-Savarts law the magnetic field in a circular loop depends upon the diameter of the coil we get differential magnetic field. This differential magnetic field acts on our metal which is ferromagnetic in nature and due to this differential magnetic field the metal keeps on levitating in the micro-gravity of space.

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An acknowledgement section may be presented after the conclusion, if desired.

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