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An Overview: Casting/Melting of Non Ferrous Metallic Materials using Domestic Microwave Oven

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Abstract—*Microwave material processing has emerged as one of the promising technique in the field of manufacturing. It's been extensively implemented in the field of joining, sintering, cladding, ceramics, powder metallurgy etc. of bulk metallic material. It is been widely used due to reduced manufacturing cost, processing time, fine microstructure, less defects etc. as compared with conventional methods. Microwave energy has been generally used in medical, food processing, drying etc. This work has been focused on the development of new emerging technology, i.e. microwave casting/ melting of non-ferrous metallic materials. Recently, microwave energy is also been focused for industrial applications.*

Keywords*: Microstructure, Microwave Hybrid Energy, Tensile strength, Hardness, Melting.*

1. INTRODUCTION

In the modern era of growing and developing technology there are lots of advancement are being developed in the field of engineering. The industries are looking forward for new and improved casting technique. With the development of technology, new material came into existence and to cast that material high energy consumption was required. But the problem associated with these technologies such as environmental degradation, high energy consumption, high manufacturing cost have led to development of all those casting techniques which can minimize these losses up to an extent. The microwave energy leads the researcher to explore in the field of microwave processing towards different areas of materials manufacturing. Recently, lot of research have reported in the field of sintering, joining, cladding, etc. and application are still increasing towards the melting of metal.

Microwave is a type of electromagnetic radiation (electromagnetic radiation takes place at different wavelength and frequency) having a range of applications, including communication, radar and industries.

Microwave has frequency ranging from about 3 billion cycles or 3 giga hertz (GHz). There are presently so many conventional and non-conventional techniques which are used for the metal casting but in order to obtain more accurate, finished product and to reduce energy consumption and processing time microwave radiations are used. Microwave metal casting experiment has been done to evaluate materials, equipments, processes, quality and energy uses in the production of metal casting. For all new processes energy comparison to conventional processes is an important factor. Along with the microwave metal casting microwave technology has wide range of application areas. Traditionally it has been used for different telecommunication purposes but it is also used for different kinds of sensing and imaging applications.

The application areas of microwave are many which can be categorized as telecom, point-to-point communication, satellite, cellular access technologies, space, spectroscopy, radio astronomy, MedTech, diagnostics, defense, radio, security, car avoidance radar, traffic surveillance, navigation, positioning and measurement, GPS, food, heating and detection of foreign bodies in food etc.

Microwave reach the object as same as the speed of light which makes its processing more rapid than any other conventional technique. In microwave processing heating takes place at atomic level over the complete volume of material. No temperature gradient is observed due to volumetric heating of material in microwave processing. In microwave processing temperature remains same throughout the material resulting in better physical and mechanical properties and with lower defects. Different heating parameter and temperature control of microwave setup make it suitable for variety production.

Conventional method for heating metals produces toxic gases, fumes, smoke etc. which leads to the environmental degradation. Energy requirement to raise the temperature inside the furnace is used to be higher than the energy requirement in microwave metal processing. Less energy utilization in microwave processing makes it energy saving as well as cost saving technique. Properties of microwave make the microwave processing eco-friendly, cheaper, fast and highly efficient.

Along with its advantages microwave processing has disadvantages too. The unknown temperature inside the

microwave cavity makes the process complicated and for smooth processing. Controlling the rate of heat and heat transfer with respect to different materials is difficult inside the cavity. All these parameters need to get optimized because overheating may get fuse the metallic powders and radiations may harm the inefficient worker, so it should be operated carefully.

2. LITERATURE REVIEW

Reddy *et al.* [2017] investigated the physical, mechanical, thermal and structural behavior of the extruded Al-Al_2O_3. Author explained that ceramic matrix composites due to its enhanced toughness and wear resistance used highly in industries. On increasing the content of hard ceramic particle in composites it improves the overall mechanical properties like yield strength, tensile strength and Young's modulus. On the other side ductility and thermal coefficient of expansion get decreases.[1]

Ravikumar K. *et al.* [2017] examined the mechanical properties of Aluminium alloy (AA6082) composite reinforced with tungsten carbide particle. Author observed that the density, hardness, tensile and impact test and conclude that density, impact strength and elongation decreases with increase in addition of tungsten carbide while the hardness of composites increase with increase in tungsten carbide. Tensile strength increase initially and then tends to decrease. [2]

Singh K. *et al.* [2015] observed that due to the volumetric heating of the material in microwave processing, it works faster than any other conventional technique. [3]

Bansal A. *et al.* [2014] concluded that the joining of stainless steel (SS-316) plates using microwave hybrid heating and conclude that the presence of chromium carbide, iron carbide and iron silicide enhance the micro-hardness of the joint.Vicker's micro-hardness in the joint zone on the grain boundary was higher than inside the grains due to presence of various hard phase.[4]

Rajkumar K. *et al.* [2014] examined Al6061 matrix material in which boron carbide and graphite are reinforced and the composite was formed by stir casting. Author concluded that microwave heat treated composite exhibit higher hardness than conventionally heat treated composite.[5]

Agrawal D. [2006] observed that the microwave processing takes very small time and produce the superior products. The mechanical properties such as modulus of rupture and hardness of microwave processed sample of PM Green bodies (comprising various metals, steel and metal alloys) were much higher than the conventional sample. [12]

Gupta P. *et al.* [2013] performed the joining of mild steel and stainless steel by microwave energy at 2.45GHz and 900W. Author concluded the tensile strength, elongation and micro-hardness are 340.16MPa, 11.67% and 130Hv respectively. [8]

Rajkumar K. *et al.* [2014] performed the microwave heat treatment and conventional heat treatment on Al (6061)-B4C composite. Author investigated that comparable mechanical properties were obtained in both microwave and conventional processing. Microwave processing takes shorter time than conventional. Hardness of composite increases on increasing amount of B4C in Aluminium composite.[6]

Loganathan D. *et al.* [2014] observed that the main advantage of microwave processing is that the specimen do not undergoes bending while processing but bending of specimen occurs in the case of conventional processing. In microwave heat treatment, heat transfer is uniform all over due to the volumetric heating of specimen and heat treatment sample has more hardness than the base sample.[7]

Srinath M.S. *et al.* [2012] explained that during microwave heating both E (TE 10) and H(TM01) fields contribute to the heating for different materials, however, there may be only one of them which dominate the heating process during microwave exposure. There is no control on selection of modes of microwaves in the software tool. One has to select either TE10 or TM01mode only. It should be noticed that the microwave heating of materials is very sensitive to the values of permittivity (ε) and permeability (μr) [9]

Srinath M.S. *et al.* [2011] investigate that the X-ray diffraction (XRD) pattern shows the conversion of some copper powder particles into copper oxides. A dense uniform structure with good metallurgical bond between the layer and interface was obtained. Author conclude that the hardness of joint area was observed to be 78+7Hv, while the porosity in joint was 1.92%, elongation of copper joint was 29.21% and ultimate tensile strength was 164.4MPa. [10]

Srinath M.S. *et al.* [2011] performed the joining of stainless steel (SS-316) to mild steel and concluded the average Vickers's micro-hardness as 133Hv and 0.58% porosity. The ultimate tensile strength of the joint was found to be 346.6Mpa with 13.58% elongation. [11]

Gupta *et al.* investigated the effect of mild steel and stainless steel weld plates using microwave energy. Microstructure analysis revealed that the joint has no cracks. Very small amount of porosity is observed. Tensile strength, elongation, and microhardness are 340.16 MPa, 11.67%, and 130 Hv, respectively [13].

Microwave processing has been continuously implemented in the field of joining/cladding/sintering etc. It can also be implemented in the field of casting/ melting of bulk metallic material or non ferrous material using microwave energy. It can be done in simple household microwave oven with frequency of 2.45 GHz and 900 W power. By implementing some adjustment in the crucible surrounded by the refractory bricks, casting/melting of non ferrous metallic materials can be done. Non ferrous metallic material with Ni based powder is placed in the crucible. After

certain time, melting will start. This crucible is covered with graphite plate of 1mm thickness. Above graphite plate charcoal is placed so as to provide heating at a particular place. Charcoal is used because it is easily available and cheap. Stirrer can also be used for providing better mixing of non ferrous metallic material and Ni based powder. After, atmospheric cooling, substrates can be used for calculating the mechanical properties of the melted/casted material.

3. GAPS IN LITERATURE REVIEW

It was observed that microwave processing is mainly focused on processing food, joining of bulk metallic materials, cladding, sintering etc. Little work has been reported in the field of casting/melting using microwave energy.

4. CONCLUSIONS:

- Microwave processing techniques has gained popularity due to its various advantages i.e. improved mechanical properties, reduced processing time, fine microstructure, energy saving etc.
- Research in variety of materials can be done using microwave hybrid heating.
- Various progresses in the pasture of microwave-processed composites were discussed and improved mechanical properties were reported.
- The most recent development in the area of microwave is microwave joining which is reported and discussed with details
- Casting/melting of metallic materials was focused.

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