Indian Journal of Science and Technology, *Vol 9(36), DOI: 10.17485/ijst/2016/v9i36/101490, September 2016*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Microwave Assisted Casting for Fabrication of Micro Components

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Abstract

Objective: To perform micro-casting operation by melting lead powder in a micro mold with the help of microwave radiation to get minute shapes in casting. As per the previous research studied, the work on the micro-casting with different shapes has not been done. **Methods:** Micro mould has been fabricated with the help of vertical machining center. Lead powder has been heated with the help of microwave radiations. Before the experimentation micro mould of graphite of having shapes of star type, and circular has been fabricated using vertical machining center. **Findings:** Different sizes of 1 mm, 2 mm, 3 mm, 4 mm and 5 mm of Pb powder was fabricated by melting lead powder in microwave oven and weights are measured in gram which involves innovation using XRD. **Applications:** Ink Printing, Shape Deposition, Investment Casting, Wax pattern, etc.

Keywords: Lead Powder, Micro-Casting, Microwave Radiations

1. Introduction

The microwave is a device in which the electrical energy coverts into microwave energy. This is that process which converts the energy directly and pass on to the materials, with the help of electromagnetic waves on molecules which are towards volumetric heating, here in this process the heat is generate internally in the material rather than outside source or that energy pass on outside. These microwaves are that kind of electromagnetic radiation, which carries their wavelength around the range of one meter to one millimeter and their frequency, lies in the range of 300 MHz or 300 GHz. But on generally 2.5 GHz frequency is used in the processing of materials. In last few years microwave energy has been used in many different applications, few applications like those who carry-on their temperature from 500 C to1000 C and in sintering or advanced material method temperature should always high then 1000 C.

Many researchers have done an investigation on microwave casting and found that microwave process gives the best result as comparable to the conventional process. In[1] studied on a numerical study of mould filling in microcasting. In this study it is described that a micro-casting mould cavity which are having a very less size channels, here a volume fluid process was taken for the purpose of identifying the free surface flows and for searching the metal. After this it was also noticed that capillary action is needed for filling process of little micro channel while performing this it was also found that the filling process was non-uniform and with this all finally the micro channel was attained with completely filled. Author concludes from all this is that the pure metal was filled and microcasting was attained with size of micro-channels. In end he described that the side edger of mould was not proper filled and there was a pressure also gained for the purpose of filling the microchannels. In[2] has been reviewed on microwave hybrid heating of materials using subsector. In this author discussed on the fundamentals of microwave hybrid heating, where author found that while using of microwave heating direct on any materials can be caused of high dielectrical loss. Where on another side it was also noticed that the low dielectrical materials can process by the microwave while using of hybrid heat-

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ing, out of this it was noticed that hybrid heating is faster as compression of direct heating. It minimize the problem of thermal runway in experience while using direct microwave heating which occurred into the high dielectrical loss of materials. Out of all this the conclusion came out was that using of microwave hybrid heating as a subsector provides the merits of using of single energy source. In[3] has studied on microwave heating of conductive powder materials in which the author did a few experiments viva using the powder particles which was covered by a layer of insulating oxide. Few parameters were analyzed like heating regimes in iron, silicon, copper powder, after that the microwave absorption efficiency, enhanced by enhancing the thickness of the shell, by using 24 GHz/3 kw grypton system was used for the purpose of heating of metal or silicon powder. In[4] has done research on Microwave drill application for concrete, glass and silicon in this research the author described about the principle of microwave drill or experimental methods after doing all this few applications were also provided for microwave drill in different materials like concrete, glass, silicon, ceramics with the help of coupled thermal electromagnetic numerical model in this the method of thermal-runway or hot spot generation with the microwave drill was designed. Few applications were provided for microwave drill to holes in concrete, ceramic, glass, etc. In[5] had research on the feasibility of microwave machining in the drilling materials. Basically in this research the focused on concentrating microwave in few areas for heating or to make a hole and this was done on aluminum, glass, wood, etc. So from all this the research conclusion was that drilling of a metal was successfully achieved in the microwave oven with the help of the microwave hybrid heating process, on another side the drilling of bone or glass, was also achieved with the help of microwave produce plasma in the oven. Later it was noticed that the drilling in bone, glass or wood was done in wet condition while it was doing it was noticed that this is good for work and can be used up to a limit of range. has done research on Microwave drill application for concrete, glass and silicon in this research the author described about the principle of microwave drill or experimental methods after doing all this few applications were also provided for microwave drill in different materials like concrete, glass, silicon, ceramics with the help of coupled thermal electromagnetic numerical model in this the method of thermal-runway or hot spot generation with the microwave drill was designed. Few applications were provided for microwave drill to holes in concrete, ceramic, glass, etc. In[6] studied on the methods with the help of microwave radiation for drilling into hard non conductive materials. Microwave drill was taken as medium for conventional microwave to attain a drill. Later in this author described that the concentrator which was used, will automatically start penetrating on the hot spot, which was attain in the process of fast thermal runway. During this it was also noticed that with the help of microwave device drill can be happen into silicon, rocks, plastics, wood, etc. up to the hard diameter of 0.5 mm to13 mm, on other side while performing it was also noticed that microwave drill was unable to penetrate into few palates like; quartz and sapphire but their melting indication were noticed on their surface[7]. Researched on microwave drilling of materials in this research the experiment had to do for microwave drilling of material with the help of setup 1. Domestic microwave, 2. Co-axial cable applicator. These two methods were used on copper, aluminum, glass, mild steel etc. Out of all this the conclusion was that the drilling was successfully attained for both metals or non metals with the help of both technique, and author investigate that it can be attained a solid state microwave drill system which are carrying the low power application or they can be set up for high power of 1200 W with coaxial wave guide. In[8] has done research on microwave drilling of bones. In this research author did research on feasibility study of drilling with the help of microwave drill in few wet bone tissue in vitro. Microwave drill was used at the power of 200W and frequency of 2.45 GHz. To drill into the bone up to the 1mm/s of speed, with the help of three point bending strength. During this research the optical and scanning electron microscopy were used for the study of microwave drill which provides the plane holes in critical bone which was attained by the mechanical drill. In[9] has studied on the work which was done by using the microwave energy in the machining area or can say that to identify the feasibility of microwave machining in the drilling materials. Basically in this research the focused on concentrating microwave in few areas for heating or to make a hole and this was done on aluminum, glass, wood, etc. So from all this the research conclusion was that drilling of a metal was successfully achieved in the microwave oven with the help of the microwave hybrid heating process, on another side the drilling of bone or glass, was also achieved with the help of microwave produce plasma in the oven. In[10] researched on software which was used for joining the process of bulk with the help of comsol and its results were shown in a multimode microwave applicator. With the help of radio frequency of microwave the design was prepared for the purpose of heating of the bulk metal in the microwave. During this the highest power was noticed at joint interface around 6.048*10 w/m^3 while average power was 3*10^8 w/m^3, the temperature was 1144 C, and it was gained at 300s on the joint interface. Out of all this the result was that the work on simulated results was match able with the experimental work. The power was around 900W microwave power the bulk material was join. In this work two modes were tested for heating like ($TE_{10,}$ TM_{01}) but in this study only TE_{10} was only used. In[11] have done study on shape deposition manufacturing with microcasting for purpose of processing of thermal and mechanical issues in this study author described about the microcasting and it was noticed that there was a control of cooling rate on both the deposited material, and substrate or residual stress effect. In this the thermal models were taken for the purpose of remelting the earlier materials by submitting molten droplets to attained metallurgic bounding. Finally few factors were determined in this with the help of shape deposition manufacturing. There was another process substrate remelting is also discussed which was used for the purpose of calculating the metallurgic or residual thermal stress. The main purpose for this whole process was to produce shape deposition manufacturing feasible or cast effective procedure for the arbitrary three dimensional shapes of different materials.

2. Experimental Procedure

Microwave heating of metallic powder was experimenting with the help of the conventional microwave oven and its configuration in Figure 1 and Table 1, this microwave was operated in the frequency of 2.45 GHz in which the lead powder was placed in the mould and that mould was fabricated on the block of graphite. Whose dimensions were 100*100*10 mm shown in Figure 2, on this graphite block the mold was fabricated with the help of vertical machining center, before this a sleeve was prepared to hold the tool end mill. These moulds were fabricated in different-different shape. Whose diameter was 1 mm but the depth was 1, 2, 3, 4 and 5 mm. Similar few others mold was also fabricated whose depth was same, but their diameters were different like 1, 2, 3 and 4 mm shown in Figure 3. All these molds were fabricated to melt the powder, lead Pb (99.5 percent) of purity. The amount of powder was filled into the all types of moulds shown in Figure 4 to check that can microwave melt the lead powder or not. After filling the powder into the mould a susceptor silicon carbide was used to provide the heat to the powder shown in Figure 5. This was placed at the top of mould shown in Figure 6 after that the graphite block with lead powder was placed in the microwave and power was switched on up to the time of 10 minutes. This one was done for the first shape of mould, similar it was done for all the mould at different times, time at which they all were attained shown in the Table 2. Similarly same process was applied to get the shape of a star. First, it was placed on the surface of microwave at that time it was not getting the proper heat, to provide the proper heat its height was increased to increase its height a brick was used as shown in Figure 7 by doing this it was getting proper heat and it start melting the lead powder.

Figure 1. Used microwave for experimentation.

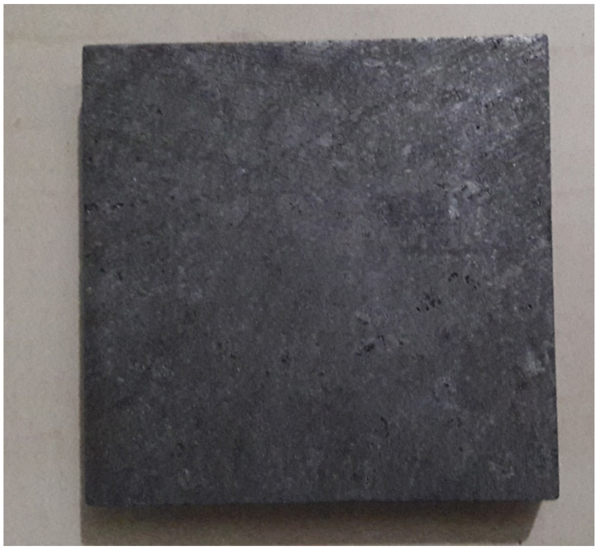

Figure 2. Graphite Block (100*100*15) Mm.

Table 1. Configuration of microwave oven

Input	230V-50Hz
Microwave	1350W
Grill	1250W
Combination	1350W
(RF) output	700W
Frequency	2450MHz

Table 2. Dimensions of the shaped fabricated mould and the time which was consumed for melting the lead powder

Depth of Mould size in mm	Approximately melted time(seconds)
1	1200
2	1620
3	2100
4	2460
5	3000
1 (shape of star mould)	1440

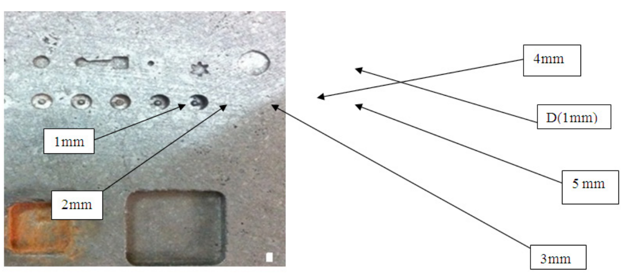

Figure 3. Graphite Block with different shapes and dimensions.

Figure 4. Graphite block with lead powder filled in mould.

3. Experimental Results

The lead powder, having the purity of 99.5 percent was placed inside the mold which was made up of graphite. Its size was 100*100*15 mm and this was placed inside the microwave for heating the lead powder on its mould the green silicon carbide was placed and it was heated up to the 700 W with microwave radiation at different -different time like 300, 600, 900 and 1200 seconds up to the 3000 seconds shown in Figure 8, this shows that the lead powder melted at different-different times. It was done for the first for the mould of having depth of 1 mm similarly, it was done for the whole mould up to the depth of 5 mm, but for the design of 1 mm was attained at the 1200 seconds as shown in Figure 9(c) and other samples were also attained at different- different time as mention in Table 2 and their final design shown in Figure 9(a, b). For star shape similarly same process was used and its shape was designed and shown in Figure 10. Oxidation was also occurring into the lead powder when it was melting shown in Figure 9(d). It was happening because of high

Figure 5. Green silicon carbide.

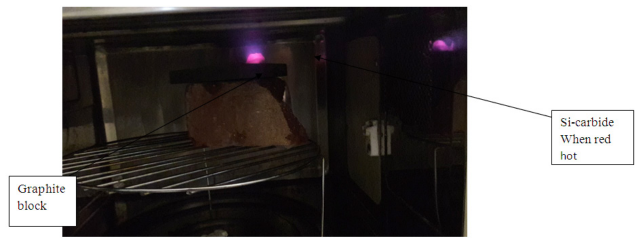

Figure 6. Green silicon carbide when it is red hot.

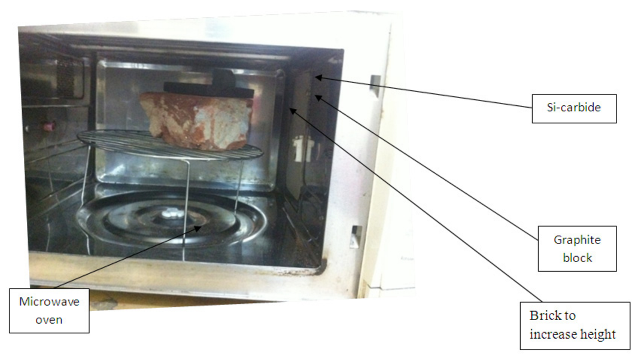

Figure 7. Placement of graphite mould in microwave oven.

melting point. To avoid this do have a control on cooling rate after the microwave switched off.


300 sec. 600 sec.


900 sec. 1200 sec.

Figure 8. Lead powder melted in a 1mm depth mold using microwave radiations.

Figure 9 (a). Samples of melted lead powder up to the depth of (2, 3, 5 mm).

Figure 9 (b). Depth size (4 mm).

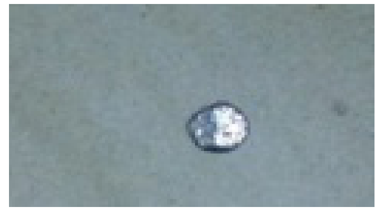

Figure 9 (c). Depth size of 1 mm.

Figure 9 (d). Lead powder when it was oxidized.

Figure 10. Star shape with diameter of 1 mm.

4. Conclusion

In the process of lead melting the eddy current which was produced in the conductive course of lead particles, where a fraction of the volume can be low up the range of 0.3-0.6 which will help to re- generate the capacity of surface, to reflect all the microwaves. Out of all these experiments the shows that the lead powder can be melted up to a limit with the help of microwave radiation. The lead powder was melted into the mould with having of different depth. This paper gives the proper elaboration of the process which helps in melting the lead powder.

6. References

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