

# REVIEWED OF MICROWAVE OVEN WELDING

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**Abstract:** Welding is a process in joining of metals which are done by using or without using of filler materials. Generally this is done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat to produce the weld. A more versatile, faster and cleaner process could have a huge impact on production. Investigations reveal that application of microwave energy as a tool in materials processing is not only a green manufacturing process, but also significantly faster at relatively low investment. Microwave welding is a form of electromagnetic welding, similar to radio frequency, laser, induction and IR welding, using a radiation frequency of typically 2.45 GHz. Ease of processing and environmental hazards, are some of the issues that need to be addressed, so this type of welding. Microwave materials processing can give an alternative to high energy consumption heating techniques that are commonly used in industries. In microwave processing, energy is directly transferred to the material through interaction of electromagnetic waves with molecules leading to volumetric heating. Heat is generated internally within the material, instead of originating from the external sources, and gets transmitted outward. In the present work, microwave joining of two similar and non-similar materials has been successfully carried out using a multimode applicator at 2.45 GHz and 900 W and Mild steel in plate forms have been successfully joined through microwave heating within 660 s of exposure time.

## I. INTRODUCTION

Welding can trace its historic development back to ancient times. The earliest examples come from the Bronze Age. Small gold circular boxes were made by pressure welding lap joints together. It is estimated that these boxes were made more than 2000 years ago. Welding is a process in joining of metals which are done by using or without using of filler materials. It is basically a joining process. Generally this is done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat to produce the weld. Many different energy sources are used to do welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. Other industrial process, welding may be performed in many different environments, including open air, under water and also in outer space. Welding is a hazardous process and precautions are taken to avoid burns, electric shock, vision damage, inhalation of poisonous gases, and exposure to ultraviolet and harmful radiation.

## II. MICROWAVE WELDING

Permanent joining of materials has been one of the prime requirements in most of the manufacturing and assembling industries. The existing techniques like welding, soldering and brazing are being widely practiced in industries; however, they have their own limitations regarding processing time, materials to be joined and characteristics of the joint. Further, ease of processing and environmental hazards, are some of the issues that need to be addressed. Thus a more versatile, faster and cleaner process could

have a huge impact on production. Investigations reveal that application of microwave energy as a tool in materials processing is not only a green manufacturing process, but also significantly faster at relatively low investment.

Microwave welding is a form of electromagnetic welding, similar to radio frequency, laser, induction and IR welding, using a radiation frequency of typically 2.45 GHz. Microwave materials processing can give an alternative to high energy consumption heating techniques that are commonly used in industries. In microwave processing, energy is directly transferred to the material through interaction of electromagnetic waves with molecules leading to volumetric heating. Heat is generated internally within the material, instead of originating from the external sources, and gets transmitted outward.

## III. EXPERIMENTAL SETUP

In our experiment we did the welding of stainless steel and mild steel. The stainless steel and mild steel are the most widely used metallic materials in the fabrication industries. Experiments were carried out with commercial grade stainless steel and mild steel plates having dimension 25 mm×12 mm×4 mm. chemical composition and mechanical properties of mild and stainless steel are shown as below which are used in the present experiment:

### 1.1 Composition of Nickel Base

Sr. No.	TEST (% BY MASS)	RESULT
1	NICKEL	96.76
2	SILICON	2.05
3	MANGANESE	0.11
4	CHROMIUM	0.08
5	CARBON	0.063

## 1.2 Composition of Mild Steel

Sr. No.	TEST (% BY MASS)	RESULT
1	CARBON	0.2026
2	CHROMIUM	0.2207
3	NICKEL	0.114
4	SILICON	0.2669
5	MANGANESE	0.5251
6	SULPHUR	0.0174
7	PHOSPHORUS	0.0428
8	MOLYBDENUM	0.0200
9	COBALT	NIL
10	TUNGSTEN	0.1329
11	BORON	0.0071
12	LEAD	NIL
13	ALUMINIUM	0.0198
14	COPPER	0.1567
15	IRON	98.127

## 1.3 Materials Used In the Process

### 1.3.1. Microwave Oven

It is the main equipment used for this process. Welding of pieces is done inside of microwave. Specifications of microwave required for this process are as follows:

Microwave frequency – 2.45 GHZ

Watts microwave – 900 Watts

Capacity- 38Ltrs

Product dimension- 527\*392\*480 (W\*H\*D)

### 1.3.2. Refractory Bricks:

These bricks are used to place the metal piece. First slots are prepared on the bricks according to the size of metal piece and then after placing the pieces over the brick, the brick is then placed inside the microwave and hence the heating process starts. These are basically of two types: (i) Soft refractory brick (ii) Hard refractory brick. These are classified on the basis of temperature they withstand.

### 1.3.3. Acetone (C<sub>3</sub>H<sub>6</sub>O):

This is used to clean the metal pieces before applying slurry near the joints.

### 1.3.4. Nickel Base Powder & Epoxy Resin:

It is a nickel based powder with particle size of 40µm is used as a sandwich layer. In this process it is also works as a hardener and mixed with epoxy resin to make slurry. We apply this layer at the joints and it acts as a heat absorber.

## 1.4. Development of Microwave Welding Set Up:

a) Refractory brick material is used to seal the bulk metallic body in order to avoid reflection of microwaves from the target materials.

- b) The slurry, also called the sandwich layer is prepared by mixing the solution of epoxy resin and Nickel based powder.
- c) The joint interfaces are cleaned ultrasonically in acetone bath.
- d) The prepared slurry is uniformly placed over the joint interfaces between the two bulk pieces.
- e) A solid layer of graphite is used to separate the charcoal powder and the sandwich layer.
- f) A principle of microwave hybrid heating is effectively used to join the metallic pieces.
- g) Charcoal powder is used as a susceptor medium to initiate coupling of microwaves which result in initial heating.
- h) The charcoal powders is placed as near as possible to the joint area so as to induce selective heating in the sandwich zone.

## IV. EXPERIMENTAL PROCEDURE

Joining of dissimilar metals is generally more challenging than that of similar metals due to several factors such as the differences in chemical compositions, mechanical properties and thermal expansion coefficients. However, compared to the welding of similar metals, there is limited information about structure–property relationships in dissimilar material welds between SS and mild steel. Increasing application of these steels calls for a better understanding of the mechanics associated with welding of dissimilar metals.

The specimens were mechanically polished with emery papers, degreased with acetone, ultrasonically cleaned and finally dried prior to joining. The prepared slurry was uniformly spread over the candidate surfaces between the two bulk pieces. Experiments were carried out in a 1 kW multimode microwave system. Bulk pieces were exposed up to 660 s in the multimode applicator at a frequency of 2.45 GHz and a power level of 900 W. All experiments were carried out in atmospheric condition. Below flowchart Illustrates the detailed stepwise description of the microwave joining of bulk metallic material carried out in the present study. At room temperature, the bulk steel reflects microwaves because the skin depth of steel is in the order of 3.1 µm at 2.45 GHz which is much lesser than the size of bulk pieces used in the present work. In order to avoid this problem, metallic pieces were placed in an insulator masks so that they are not directly exposed to microwaves. Charcoal powder was used for initial coupling of microwaves with metallic material. Below figure illustrates the schematic view of the experimental process of the microwave hybrid heating used for joining of metallic materials.

## V. LITERATURE REVIEW

- Osepchuk John M., [1984] explained on the basics of micro wave heating and presented the

brief history of micro wave energy .He recovered various sections micro wave energy and described the biological effects of micro wave energy. He has also discussed brief history of applications of microwave power.

- **Clark De. Et al., [1996 ]** reported that the successfully sintering of the pure metallic powders like Cu, Al, Ni, Mo, Co, Ti, W, WC, Si, etc. Through this microwave technique. They put their efforts while using microwave energy in materials processing.
- **Rodiger k. Et al., [1998]** explained that microwave sintering of metal powders having high electrical conductivity is the new area with growing interest. Microwave heating allows an instantaneous volumetric and provide rapid heating in comparison with the conventional heating process .Microwave heating provides an enhanced sintering kinetics which results that it allows a reduction of process temperature and as well as time .This leads to an increased productivity and reduction in energy consumption. During last decade, the microwave has been used in sintering the various particulate metals. Powdered composition consists of iron (Fe), copper (2%) and graphite (0.8%). These have been sintered in a microwave field at 1200 \_C for 30 minutes having great excellent density.
- **Roy R. Et al., [1999]** reported that a porous, powder metal compact could be heated and sintered in a microwave field. At that time it is considered surprising because as the electrically conducting materials were supposed to reflect microwave radiation. At that time other researchers also demonstrates that all powder metals at room temperature absorb microwaves and only bulk metals reflect the microwaves and allows it only surface penetration. However, these empirical studies did not sufficient to give an explanation of the observed heating trends. And at present, there are few reports regarded that the details of the direct interaction of microwaves with powder metal compacts. Platelets microstructure embedded in a fine-grained hard metal matrix having an average size of 0.61 $\mu$ m was obtained.
- **Gupta M. And Wrong WLE. [2005]** reported that two-directional microwave assisted rapid sintering of aluminium, magnesium and lead free solder. The results shown that the density of the microwave sintered and sintered samples are same .While the marginal increase in micro hardness with superior ultimate tensile strength of the microwave sintered aluminium and magnesium. Overall mechanical performance of metallic materials increased while using two-directional microwave assisted rapid sintering.

- **Aggrawal Dk., [2006]** reported that joining of regular steel and cast iron in a microwave field within 2–3 min using a braze powder. But it is not reported that joining of bulk metallic materials using microwaves.

## VI. RESULT

Metallurgical bonding of thermally conductive materials through conventional welding processes is extremely difficult. In the present work, trials were conducted for joining of mild steel-mild steel using microwave hybrid heating. Metallurgical bonding has been achieved in this work. Joining process has been successfully carried out with controlled microwave irradiation as discussed. A few typical joints of mild steel plates and microstructure of a typical section of a butt joint produced presented in Fig.6.1, Fig.6.2, respectively. Good metallurgical bonding between the bulk metallic plates has been seen. The sandwich layer of the metallic powder has been observed to be completely fused. The area beyond the fused zone appears least affected by the heat of fusion as the rapid heating is initiated through the microwave metal interaction. Results are discussed with suitable illustrations in the following sections.



Fig6.1 Microscopic view of welded first specimen



Fig6.2 Microscopic view of welded second specimen

## CONCLUSION

In the present work, microwave joining of mild steel to mild steel in bulk form has been successfully

carried out using a multimode applicator at 2.45 GHz and 900 w. Joining of mild steel in bulk form has been carried out using microwave energy in a multimode applicator at 2.45 ghz and 900 w. Charcoal was used as suceptor material to facilitate microwave hybrid heating (mhh). Mild steel in plate forms have been successfully joined through microwave heating within 660 s of exposure time. A sandwich layer of ni powder and epoxy resin with approximately 0.5 mm thickness was introduced between the two mild steel surfaces. Near complete melting of the powder particles in the sandwich layer does take place during the microwave exposure leading to metallurgical bonding of the bulk surfaces. Characterization of the joints has been carried out through microstructure study and micro hardness. A dense uniform microstructure with good metallurgical bonds between the sandwich layer and the interface was obtained. The hardness of the joint area was observed to be 130 hv

## REFERENCES

- [1] Osepchuk John M, A history of microwave heating applications. IEEE Trans Microwave Theory Technol, MIT 1984; 32(9):1200–24.
- [2] Osepchuk John M. Microwave Power applications. IEEE Trans Microwave Theory Technol 2002; 50(3):975–85.
- [3] Sutton WH. Microwave processing of ceramic materials. Am Ceram Soc Bull 1989; 168:376–86.
- [4] Clark DE, Sutton WH, Lewis D. Microwave processing of materials. Annu Rev Mater Sci 1996; 26:299–301.
- [5] Sharma AK, Aravindan S, Krishnamurthy R. Microwave glazing of alumina–titania ceramic composite coatings. Matt Let 2001; 50:295–301.
- [6] Brosnan Kristen H, Messing Gary L, Agrawal DK. Microwave Sintering of Alumina at 2.45 GHz. J Am CerSoc 2003; 86(8):1307–12
- [7] Rodiger K, Dreyer K, Gerdes T, PoradaWillert M. Microwave Sintering of Hardmetals. Int J Refract Met Hards Mater 1998; 16:409–16.
- [8] Prabhu G, ChakrabortyAmitava, SarmaBijoy. Microwave sintering of tungsten. Int. J Met Hard Mater 2009; 27:545–8.

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