UNIVERSITY GRANTS COMMISSION BAHADUR SHAH ZAFAR MARG NEW DELHI – 110 002.

Research Funding Council for

Major and Minor Research Projects during the Tenth Plan Period

MICROWAVE ASSISTED WELDING

F. No. 42-904/2013 (SR), Dated 25th March 2013

FINAL PROJECT COMPLETION REPORT

PROFESSOR (DR.) VINAY SHARMA

BIRLA INSTITUTE OF TECHNOLOGY
MESRA RANCHI-835215 JHARKHAND (INDIA)

ज्ञान-विज्ञान विमुक्तये

Annexure – IX

UNIVERSITY GRANTS COMMISSION

BAHADUR SHAH ZAFAR MARG

NEW DELHI – 110 002.

PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. **NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR:**

Dr. Vinay Sharma, Professor

Department of Production Engineering

Birla Institute of Technology, Mesra Ranchi-835215

Email: vinay@bitmesra.ac.in; vinay1970@gmail.com

Mobile: +91-9431382632; +91-8877024445

2. **NAME AND ADDRESS OF THE INSTITUTION:**

Birla Institute of Technology, Mesra Ranchi-835215

3. **UGC APPROVAL NO. AND DATE:**

F.No: 42-904/2013(SR), Date 25/03/2013

4. **DATE OF IMPLEMENTATION:**

Date: 01/04/2013

5. **TENURE OF THE PROJECT:**

Three Year

6. **TOTAL GRANT ALLOCATED:**

Rs. 5,55,000.00 (Rupees Five lakhs and fifty-five thousand only)

7. **TOTAL GRANT RECEIVED:**

Rs. 4,92,500.00 (four lakhs ninety-two thousand and five hundred only)

8. **FINAL EXPENDITURE:**

Rs. 4,73,163.00 (four lakhs seventy-three thousand one hundred and sixty three only)

9. TITLE OF THE PROJECT:

MICROWAVE ASSISTED WELDING

10. OBJECTIVES OF THE PROJECT:

Microwaves are emerging as a new tool for different manufacturing processes. The physics of the process is complex and is of multidisciplinary in nature. Out of the different application of the microwave, welding is one of the fastest growing areas. In conventional method of welding the work piece is heated either by convection, radiation, resistance or a combination of them. In all these cases, the heat is transferred from the surface to the core. This creates metallurgical problems in welded zone like uneven grain growth and heat affected zone which exaggerated with increase in the cross-sectional area. Therefore, weld zone requires post processing. The microwave welding addresses all these problems of conventional welding. In case of microwave welding, the electromagnetic energy is absorbed by the material which results in volumetric heating rather than progressive heating as in the case of conventional welding. The absorbed microwave generates heat either by magnetic permittivity or eddy currents or loss tangent mechanism or a combination of them. Because of energy conversion, the heating is very rapid, uniform and highly energy efficient. The microwave welding possesses several characteristics like- penetration radiation, controllable electric field distribution, rapid heating, selective heating of materials through differential absorption, self-limiting reaction. These characteristics either singly, or in combination present opportunities and advantages over conventional welding methods, such as unique microstructure and properties, improved product yield, energy savings, lowering the manufacturing cost. The application of microwave welding for thermoplastic is one of the fastest growing areas. Thermoplastics have a high range of applications than any other class of polymer materials available. Some of applications are: packaging, building appliances, electronics, automotive, aerospace, and many more. Joining of thermoplastics is a critical and the most effective method is welding. It is a matter of intense research because traditional welding is not always favorable, and cost is also very high.

11. WHETHER OBJECTIVES WERE ACHIEVED: YES

The main objective of the project was, development of a commercial microwave oven to the expected welding system by using the power source of microwave i.e. magnetron and oven cavity of the microwave oven.

This objective was successfully implemented.

12. ACHIEVEMENTS FROM THE PROJECT:

Welding of microwave absorbent materials is always a challenging step in the field of engineering by using microwave energy. The main purpose of this experimental investigation is to achieve a suitable condition for welding of microwave absorbent materials by using microwave energy. In case of microwave heating method, the special advantage is its volumetric or density heating over the material, this advantage of microwave heating becomes a huge disadvantage for welding purpose because welding requires concentrated heating on a point at the welding zone.

To avoid this disadvantage of microwave heating following steps have been taken as discussed below:

- A system has been developed to concentrate the whole microwave energy at a point by using metal waveguide.
- It can be easily concluded from the observations that heating zone has been reduced to approx. 10% of base portion of oven cavity instead of whole microwave oven cavity by using metal waveguide.
- Welding ability of the system has been tested and verified for the different plastic composite materials.
- It is very difficult to reduce the heating zone more than the area discussed, so the area of heating zone can be reduced by applying external magnetic field over the material where heat is not required, effect of external magnetic field is also discussed with the positive result.

  So, from the overall discussion it can be easily conclude that welding of the microwave absorbent material can be done by using the direct microwave energy without using any external interference of material. Rapid heating can also be achieved by increasing the input power of the magnetron.

13. SUMMARY OF THE FINDINGS (IN 500 WORDS):

Microwaves have been used for long time to heat the materials in the industries because of its volumetric heating. The main advantage of microwave heating is its capability of volumetric heating but this advantage of heating becomes a very huge disadvantage in the field of welding application because welding requires heating at a point i.e. welding zone. Theoretical models have been developed to overcome these kinds of problems, and different simulations have been done for the different models for different conditions of heating effect by using COMSOL Multiphysics. Analysis has been done for the most suitable condition for the welding application and experimental investigation is being done for the real-time observations. A microwave system has been developed and different tests is being conducted for welding ability of the system with the different thermoplastic materials like LDP, PP and HDP, and discussion about the control of thermal runway which is caused by the microwave heating by applying external magnetic field over the material.

The target is to strike the microwave at the center of the base portion of the oven cavity, hence all the dimensions has been taken according to the target point as shown in the fig 1.

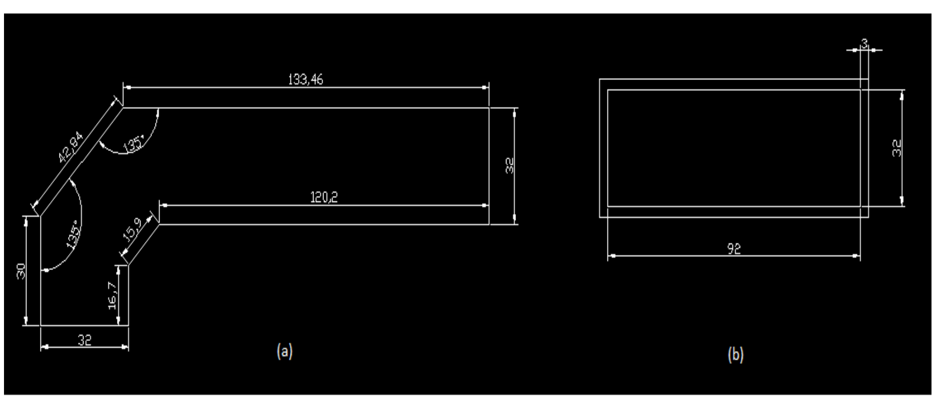

Figure 1:(a) side view (E-plane) dimensions (in mm) of the waveguide. (b) Dimensions of E & H-plane and wall thickness of the rectangular shaped waveguide.

The dimensions of the E & H-plane of the rectangular waveguide are taken according to the output cross sectional area of the given microwave oven. E-plane bend length is considered as the half of the width (295mm) of the oven cavity as required for the project.

The design of the waveguide described below in the table 1:

Table 1:Design of the waveguide

Design	Description
Material	Aluminium
Wall thickness	3mm
Type	90-degree E-bend Rectangular waveguide
E-plane	32 mm (without wall thickness)
H-plane	92 mm (without wall thickness)

Metal waveguides is suitable for the high frequency microwave to transmit it from one point to other, so the material taken here is aluminum which is a very good reflector of the microwave and suitable for the internal reflection of the microwave. High frequency microwave at 2.45GHz can harm the wall of the waveguide if total internal reflection will not take place, to avoid this problem sufficient amount of wall thickness is required for the total internal reflection. So, here wall thickness has been taken as 3mm. The waveguide used here in this project has been shown in fig. 2.

Figure 2: Waveguide with desired design

Waveguide is being implemented to the given microwave oven such that the output of the microwave from the magnetron becomes an input to the waveguide as shown in the fig.3. The flange of the waveguide is taken such that after the implementation of the waveguide, a tight fitting can happen with the wall, for controlling the unnecessary leakage of microwave energy from the start point i.e. input port of waveguide.

Figure 3: Implementation of waveguide into the oven cavity

After implementation of the waveguide it is necessary to test the system by considering the area of heat distribution over the oven cavity. The whole microwave energy is being dissipated at the base portion of the oven cavity.

Wavelength of the microwave inside the waveguide changes according to the inner cross section of the waveguide because of the internal reflection, and that can be calculated by using equation given below.

$$\left(\frac{1}{\lambda g}\right)^2 = \left(\frac{1}{\lambda o}\right)^2 - \left(\frac{1}{2a}\right)^2$$

Were,

λg = wavelength in the waveguide.

λo = original wavelength of microwave.

a = inner length of the waveguide on H-plane.

Wavelength, $\lambda o = \frac{speed\ of\ light}{frequency\ of\ the\ microwave}$

Investigation of designed system will be based on the heat distribution over the base portion of the microwave. A spherical shaped silica glass dish is being used at the base portion of the microwave oven that is the good absorbent of the microwave energy and heats very well in the presence of the microwave. This silica glass dish has been taken here to find out the heat distribution over the base portion, to find out the maximum heating zone by using the developed microwave system. K-type thermocouple sensor is being used to sense the temperature at the point.

A spherical shaped silica glass dish has been used here to find out the heat distribution at the base portion of the oven cavity as shown in fig.4. The diameter of the silica dish is measured as 240mm and it is divided into the discrete form by hashing the entire glass into 20x20mm cross sectional area to find out the exact temperature at the point. Two-dimensional axis as x-axis and y-axis to adjust the specific position.

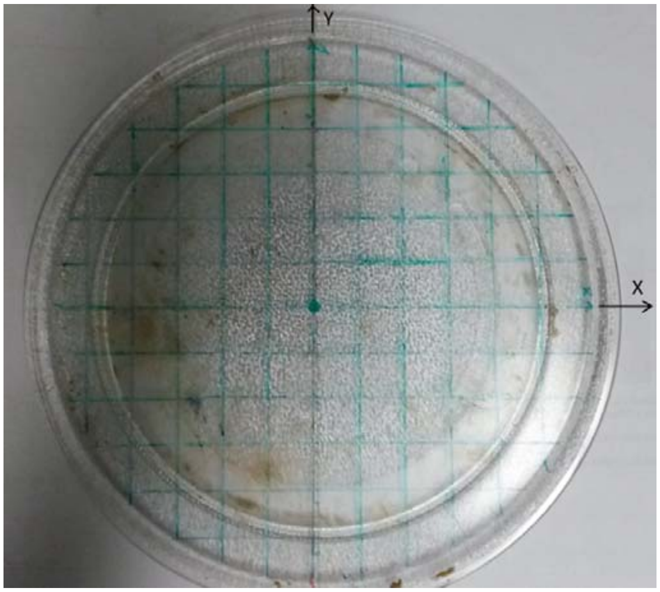

Figure 4: Silica glass dish used to find out the heat distribution over the base portion of oven

It is well known that heat distribution over the oven cavity is almost uniform at the normal condition, but here a practical approach has been taken to find out the exact difference between initial condition and after modifying the system. The time duration is taken here is 10 min and the heat distribution in degree centigrade over the silica glass is shown in fig 5.

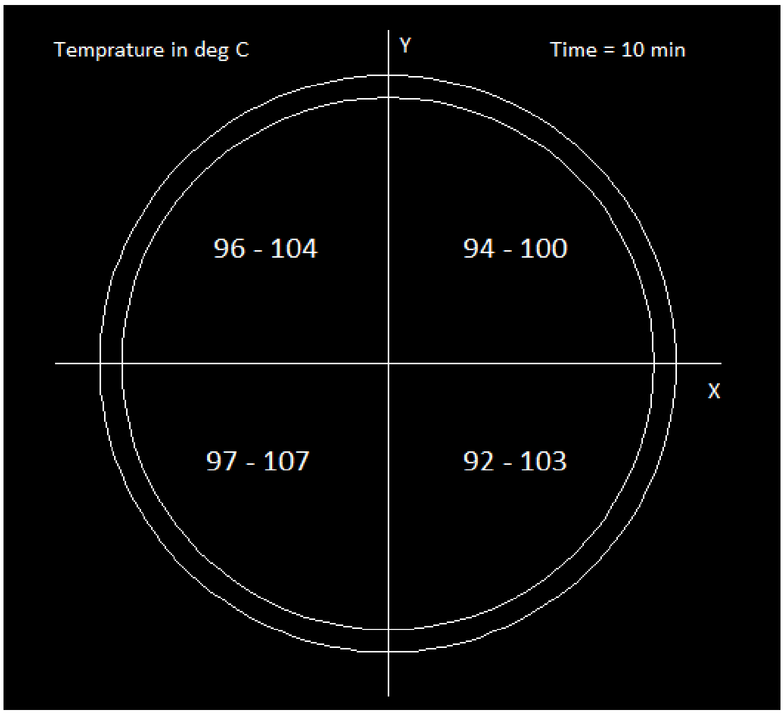

Figure 5: Heat distribution on base glass at normal condition

The observation is taken by dividing the glass into the four section and random temperature has been measured over the sections at each corresponding coordinate. The minimum to maximum temperature is monitored for every (x,y),(-x,y),(-x,-y) and (x,-y) plane as shown in the fig 5. From the observations, it can be easily concluded that the heat distribution over the base portion is almost uniform for all the sections.

The heat distribution at the base portion of the oven cavity after modification of system by using waveguide as described in the previous section is shown in the fig. 5, the measurement of the temperature gives the exact heat distribution over every discrete area of the silica glass as shown in fig 6.

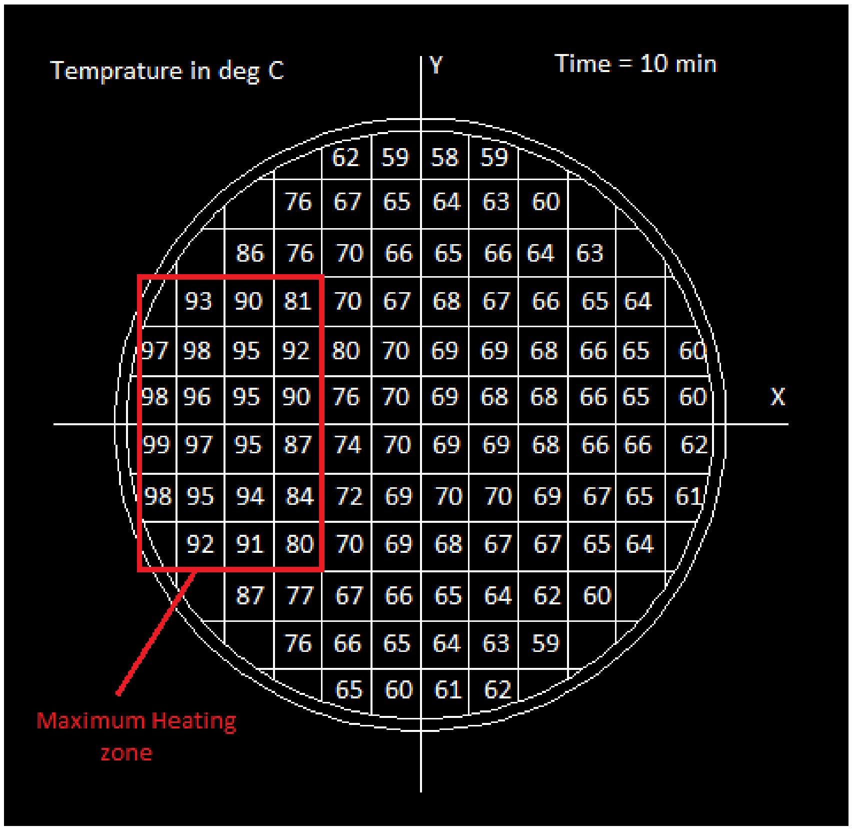

Figure 6: Heat distribution on base glass after modifying the system

From the above fig 6 it can be easily concluded that the maximum heat has dissipated at the left side (cross sectional area represented in red color) of the glass i.e. at the –x-axis portion. According to the properties of the silica glass induction heating has been takes place all over the glass, so to find out the exact portion of heating zone by the developed system, a pure non-conducting material has to be used.

It is described in the previous section maximum heating takes place on the left portion of the base of oven cavity as shown in the fig. 6. But due to the conduction heating of the material used here, which carry the conduction heating, so the exact heating zone cannot be found in this process.

There are 12 number of PP strips of cross sectional area of 15x125 mm which has been used here to find out the exact heating zone of the developed system. As discussed before the maximum zone of heating takes place on the left portion of the base of oven cavity, so the PP strips are arranged over the glass such that to cover the maximum heating zone as shown in the fig. 7. Silica glass is used here at the base to avoid the reflection of the microwave.

Figure 7: Arrangement of PP strip inside the oven cavity

This arrangement of PP strips over the silica glass placed inside the oven cavity as shown in figure 7, according to the axis defined in the cavity. Heat treatment has to apply over this arrangement by the system until some portion of the PP is being melted to calculate the area of the heating zone.

The time taken is about 10 min for complete melting of the PP thermoplastic to find out the maximum melting zone by the developed system. After 5.15 min of time the silica glass has been broken due to the increase in surface tension of the silica glass under some circumstances. According to the microwave theory the heat transfer takes place from the base to the bottom portion, so that some area is being melted in 5.15 min as shown in fig.8.

Figure 8: Melted portion of PP strips arrangement after heat treatment by modified system

From the fig. 8 it can be concluded that the area of heating is in the circular form and by taking the center portion of the melting zone and by putting the individual strips at x-axis and y-axis respectively the heating zone can be calculated as described in the next section.

Calculation of heating zone:

Two PP strips with the same specification has been used to find out the maximum heat distribution by placing one by one at x-axis as well as y-axis from the defined center portion respectively. Heat treatment has done for both strips until it is fully melted and dimensions have been taken for the melted portion:

- Melted length of strip on x-axis: 65mm
- Melted width of strip on y-axis: 92mm

It can be assumed from the above discussions and by taking the exact dimensions of melted portions that the heating is generated in elliptical shape. To find out the area of heating the following formula can be used:

$$Area\ of\ ellipse = \pi ab$$

Where,

a = radius of major axis

b = radius of minor axis

So, here in this case 'a' is taken as 46 mm and 'b' is taken as 32.5 and the area of heating can be calculated as follows:

- $Area\ of\ heating\ zone = 3.14 \times 46 \times 32.5\ mm^2$

  $= 4694.2\ mm^2$

Total area of surface i.e. area of silica glass has been calculated to find out the percentage of heating area:

- $Total\ area = \pi r^2$

  $= 3.14 \times (120)^2\ mm^2$

  $= 45216\ mm^2$

The calculation of percentage area of heating zone is as follows:

- $\%\ area\ of\ heating\ zone = \frac{Area\ of\ heating\ zone}{Total\ area} \times 100$

  $= \frac{4694.2}{45216} \times 100$

  $= 10.381\ \%$

From the above calculations it is concluded that, by using modified system 10% of heating area has been achieved instead of 100% of heating zone which is suitable for the welding of the microwave absorbing materials at the particular point.

Weldability of developed microwave system:

Plastic composite materials can be welded by applying direct microwave energy at the frequency of 2.45 GHz, so here a practical approach has been done for the two plastic composite materials, one is for low density polymer (LDP) and another one is for high density polymer (HDP). One pair of LDP strip and one pair of HDP strip is being placed over the welding zone one by one respectively and observed the welding ability of material as shown in fig. 9.

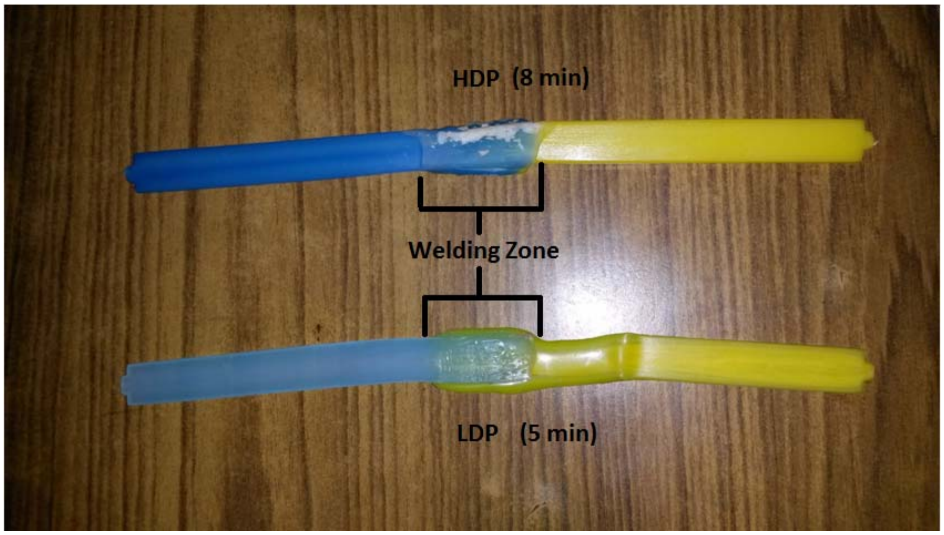

Figure 9: welding of two different plastic composite materials (LDP & HDP) by using developed microwave system.

The heat treatment by the microwave on HDP has been done for 8 min and for LDP is 5 min. After removing the strips, it has been observed that the welding has been done successfully for both random selected materials. But main problem has been observed that the heating has been achieved in small area except welding zone and also being melted with respect to the welding zone. To avoid this problem external magnetic field can be applied on the strip except welding zone to control the dipolar movement of the molecules that causes heat, the effect of magnetic field over the material is being discussed in the next section.

Tensile test for polymer (LDP & HDP) by using series 9 Automated material system:

Tensile test for the both randomly selected materials LDP as well as HDP has been done after welding process; test is being done by using series 9 automated material system and their respective result is shown in (table 2,3 and figure 10 and 11)

Table 2 Tensile test for HDP:

Sample comments: HDP2A

	Load at Upper Yield (kN)	Load at user Break (kN)	Maximum Percent Strain (%)	% Strain at user Break (%)	Modulus (AutYoung) (MPa)	% Strain at Upper Yield (%)	Strain at user Break (mm/mm)	Stress at Upper Yield (MPa)	Stress at user Break (MPa)
1	-	0.000	5.265	5.265	359.892	-	0.053	-	0.000
2	0.491	0.023	3.922	3.922	393.272	3.076	0.039	7.480	0.344
3	0.608	0.021	6.088	6.088	402.058	5.698	0.061	8.639	0.301
Mean	0.000	0.015	5.092	5.092	385.074	0.000	0.051	0.000	0.215
S.D.	0.000	0.013	1.094	1.094	22.246	0.000	0.011	0.000	0.187

	Stress at Max.Load (MPa)	% Strain at Max.Load (%)	Stress at Ultimate (MPa)	oughness (MPa)
1	8.634	5.243	8.634	0.300
2	7.480	3.076	7.480	0.172
3	8.639	5.698	8.639	0.347
Mean	8.251	4.673	8.251	0.273
S.D.	0.667	1.401	0.667	0.091

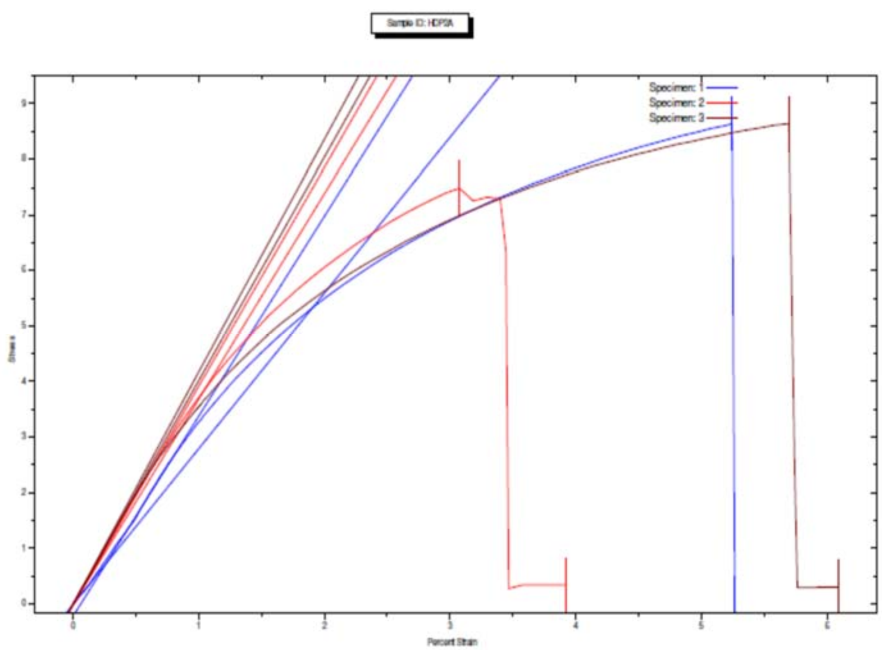

Figure 10: Percent strain verses stress graph for HDP

Table 3: Tensile test for LDP

Sample comments: LDP7A

	Load at Upper Yield (kN)	Load at user Break (kN)	Maximum Percent Strain (%)	% Strain at user Break (%)	Modulus (AutYoung) (MPa)	% Strain at Upper Yield (%)	Strain at user Break (mm/mm)	Stress at Upper Yield (MPa)	Stress at user Break (MPa)
1	0.273	0.010	22.273	22.273	79.974	15.947	0.223	3.864	0.138
2	0.254	0.000	26.195	26.195	84.813	18.092	0.262	3.939	0.007
3	0.260	0.003	19.305	19.305	74.749	16.813	0.193	3.868	0.041
Mean	0.263	0.004	22.591	22.591	79.845	16.951	0.226	3.890	0.062
S.D.	0.010	0.005	3.456	3.456	5.033	1.079	0.035	0.042	0.068

	Stress at Max.Load (MPa)	% Strain at Max.Load (%)	Stress at Ultimate (MPa)	Toughness (MPa)
1	3.865	16.770	3.865	0.710
2	3.939	18.092	3.939	0.881
3	3.868	16.813	3.868	0.586
Mean	3.890	17.225	3.890	0.726
S.D.	0.042	0.751	0.042	0.148

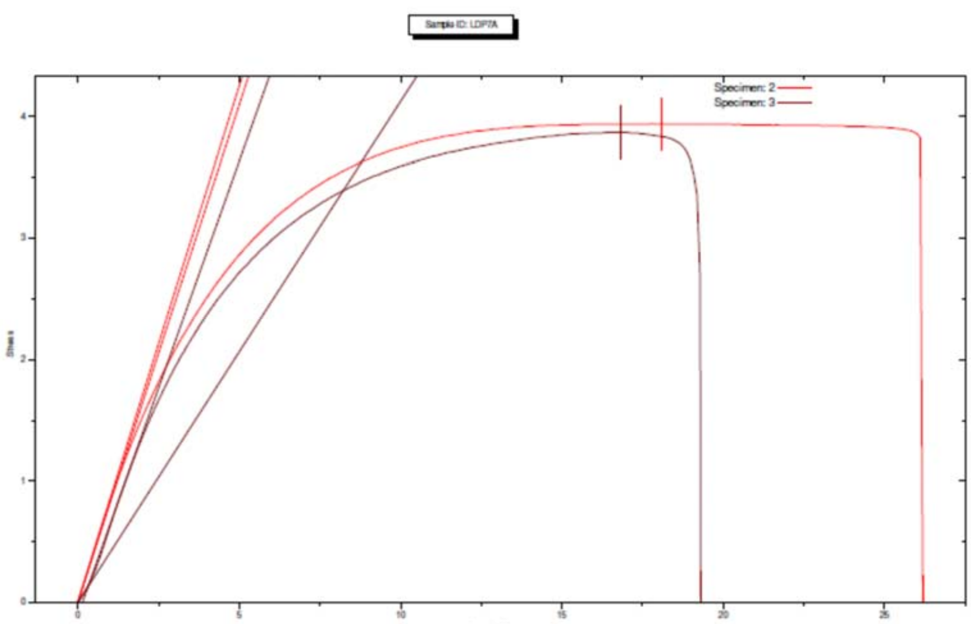

Figure 11: Percent strain verses stress graph for LDP

Heating effect on plastic composite material by applying external magnetic field: Here in this section an alternative is used for magnetic field as alnico bar shaped magnet, but when it gets exposed to the presence of high frequency electromagnetic waves, then after some time it lose its magnetic properties with respect to increase in temperature.

Due to the limitations of this alnico magnet, experiments have been done for the minimum time (below 1 min) as possible. A strip of HDP has sandwiched with the one pair of magnet with alternative poles by exposing some area which has to be heated as shown in the fig.12. Exposed area is being placed over the heating zone.

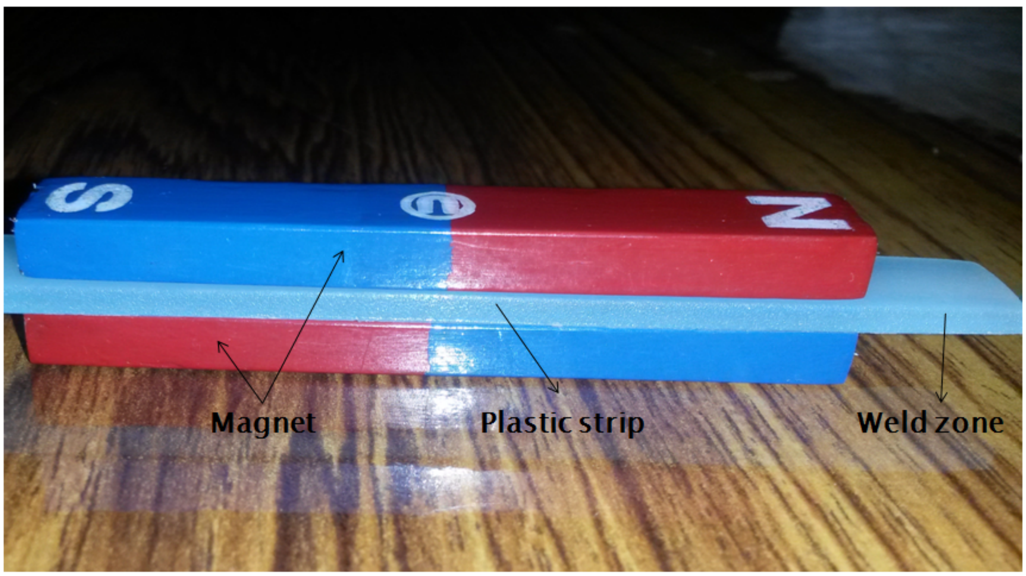

Figure 12: Arrangement of sandwiched HDP with two bar magnets

Several experiments have been done with different position of the magnets, and it has been observed from the experiments that heat is only increased on the exposed area i.e. weld zone. No thermal runway takes place on the test piece after applying the magnetic field. So, it can be easily concluded that the welding can be done perfectly at a point by using the microwave energy.

14. CONTRIBUTION TO THE SOCIETY (GIVE DETAILS)

The potential benefits of this technique over conventional methods are –shorter weld times and non-contact processing. Commercially the benefits of this new technique, will be in terms of a reduction in capital cost of equipment, particularly for welding complex components. Repairing leaking pipes in out of way locations, welding of internal hidden walls, aerospace application, typical automotive components such as bumper, dashboard assembly may require several welding operations. A further saving will be gained because the equipment is not dedicated to one application and can be used to process a variety of components without major tooling costs and changes. This is still under development.

15. WHETHER ANY PH.D. ENROLLED/PRODUCEDOUT OF THE PROJECT

One PHD enrolled and pursuing.

16. NO. OF PUBLICATIONS OUT OF THE PROJECT (PLEASE ATTACH RE-PRINTS)

PAPERS IN INTERNATIONAL JOURNALS:

1. Arpita Roy Choudhury, Vinay Sharma, B. K. Singh, "Microwave Welding: A New Tool for-WELDING OF THERMOPLASTICS", published in Journal of Mechatronics and Intelligent Manufacturing, Volume 3, Number 3-4,2015, Nova Science Publishers, Inc., ISSN:1949-4904.
2. Arpita Roy Choudhury, Dr. VINAY Sharma, "Microwave Welding: A Comparative Analysis with Contemporary method of Welding Thermoplastics based on Prioritization Matrix", published in IJSER, Vol.5, Issue10, October 2014 edition, ISSN:2229-5518.
3. Arpita Roy Choudhury, B. K. Singh, Vinay Sharma, "Microwave Assisted Welding: A New Tool for Welding of Plastics", published in KIJSET/JAN- MARCH2014/VOL.1/Issue-1/ISSN:2348-5477.

PAPERS IN CONFERENCES:

4. Arpita Roy Choudhury, Vinay Sharma, B. K. Singh, "Microwave Welding: A New Tool for Welding of Thermoplastics", International Conference on Industrial, Mechanical and Production Engineering: Advancement and Current Trends(ICIMPACT-2014) Organized by the Dept. of Mechanical Engineering, MANIT, Bhopal (M.P) India, during 27th-29th November 2014.
5. Arpita Roy Choudhury, Vinay Sharma, B. K. Singh, "Microwave Assisted welding: A New Tool for Welding of Plastics",27th NCPE & National Seminar on Advancement in Manufacturing Vision 2020, BIT Mesra Ranchi, May 25-26,2012.

(VINAY SHARMA)

(PRINCIPAL INVESTIGATOR) **(REGISTRAR/PRINCIPAL)**

ज्ञान-विज्ञान विमुक्तये

UNIVERSITY GRANTS COMMISSION BAHADUR SHAH ZAFAR MARG NEW DELHI – 110 002

particularly for welding complex components. Repairing leaking pipes in out of way locations, welding of internal hidden walls, aerospace application, typical automotive components such as bumper, dashboard assembly may require several welding operations. A further saving will be gained because the equipment is not dedicated to one application and can be used to process a variety of components without major tooling costs and changes. This is still under development.

15. WHETHER ANY PH.D. ENROLLED/PRODUCEDOUT OF THE PROJECT

One PHD enrolled and pursuing.

16. NO. OF PUBLICATIONS OUT OF THE PROJECT (PLEASE ATTACH RE-PRINTS)

PAPERS IN INTERNATIONAL JOURNALS:

1. Arpita Roy Choudhury, Vinay Sharma, B. K. Singh, "Microwave Welding: A New Tool for-WELDING OF THERMOPLASTICS", published in Journal of Mechatronics and Intelligent Manufacturing, Volume 3, Number 3-4,2015, Nova Science Publishers, Inc., ISSN:1949-4904.
2. Arpita Roy Choudhury, Dr. VINAY Sharma, "Microwave Welding: A Comparative Analysis with Contemporary method of Welding Thermoplastics based on Prioritization Matrix", published in IJSER, Vol.5, Issue10, October 2014 edition, ISSN:2229-5518.
3. Arpita Roy Choudhury, B. K. Singh, Vinay Sharma, "Microwave Assisted Welding: A New Tool for Welding of Plastics", published in KIJSET/JAN- MARCH2014/VOL.1/Issue-1/ISSN:2348-5477.

PAPERS IN CONFERENCES:

4. Arpita Roy Choudhury, Vinay Sharma, B. K. Singh, "Microwave Welding: A New Tool for Welding of Thermoplastics", International Conference on Industrial, Mechanical and Production Engineering: Advancement and Current Trends(ICIMPACT-2014) Organized by the Dept. of Mechanical Engineering, MANIT, Bhopal (M.P) India, during 27th-29th November 2014.
5. Arpita Roy Choudhury, Vinay Sharma, B. K. Singh, "Microwave Assisted welding: A New Tool for Welding of Plastics",27th NCPE & National Seminar on Advancement in Manufacturing Vision 2020, BIT Mesra Ranchi, May 25-26,2012.

(VINAY SHARMA)
(PRINCIPAL INVESTIGATOR)

(REGISTRAR/PRINCIPAL)
Registrar
Birla Institute of Technology

ज्ञान-विज्ञान विमुक्तये

UNIVERSITY GRANTS COMMISSION BAHADUR SHAH ZAFAR MARG NEW DELHI – 110 002.

UNIVERSITY GRANT COMMISSION BAHADUR SHAH ZAFAR MARG NEW DELHI -110002

Annexure-IV

UTILIZATION CERTIFICATE

Certified that the grant of Rs.492500.00 (Rupees four lakhs ninety two thousand five hundred only) out of Rs.555000.00 received from the University Grants Commission under the scheme of support for Major Research Project entitled " MICROWAVE ASSISTED WELDING " vide UGC letter No. F. 42-904/2013 dated 25.03.2013. A sum of Rs.473163.00 has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the university Grants Commission. You are requested to kindly release the balance amount after deduction of unspent balance of Rs.26697/- .

(Vinay Sharma) Registrar /Principal Statutory Auditor

ज्ञान-विज्ञान विमुक्तये

UNIVERSITY GRANTS COMMISSION BAHADUR SHAH ZAFAR MARG NEW DELHI – 110 002.

Project Ledger Name:		MRP Prof. (Dr.) Vinay Sharma Material Science RS 04/13 [05147]								
Project Reference Number:		F.NO.42-904/2013 (SR)								
Project Title:		MICROWAVE ASSISTED WELDING								
Duration:		01/04/2013 to 31/03/2016								
Co-Ordinator Name:		Prof. (Dr.) Vinay Sharma							Total Expenditure	Closing
Heads	Sanction	Opening	Receiving	INTEREST	Expenditure13-14	Expenditure14-15	Expenditure15-16	Expenditure16-17	Amount Rs.	Amount Rs.
BOOKS & JOURNALS	20,000.00	0.00	20,000.00		0.00			12488.00	12,488.00	7,512.00
EQUIPMENT	400,000.00	0.00	400,000.00		395,025.00				395,025.00	4,975.00
CONSUMABLE	50,000.00	0.00	25,000.00		0.00			18631.00	18,631.00	6,369.00
CONTIGENCIES	25,000.00	0.00	12,500.00		0.00	5985.00		6515.00	12,500.00	0.00
TRAVELLING/HIRING EXPENSES	50,000.00	0.00	25,000.00		24,519.00				24,519.00	481.00
OVERHEAD	10,000.00	0.00	10,000.00		3,330.00		3330.00	3340.00	10,000.00	0.00
INTEREST ON PROJECT				7,360.00					0.00	7,360.00
TOTAL	555,000.00	0.00	492,500.00	7,360.00	422874.00	5985.00	3330.00	40974.00	473,163.00	26,697.00

18/5/2017

(VINAY SHARMA)

Signature of the Principal Investigator

RANCHI

M·N-410224