Executive Summary of the project entitled

"DEVELOPING PROCESSING MAPS FOR DIFFUSION BONDING OF HIGH MELTING TEMPERATURE DISSIMILAR MATERIALS"

Sponsoring Agency

UNIVERSITY GRANTS COMMISSION (UGC)
MAJOR RESEARCH PROJECT SCHEME (MRPS)
NEW DELHI

UGC File No: 42-905/2013 (SR) dated 25.03.2013

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UNIVERSITY GRANTS COMMISSION

BAHADUR SHAH ZAFAR MARG

NEW DELHI – 110 002

PROFORMA FOR FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. TITLE OF THE PROJECT : Developing processing maps for diffusion bonding of high melting temperature dissimilar materials.

2. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR:

Dr. S. RAJAKUMAR
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3. NAME AND ADDRESS OF THE INSTITUTION:

The Registrar
Annamalai University
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4. UGC APPROVAL LETTER NO. AND DATE: **F. No. 42-905/2013 (SR) dated 25.03.2013**

5. DATE OF IMPLEMENTATION : 01.04.2013

6. TENURE OF THE PROJECT : From 01.04.2013 to 31.03.2017

7. TOTAL GRANT ALLOCATED : Rs.13,00,800

TOTAL GRANT REALLOCATED : **Rs.13,00,800**

8. TOTAL GRANT RECEIVED : Rs.12,33,000

9. FINAL EXPENDITURE : Rs.12,33,000

[**Rs. 12,33,000/-:** Expenditure from the Grant released, Rs**. 67,800/-:** Expenditure incurred against the third installment amount, to be released by UGC].

10. TITLE OF THE PROJECT : Developing processing maps for diffusion bonding of high melting temperature dissimilar materials.

11. OBJECTIVES OF THE PROJECT

- Construction of diffusion bonding windows (DBW) i.e. processing maps such as Temperature – Time (T-t) and Pressure – Time (P-t) diagrams for the effective and successful joining of high melting temperatures dissimilar materials combinations such as Stainless Steel-Titanium and Titanium-Aluminium.
- Development of empirical relationships to predict the shear strength and bonding strength of diffusion bonds.
- Optimization of diffusion bonding process parameters such as bonding temperature, bonding pressure and holding time to attain maximum shear strength and bonding strength using Response Surface Methodology (RSM).

12. WHETHER OBJECTIVES WERE ACHIEVED:

YES

13. ACHIEVEMENTS FROM THE PROJECT

- The greatest achievement of this project is the fabrication of Cp-Ti/AA7075 joints by using solid state diffusion bonding process.
- Empirical relationships were developed incorporating the diffusion bonding process parameters.
- A developed empirical relationship is used to find out the unknown process parameters and it is very much useful to the design engineers in research and development for the industrial applications.

14. SUMMARY OF THE FINDINGS

The joining of dissimilar materials by conventional welding techniques becomes difficult if the physical properties such as melting temperature and the thermal expansion coefficient of the two materials differ a lot, as it is necessary to have controlled melting on both sides of weld joints simultaneously. Even if this criterion is met, it may not be possible to have an appropriate joint when the two materials are metallurgically incompatible. By means of diffusion bonding, it is possible to bond all the materials whose chemical and metallurgical properties are different. For dissimilar materials combinations, stress development at interface occurs owing to their difference in coefficient of linear expansion and this leads to the formation of micro-cracks in the bonded region. Sometimes new phases also occur at the bond region, which is different from base metals, when diffusion bonding between dissimilar materials takes place. The brittle intermetallic compounds formed could weaken the bonding performance. Therefore, it is important to study the formation of intermetallic compounds (diffusion layer) at the interfaces in order to control the process parameters during the diffusion bonding of dissimilar materials.

Hence, the present investigation was carried out to construct diffusion bonding windows such as temperature – time and pressure – time diagrams for joining dissimilar materials, namely cp Ti /AA 7075 and Ti-6Al-4V / AISI 304. Nearly 35 experiments were conducted to fabricate dissimilar joints. From the experimental results, working ranges of bonding parameters were identified. Using these parameters, diffusion bonding windows were constructed. To predict shear strength cp Ti/AA 7075 and Ti-6Al-4V / AISI 304 dissimilar joints an attempt was made to develop empirical relationships using statistical tools such as the design of experiments (DOE), analysis of variance (ANOVA) and response surface methodology (RSM). The relationship between the optimum process parameter. Diffusion bonding process parameters were optimized to attain maximum strength using response surface methodology. A detailed analysis was carried out to understand the effect of process parameters such as bonding temperature, bonding pressure and holding time on mechanical and metallurgical properties of cp-Ti / AA 7075 and Ti-6Al-4V / AISI 304 dissimilar bonds.

15. CONTRIBUTION TO THE SOCIETY

The societal benefits of this project are high and few of them are

i. It can be used to manufacture space shuttle fuel tanks.

16. WHETHER ANY Ph.D. ENROLLED/PRODUCED OUT OF THE PROJECT Ph.D.

Enrolled : YES

Candidate Name : A.Arun Negemiya

Enrolled on : December 2015

Status : Ongoing.

17. NO. OF PUBLICATIONS OUT OF THE PROJECT

S. No.	Paper Title	Name of the Journal/ Conference	Status
1	Diffusion Bonding of Titanium and AA 7075 Aluminium Alloy Dissimilar Joints - Process Modelling and Optimization using Desirability Approach	Advanced Manufacturing Technology	Published During 2016
2	Effect of Diffusion Bonding Temperature on Mechanical and Microstructure Characteristics of cp Titanium and High Strength Aluminium Dissimilar Joints	Applied Mechanics and Materials	Published during Jan. 2015
3	Multi-Response Optimization of Diffusion Bonded Dissimilar of CpTi and AA 7075 Joints	International conference on IC2014	Published during Dec 2014
4	Effect of diffusion bonding temperature on mechanical and microstructure characteristics of cp titanium and high strength aluminium dissimilar joints	International conference on sustainable energy resources, materials and technologies (ISERMAT-2015)	Published during Jan. 2015
5	An investigation on microstructure and mechanical properties of AISI 304 to Ti–6Al–4V diffusion bonded joints	International Conference on Futuristic Innovations in Mechanical Engineering and Manufacturing Management (ICFIMEMM17)	Published during Mar. 2017
6	Developing Processing Maps for Diffusion Bonding of Commercially Pure Titanium and High Strength Aluminium Dissimilar Joints	Recent Trends in Welding Technology and Non-Destructive Testing	Published during Sep. 2013