A REVIEW PAPER- THE EFFECT OF ACTIVATING FLUX IN TIG WELDING OF SS321

[1]Maulik J. Patel, [2]Prof. Pradip S. Chaudhari, [3]Prof. Trushar R. Shah, [4]Prof. Pavan S. Patel

[1] P.G. Student, Mechanical Engineering dept., U. V. Patel College of Engineering, Gujarat, India
[2] Assistant Professor, Mechanical Engineering department, U. V. Patel College of Engineering, Ganpat Vidyanagar, Gujarat, India
[2] Assistant Professor, Mechanical Engineering department, U. V. Patel College of Engineering, Ganpat Vidyanagar, Gujarat, India
[3]Assistant Professor, Mechanical Engineering department, B. S. Patel Polytechnic, Ganpat Vidyanagar, Gujarat, India

ABSTRACT

Welding is a manufacturing process which is carried out for joining of metals by Tungsten inert gas (TIG) welding. This is the one type of Gas tungsten arc welding (GTAW), during which Argon (Ar) inert gas is supplied or used as an inert gas. Shielding gas argon is used and non-consumable tungsten electrode is used which also plays role of conductor. TIG welding is versatile, gives very little loss of alloying elements and can be operated as semi as well as fully automated.
All welds were prepared by TIG welding technique. We have studied design of experiments for this work and by use of the experimental data have optimized by analysis of variance (ANOVA) method. In which input parameters for TIG welding are welding current, Arc voltage and welding speed and the output parameter is tensile strength and microstructure. We were used austenitic stainless steel of AISI 321 material and Cr_2O_3 and $MgCO_3$ flux used for during welding process. Joint of plate have been planned to perform on 6 mm plate thicknesses of stainless steel 321 and direct square butt joint is used for this study. For Experimental design we were use Taguchi method (L9) orthogonal array to find out number of readings. The output factors are measured in UTM and microscope. Results show robust relation and strong comparison between the weld strength, microstructure and process parameters. To find out proportion contribution of every input parameter for getting optimum conditions, we were used analysis of variance (ANOVA) method.

Keyword- *A-GTAW, Active flux, Tensile strength, Microstructure.*

---

1. INTRODUCTION

In industry most of the materials are fabricated into the desired shape mainly by one of the following methods viz. casting, forming, machining and welding. The selection of a particular technique depends upon different factors which may include shape and size of the component, precision required, cost, material and its availability. Sometimes one specific process may be used to achieve the desired object. However, more often it is possible to have a choice between the processes available for making the end product. Among the available options economy plays the decisive role in making the final choice.

1.1 DEFINITION OF WELDING

Defines weld as a localized coalescence of metals or non-metals produced either by heating the materials to suitable temperatures with or without the application of pressure alone and with or without the use of filler material.

1.2 DEFINITION OF TIG WELDING

Gas tungsten arc welding (GTAW) or tungsten inert gas (TIG) welding is an arc welding process that uses a tungsten (non consumable) electrode to produce the weld.

Shielding gas (usually an inert gas such as argon) is used to protect the weld area from atmospheric contamination, and a filler metal is normally used whereas some autogenous welds do not require it. Energy produced is supplied by a constant-current welding power source which is conducted across the arc through a column of highly ionized gas and metal vapors known as plasma. It is also known as a metal arc weld technique wherein coalescence is made by heating the workpiece within the electric arc stricken among the job with metallic element conductor. A shield gases like argon, helium, nitrogen or mixture of gases etc. is use to avoid atmospherically contaminant of melted weld pool. An appropriate filler metal could also be added if needed."

Stainless-steel and non-ferrous metal like metallic element, copper and magnesium alloy are normally welded by GTAW. The method provides the operator larger management above the welding than competitive processes similar to protected manual metal arc weld and gas metals arc welding, providing stronger and better quality welds. However, GTAW being considerably very slow than most alternative welding techniques is relatively additional complicated, unsafe and troublesome to master.

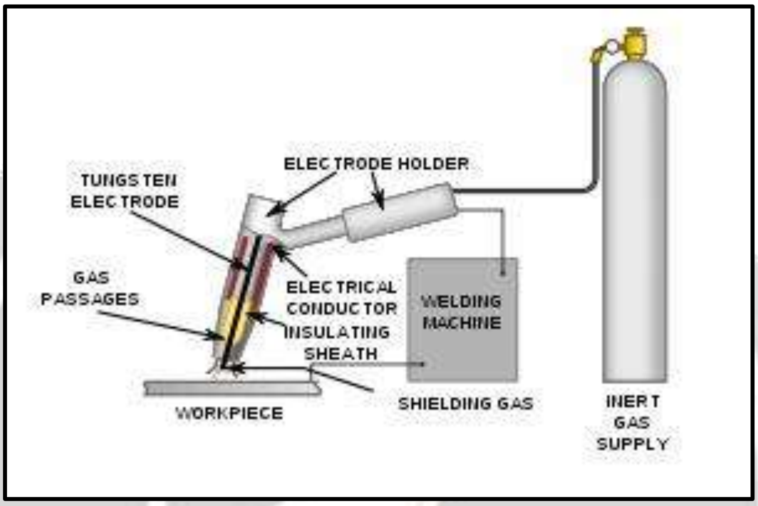


Fig 1: Gas Tungsten Arc Welding

1.3. APPLICATIONS

When the craft trade is the first users of metal inert gas welding, the method is employed during a queue of different engineering areas. Several industries or trade use tungsten inert gas (TIG) for welding skinny work pieces like nonferrous work piece. It also comprehensive with in production of area vehicles, and is additionally again and again used to weld thin-wall tube, small-diameter like those utilized in the bicycle business. GTAW is commonly accustomed create initial for piping of welds pass assorted its size. The repair and maintenance works the method is usually wont to repairing dies and tools particularly elements create from Al, Mg etc. as the result of weld metal isn't directly supply across the electrical arc same as effective open arc joining technique, an outsized type of weld filler work piece is on the market to the fastening persons. This phenomenon, no alternative joining method allow the joining of such a lot of alloys in such a more amount of configurations like this. Filler wire alloy is missing supply the electrical arc from volatilize. They lost doesn't due to the TIG.

GTAW welds are extremely proof against cracking and corrosion over while periods as a result of the ensuing welds have a similar chemically continuum because the real parent matching the bottom foundation materials additional nearly. TIG is that the welding technique of selection for essential welding processes like protection.

1.4. ADVANTAGES OF GTAW

- No required flux
- Increased corrosion resistance
- No slag formation
- Higher rate of deposition
- Deeper penetration rate
- Welds for all metals including stainless steel and aluminium.

1.5. DISADVANTAGES OF GTAW

- Equipment used is costlier and less portable
- Difficult to weld in sharp corners
- Less suitable for outdoor work
- Radiations can produce harmful effects to the operator if exposed continuous for more time.
- Non consumable electrode requires frequent grinding

How to Apply the Flux?

For the experiment, the flux is used in paste kind, that the solder flux is mixed with acetone of 20-40 ml and a 2-3 mm thick paste is formed and painted on the piece of labor as shown in the figure 2.

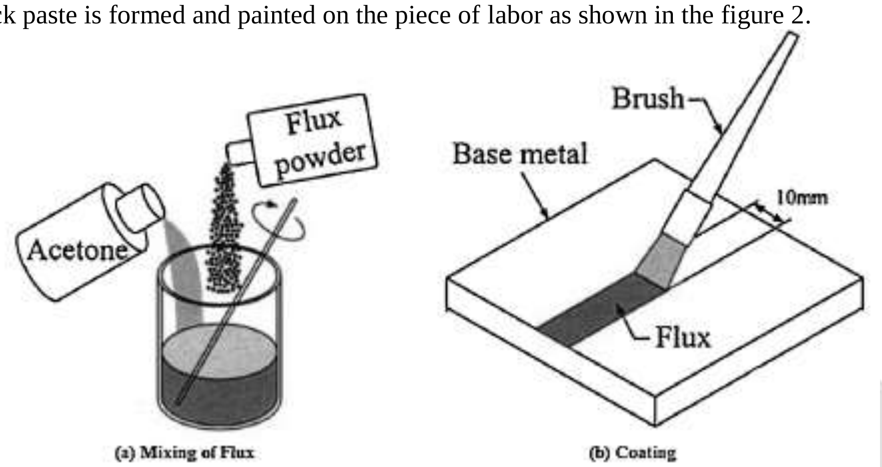


Fig.2 Preparation and application of flux paste.

The flux is obtainable in powder form not applied uniformly on the surface of the weld metal. For this reason, the powder is regenerate into paste type by intermixture it with acetone as shown in Fig.2. Acetone has perspective to vaporize fastly leave the oxide flow equally distributed on the surface of the fabric. To possess an identical quantity of flux constituents over the proper all length of the piece, the brush touched each forward and backward within the desired space till all of the flux paste was consumed.

Application of activated flux method

The activation flux method will be applied in each manual and machined welding operations. However, because of the necessity to keep up a brief arc length to attain deep penetration, it is most frequently applied in mechanized applications.

Mechanisms for Deep Penetration

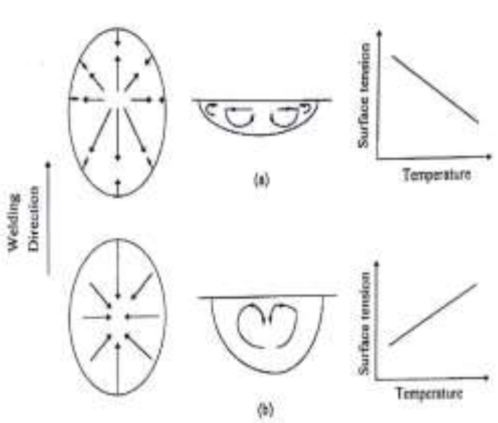
At the present, no theory of the mechanisms by which the activating flux leads to an increased penetration of the weld bead is generally agreed. Available literatures show that some of the mechanisms, which play major role in increase depth of penetration, are given below.

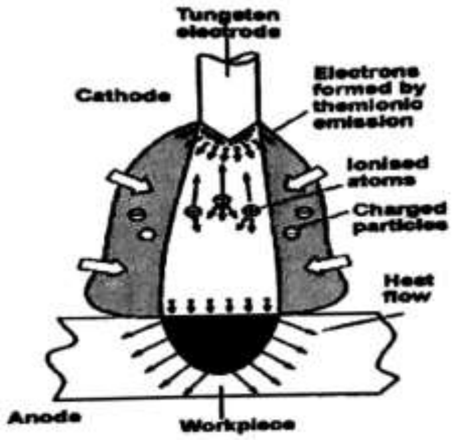
1. Marangoni Effect.

Dissolved flux in molten weld pool can change surface tension properties. In particular, a change from negative to positive gradient of the surface tension with temperature can change surface convection flow in the weld pool being radially inward flow along the surface of the weld pool leads to down wards thus resulting deeper penetration.

2. Effect of arc constriction due to negative ions.

Electron attachment at the edge of the arc to form negative ions could cause arc constriction and an increase in current density at the anode centre, thus leading to an increase weld depth as shown in figure. The process of electron attachment occurs only in outer region of the arc for temperature below 1000k current density are dominated by the central region of the arc where the electron densities are four or five orders of magnitude higher.





1) Marangoni Effect. 2) Arc constriction due to negative ions

3. Effect of arc constriction due to insulating four regions.

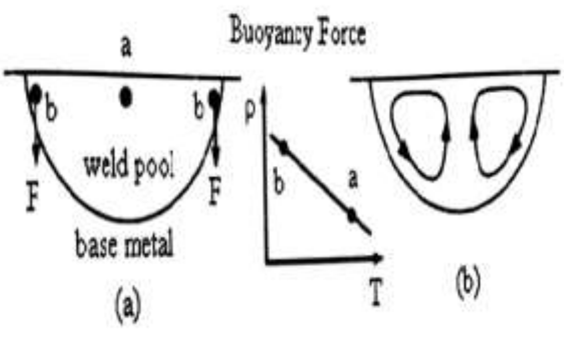
The surface of the work piece is covered with a thin layer of the flux, which is usually a metal oxide. This layer will act as an insulation barrier to the arc current. Temperature at the centre of the weld pool will be sufficient to melt the flux so that the electric current can penetrate the flux to the weld pool and workpiece. The arc diameter at the weld pool surface is reduce by the insulating effect of the flux for the outer region of the arc. For given welding current, the current density at the centre of the weld pool increased, resulting in strong convection floe downward in the weld pool and to increased weld depth.

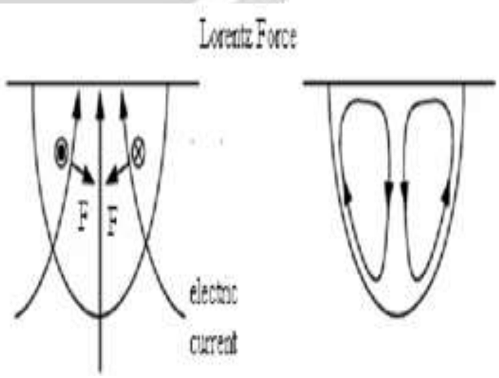
4. Buoyancy or gravity force.

The density of the liquid metal is decrease with increasing temperature because the heat source is located above the centre of the pool surface, the liquid metal is warmer at point(a) and cooler boundary, where the temperature is lowest at the melting point as shown in figure.

5. Electromagnetic or Lorentz force.

Electromagnetic theory predicts that electric and magnetic fields interact with one another to produce a force in an orthogonal direction. This force is called electromotive force or emf and it is also known as Lorentz force. The effect is particular pronounced due to the divergent current path in the weld pool and magnetic field it generates. The direction of circulation by Lorentz force is form the edge to centre of the weld pool and magnitude of this force leads to circulation velocity of about 10 cm/sec.





4) Buoyancy or gravity force. 5) Electromagnetic or Lorentz force.

2. LITERATURE REVIEW

In this existing work, a literature survey is created. This survey covers GTAW/TIG welding, welding of stainless steels, performance testing of welds, method optimization and process parameter, mathematical modeling, analysis of experimental data etc.

Kamal H. Dhanda, et al, [1]done experimental study the effects of activating fluxes on mild steel welds. Maximum 2 to 3 mm thickness plate of (SS) stainless steel and carbon steel can be welded with TIG welding under autogenous welding process. The activating flux welding process is considered as potential optional to increase process productivity. In this investigation 91 grade steel is used as a work piece material. A GTAW weld on P 91 grade steel in using oxide flux Fe_2O_3, CaO, CrO_3, ZnO, MnO_2 and TiO_2 was used as flux material to make a bead on weld plate. This method is most effective for increased in penetration depth and mechanical properties and also weld width was reduced. Heat input was increased with use of flux.

Tseng, et al, [2] have studied the effect of activating flux in (TIG) welding process on penetration, hardness, angular distortion, of 316 stainless steels grade material. An automatic GTAW welding on 6mm thickness stainless steel 316 plates through a 0.2 to 0.4mm flux layer thickness to produce shield to atmospheric contamination of joint. The fluxes are used to pack in powder form. In this study finally conclusion is indicate that the SiO_2 flux is more preferable over the flux Al_2O_3 and also increase weld penetration and mechanical properties were used SiO2 flux.

Ravi Patel, et al, [3] have studied the parametric optimization of TIG welding using active flux on weld penetration on 304 steel on weld Penetration and weld strength when using 6 mm thickness plate stainless steel 304 using oxide flux in this research work Cr_2O_3, $MgCO_3$, MgO, CaO, Al_2O_3.from this literature survey input parameter is Welding current, Arc Voltage, Gas Flow Rate, Activated Flux to find out optimum welding parameter for penetration using activated flux. This research done at three phases, one is without activated flux, second is with TiO_2 flux and third one is with $MgCO_3$ flux, from experiment result we found that all three Parameters have their own percentage contribution on penetration in GTAW. From Experiment Result we can shows that MgCO3 flux are gives maximum increase penetration and also maximum Tensile Test of joint stainless steel 304 material. By ANOVA analysis conclude that we can use effective or optimum parameters is welding Current, arc voltage, gas flow rate and activated flux is $MgCO_3$.

ErBhawandeep, et al, [4] have studied the result of various types of chemical compound powder fluxes like Cr_2O_3, $MgCO_3$, MgO, CaO, Al_2O_3, on method parameter is welding current, voltage, and investigate output parameter during this paper is penetration depth, weld width ratio, on mild steel plate. They found that activating flux assisted GTAW enhanced the weld penetrate, tending to decrease the width of welds. Additionally with the appliance of flux on mild steel its hardness gets reduced depth to width ratio increases. The Cr_2O_3 flux made most noticeable result than other all fluxes and $MgCO_3$ flux produce a positive result towards increase penetration and improve strength.

A. R. Loureiro, et al, [5] the aim of this research is to study Effect of activating flux and shielding gas on Microstructure of TIG welds in austenitic Stainless steel 316 material. In this study two shielding gases argon and helium are used and a weld currents selected range on the microstructure of autogenous A-TIG welds on an austenitic stainless steel 316. In this study input parameter is welding current, electrode type, electrode diameter, electrode tip angle, arc length, shielding gas flow rate, welding speed, finally conclusion in this study Increase in welding current coarsened the microstructure and increased the ferrite content in welds, during welding when using TiO2 flux show higher ferrite content.

E. Ahmadi, et al, [6] studied the performance of A-GTAW on 304L austenitic stainless-steel plates .They used two oxide fluxes, TiO_2 and SiO2 to analyze the result of A-GTAW method on weld morphology, microstructure and mechanical properties of weldments. E. Ahmadi have studied during this work they take input parameter is welding speed, current, electrode angle, arc length, gas rate, electrode diameter. They found that A-GTAW may increase the penetration and depth width ratio of the weld pool and the delta-ferrite content may be increase of weld metals and improve the mechanical properties.

Prof. A.B. Sambherao, et al, [7] investigated the effect of TiO_2, Fe_2O_3, SiO_2 and Al_2O_3 fluxes on the surface appearance, weld morphology and retained δ-ferrite content obtained with the GTAW process when using to the welding of 6mm thick AISI 316L austenitic stainless steel plates. A. B. Sambherao had studied in this research input parameter take welding current, welding speed, arc length. He observed that the finally conclusion in this study is use only TiO_2 flux achieving increase in the depth of penetration than all use other flux and slightly decrease of bead width. He found out that penetration was increase when using TiO_2 flux. This effect is due to the reverse of marangoni convection and the arc constriction produced by the flux. Al_2O_3 produced only a small increase in weld depth. He had find out best result in this study we take that combination of fluxes such as mixture of TiO_2 and Fe_2O_3 flux should be used to achieve desirable properties of the weld.

K. DevendranathRamkumar, et al, [8] have studied on the tensile properties, weldability, and microstructure of autogenous GTAW welded AISI 430 steel with and without flux when welding of 6mm thick AISI 430 plate using SiO2 and Fe_2O_3 flux powder through a thin layer of the flux to apply on weld surface, In this investigation input parameter is voltage, current, shielding gas, welding speed, flow rate, heat input and find out different zones of microstructure and tensile strength of AISI 430. Finally conclusion in this investigate SiO_2 and Fe_2O_3 flux improved the depth of penetration, hardness and ductility increase when SiO_2 flux and Fe2O3 flux used tensile strength are increase and low carbon martensitic structure slightly improved.

Huang, et al, [9] have studied the effect of active flux on mechanical properties of welded joint like tensile Strength, hardness and angular distortion in (GMAW) gas metal arc welding on 6mm weld plate thickness used AISI carbon steel 1020 and using oxide flux SiO_2, Fe_2O_3, and $MgCO_3$ as activating flux are used in this study. Huang had studied in this research was taken input process parameter is welding speed, joint gap, Arc voltage and welding current. In this survey finally conclusion is $MgCO_3$ flux was increased hardness, joint strength, and angular distortion of the weldment was reduced.

PROBLEM STATEMENT

- To evaluate the effects of different process parameter on TIG welding operation.
- To find out the optimal condition of different parameters using optimization technique.
- In gas tungsten arc welding (GTAW) we were found that the effect of activated flux at activating condition.
- We were used TAGUCHI experimental design to known about the number of experimental readings.
- To find which flux is very most effective and can give the better performance for this process by analysis of variance (ANOVA).
- To find out joint strength of weld and to observed different microstructure of metal for best output or application.

3. EXPERIMENTAL PLAN

Taguchi's plan of orthogonal array, as mentioned within the previous chapter, has been adopted for coming up with the experiments of attachment of primary solid solution stainless-steel. L9 array were designated of 3 factors and 3 levels of every factor. During this investigation input factors are: weld current, arc voltage, and speed. 9 butt welded samples are created exploitation totally different levels of weld current, arc voltage, and weld speed. The responses measured are final strength. Supported the trial runs and literature review, the levels of the factors are determined. Table 1. Shows the input and output parameter. Table 2. is factors and their levels, as used in experimental runs.

Table 1. Input and output parameter

INPUT PARAMETER	OUTPUT PARAMETER
Welding current (Amp)	Tensile strength (MPA)
Arc voltage (V)	Microstructure
Welding speed (mm/min)	

Table 2. Process parameters and their levels

Process Parameters	Unit	Level 1	Level 2	Level 3
Welding Current	Ampere (A)	140	160	180
Arc voltage	V	16	18	20
Welding speed	mm/min	130	140	150

ORTHOGONAL ARRAY

Orthogonal array is high efficiency orthogonal network plays a role in achieving the Taguchi method. Orthogonal array (OA) is received by a line from the experience counsel of the code includes a very sophisticated, that mathematical algorithms of combinations, in the finite being of the field, and the geometry, an error correction. Table 3 is used for L9 Orthogonal Array for experimental runs with constant Cr_2O_3 flux, constant $MgCO_3$ flux, and without activating flux.

Table: 3- L9 Orthogonal Array for Experimental Runs

Sr. No.	**Welding current (A)**	**Arc voltage (V)**	**Welding speed (mm/min)**	**$MgCO_3$ flux (%)**	**Cr_2O_3 flux (%)**
1	140	16	130	100	100
2	140	18	140	100	100
3	140	20	150	100	100
4	160	16	140	100	100
5	160	18	150	100	100
6	160	20	130	100	100
7	180	16	150	100	100
8	180	18	130	100	100
9	180	20	140	100	100

4. CONCLUSION

From the survey of existing literature, a number of gaps have been observed in the effects of activated flux in GTAW welding.Based on those existing literature survey it is found that there are many investigate done by using flux in TIG welding. But very less researches found on AISI 321 grade material. From the survey of this all research paper activated flux is very most effective for (GTAW) gas tungsten arc welding operation to increase mechanical properties of weld joint.Activated flux is very most effective for GTAW process to increase joint strength. Such that has been selected to my dissertation experiments on AISI 321 grade material and Cr_2O_3 and $MgCO_3$ flux are used for this study and my work is optimization based on ANOVA (Analysis of variance) method is continue.

5. REFERENCE

1. Kamal H. Dhandha, Vishvesh j. badheka "effect of activating fluxes on weld bead morphology of P91 steel bead on plate welds by flux assisted tungsten inert gas welding process" journal of manufacturing processes volume 17, January 2015.

2. Kuang-Hung Tseng, Chih-Yu Hsu "Performance of activated TIG process in austenitic stainless steel welds" Journal of Materials Processing Technology 211 (2011) 503–512.

3. Bimal Patel, Ravi Patel "Penetration Enhancing Activated Flux for TIG Welding of Stainless Steels" International Journal for Scientific Research & Development Vol. 3, Issue 03, 2015 ISSN.

4. ErBhawandeepsingh, ErAvtarsingh "Performance of activated TIG process in mild steel welds" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).

5. A. R. Loureiro, B. F. O. Costa, A. C. Batista and A. Rodrigues "Effect of activating flux and shielding gas on microstructure of TIG welds in austenitic Stainless steel" 2009 Institute of Materials, Minerals and Mining Published by Maney on behalf of the Institute Received 23 June 2008.

6. E. Ahmadi, A. R. Ebrahimi, R. Azari Khosroshahi "Welding of 304L Stainless Steel with Activated Tungsten Inert Gas Process (A-TIG)" International Journal of ISSI, Vol.10 (2013), No.1, pp. 27-33.

7. Prof. A.B. Sambherao "Use of Activated Flux For Increasing Penetration In Austenitic Stainless Steel While Performing GTAW" International Journal of Emerging Technology and Advanced Engineering ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 12, December 2013.

8. K. DevendranathRamkumar, Sidharth Dev, VimalSaxena, AyushChoudhary, N. Arivazhagan, S. Narayanan "Effect of flux addition on the microstructure and tensile strength of dissimilar weldments involving Inconel 718 and AISI 416" Materials and Design 87 (2015) 663–674.

9. Her-Yueh Huang "Effects of activating flux on the welded joint characteristics in gas metal arc welding" Materials and Design 31 (2010) 2488–2495.