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Research Paper

EVALUATION OF MECHANICAL PROPERTIES OF FRICTION WELDED JOINTS OF EN-24 STEEL CYLINDRICAL RODS

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Owing to superior properties of EN-24 steel which play an important role in Automotive industries for manufacturing Axle, gear and shaft. It is observed that a wide range of dissimilar materials can be easily integrated by solid phase bonding. In this experimental work which focuses on friction welding of EN-24 steel rods using different process parameters. The experiments are conducted on KUKA Friction welding machine in Welding research Institute of BHEL. The influence of process parameter which include friction pressure, upsetting pressure and friction time on the axial shortening, hardening and Tensile properties of friction welded joints of EN-24 steel cylindrical rods.

Keywords: Friction welding, EN-24, Process parameters, Hardness, Tensile strength

INTRODUCTION

Friction welding (FW) is a class of solid-state welding processes that generates heat through mechanical friction between a moving work piece and a stationary component, with the addition of a lateral force called “upset” to plastically displace and fuse the materials. Technically, because no melt occurs, friction welding is not actually a welding process in the traditional sense, but a forging technique. (Sahin M and Erol Akata H, 2003) investigated, the effects on the welding zone of plastic deformation material such as carburizing steels. A feasibility study has been carried out to investigate various aspects of joining a Fe 3 Al oxide dispersion strengthened (ODS) alloy using continuous drive rotary friction welding by Sketchley (Sketchly PD *et al*., 2002) Insu WOO *et al*., 2002) investigated the study of the metallurgical and mechanical properties of high nitrogen steel (HNS) friction welds and also found the correlation between the microstructure and joint strength .Mortenson (Mortensen KS, 2001) investigated, the friction welding of 416 stainless steel, its

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tensile strength and impact toughness, welding parameters, sulfur orientation, and brittle failure of friction weld. Vairis (Vairis A, Frost M, 2000) investigated the analytical and numerical models of linear friction welding of Ti 6 Al 4 V (numbers indicate wt %), established to predict temperature rises during the initial phase of the process and the effects of the exothermic. ReInkson (ReInkson *et al*., 1994) investigated, the effects of the Y 2 O 3 dispersion on the microstructure and mechanical properties of the parent material and welds under a range of processing conditions. North (North Murti K G K and Sundarasan S, 1983) investigated, the factors determining particle fracture in friction welded aluminum based composites material. A combination of experimental and numerical modeling results are used to support the proposition during MMC/MMC (metal matrix composites) joining. Takeshi [8] investigated the influence of welding parameters on tensile properties of friction welded joints by similar materials of spheroidal graphite iron casting and gray iron casting. Dunkerton investigated the effects of the parameters such as rotation speed, friction pressure, and forging pressure in friction welding methods for steel. Yilbas (Yilbas B S *et al*., 1995) investigated the mechanical and the metallurgical properties of dissimilar materials (Al-Cu) welded by friction welding. Murthi a study about parameter optimization using a statistical approach based on factorial experiment design friction welding of dissimilar materials. (Lippold J C and Odegard B C, 2003) investigated annealed 416 stainless steel welds, which would be susceptible to hot, or cold cracking, or heat affected zone micro fissures. (Linert, 2002) investigated flow lines in inertia welded 8009 aluminum. He showed that the flow lines of Si-C-rich and Si-C-depleted bonds followed spiral shaped paths for inertia friction welds. From the observations made on the above literature, Medium carbon steel does not conducted in friction welding. In this experimental work similar friction welding joints are conducted in EN-24 steel cylindrical rods.

EXPERIMENTAL SET UP

Figure 1: KUKA Friction Welding Machine (WRI, BHEL)

Figure 2: Friction Welded Joints of EN-24 Cylindrical Rods

Material: EN-24 Steel cylindrical rods

Dimension: dia 25X100mm

No of experiment conducted: 5

Table 1: Chemical Composition of EN-24 steel

C	Si	Mn	S	P	Ni	Cr	Mo
0.35	0.15	0.45	0.05	0.05	1.5	1.5	0.25

Table 2: Mechanical Properties EN-24 Steel

Max. Stress	Yield stress	Proof stress	Elonga-tion	Impact strength	Hardness value
850 N/ mm^2	465 N/ mm2	450 N/ mm2	16%	28j	255 Brinell

Figure 3: Rockwell Hardness Testing Machine

Figure 4: Tensile Test on EN-24 Rods

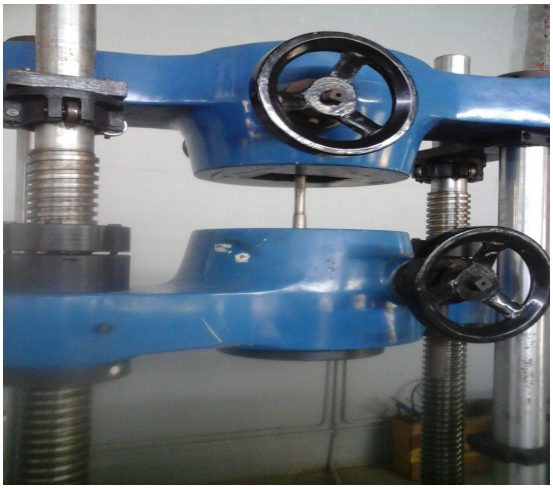

Figure 5: Tensile Test Specimen

FRICTION WELDING PARAMETERS

Table 3: Friction Welded Parameters of EN-24 Cylindrical Rods

Material 1	Material 2	Size 1&2	L1	L2	Total length	Heating pressure	Upsetting Pressure	Heating Time	Upsetting Time	Speed	Feed Rate	Final Length	Material Loss
EN-24	EN-24	MM	MM	MM	MM	BAR	BAR	SEC	SEC	RPM	MM\SEC	MM	MM
EN-24	EN-24	25	104.9	103.3	208.2	15	25	7	5	1500	0.5	208	0.2
EN-24	EN-24	25	104.3	104.5	208.8	15	25	7	8	1500	0.5	206.6	2.2
EN-24	EN-24	25	101.0	102.6	203.6	20	30	6	8	1500	0.5	201	2.6
EN-24	EN-24	25	102.4	104	206.4	35	35	5	8	1500	0.5	205.6	1.8
EN-24	EN-24	25	99.1	102	201.1	30	40	8	8	1500	0.5	199	2.1

RESULTS AND DISCUSSION

After conducting the experiment of Friction welding on EN-24 steel cylindrical rods in different welding parameters the following results were obtained.

- Friction pressure is a dominating parameter of Friction welding parameter of EN-24 cylindrical rods.
- The optimum parameter of friction welding is 125 Mpa for friction pressure and 180Mpa for forge pressure and 3 sec for friction time.
- Increase friction pressure results in slightly higher the hardness values
- However EN 24 steel cylindrical Rods provide good weldability characteristic and Produce excellent surface finish.
- EN 24 steel cylindrical rod welded joints produce good surface finish and produce minimum crack tendency.

Hardness Test

EN-24 friction welded joints are tested by using Rockwell hardness machine. It gives the hardness values of friction welded joints are 125 MPa for friction pressure and 180 MPa for forge pressure and 3 sec for friction time.

Table 4: Hardness Value of EN-24 Steel Cylindrical Rods

MATE-RIAL	LOAD APPLIED (N)	INDICA-TOR USED	SCALE	RHN	AVG
EN-24 Specimen	100	1\16	B	53 52 51 44	50

Tensile Test

The EN-24 friction welded joints are tested by universal testing machine and ultimate stress value of friction welded parameters are 150 Mpa friction pressure 220 Mpa forge pressure and friction time 5 sec.

Table 5: Hardness Value of EN-24 Steel Cylindrical Rods

S.No.	Applied Loan (KN)	Yield stress (KN)	Ultimate stress (KN)
1	40	124	154

Radiography Test

EN24 friction welded joints are performed to conduct radiography test and find out it does not have any defect and porosity.

Table 6: Radiography Test of EN-24 Steel Cylindrical Rods

SEG-MENT	IQISENSI-TIVITY	THICKNESS (mm)	FILM SIZE	OBSER-VATION	RESULT
A	25 - 2T	25	4×6	ND	ACCEPT-ABLE
B	25 - 2T	25	4×6	ND	ACCEPT-ABLE

CONCLUSION

(i) Friction welding can be used successfully to joint EN-24 steel rods.The processed joints exhibited better mechanical property as compared to those made with fusing welding Technique.

(ii) The axial shortening exponentially increased by increasing friction pressure and friction time and plays an important role in Hardness and Ultimate strength of EN24 steel rods.

(iii) After welding process the joints tends to severe deformation and produce grain refinement with strain hardening. The intensity of orientation was found

to be dependent on the welding parameters and affected thermo mechanically and produces deformation zone. The deformed region increases from the central of peripheral region and subjected to severe plastic Deformation.

(iv) The optimum parameters of High Hardness value of EN-24 steel rods are 125Mpa of friction pressure, 180Mpa of forge pressure and 3Sec of friction time.

(v) The optimum parameters of high ultimate strength of EN-24 steel rods are 150Mpa of friction pressure, 220Mpa of forge pressure and 5 sec of friction time.

(vi) EN-24 steel rods of Welded joints provide good strength and better ultimate strength and improve toughness after welding process.

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