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Experimental evaluation of mechanical properties of friction welded mild steel

Eko Nugroho[1], Eko Budiyanto[2*], Enggal Bagus Suseno[3]

[1,2,3]Prodi Teknik Mesin, Fakultas Teknik, Universitas Muhammadiyah Metro
Jl. Ki Hajar Dewantara 15 A Kota Metro, Lampung, Indonesia
**Corresponding author*: ekobudiyantoiyan@gmail.com

Abstract

Friction welding is a solid state joining process used to join similar and dissimilar metals, not possible with other available welding techniques. Now a day's Friction welding is most commonly used in industry that is aeronautical engineering, automobile engineering, submarine industry and heavy industry. In this research, an experimental setup was designed and fabricated in order to accomplish friction welded joints mild steel. Thereafter, the effect of forging pressures and rotation speed on the mechanical properties of friction welded ST 42 steels, produced by mechanical joining, have been investigated. Samples were welded under friction pressure 10 MPa by different forging pressures 25 MPa and 35 MPa with different rotation speed 1095 rpm, 1200 rpm, and 1400 rpm. The tensile strength values of the weldments were determined and evaluated. The top result is produced from sample were welded under forging pressures 35 MPa at rotation speed 1400 rpm that is tensile strength 437,27 N/mm^2 and yield strength 399,75 N/mm^2.

Keywords : friction welding, forging pressure, tensile strength, yield strength, and elongation.

Introduction

Steel is an important engineering material. It has found applications in many areas such as vehicle parts, truck, bed floors, automobile doors, domestic appliances, etc. It is capable of presenting economically a very wide range of mechanical and other properties. Traditionally mechanical components has been joined through fasteners, rivet joints etc. In other to reduce time for manufacturing, weight reduction and improvement in mechanical properties, welding process is usually adopted [1].

Friction welding is a solid state joining process used to join similar and dissimilar metals, not possible with other available welding techniques [2][3][4][5]. Now a day's Friction welding is most commonly used in industry that is aeronautical engineering, automobile engineering, submarine industry and heavy industry [3][6]. Friction welding method is one of the most simple, economical and highly productive method in joining dissimilar materials. It is widely used in the automotive, medical, and aerospace industrial applications [7].

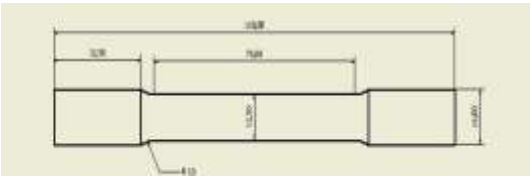
Friction welding requires rapid rotation of one component at high rpm and other component is brought into contact at high forging pressure to get upset. Two pieces rotate in contact and heat necessary for welding is generated on friction plane [2]. The principle of this process is the changing of mechanical energy into heat energy. One work piece is rotated about its axis while the other work piece to be welded to it is stationary and does not rotate but can be moved axially to make contact with the rotating work piece. The rotation is stopped at the point of fusion and forging pressure is applied axially on to the stationary work piece. The hot work causes refinement of grain structure. Then welding is done, without melting of parent metal [4]. Considering the relative velocity and the friction motion between the interfaces, friction welding processes can be classified in two groups. The first group represents the various means where the heat is generated by the relative movement between the surfaces. The classical processes with rotary, linear, and orbital motion are representatives of this group.

Processes generating the friction due to a relative motion between a non-consumable tool and the work piece surface can be classified as the second group. Friction Stir Welding (FSW) was developed by W.M. Thomas as a solid-state joining process which operates by way of a non-consumable rotating tool with a specially designed pin and shoulder [8].

Material and Methods

Material

The material used in this experiment was mild steel (ST 42). All the specimens were made in cylindrical form having 15 mm diameter and 150 mm length. Tensile test specimens used ASTM E8 tandard as shown in Figures 1. A turning machine was used for friction welding process as shown in Figure 2. A specification turning machine was used for friction welding process as shown in Table 1.



Figue 1. Tensile test specimen dimension

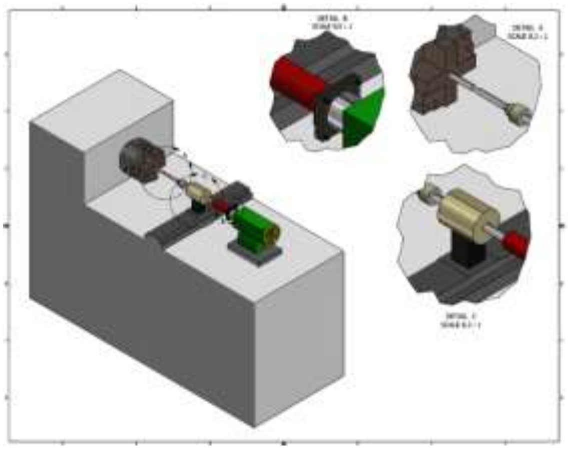


Figure 2. Scheme of friction welding process

Figure 3. A turning machine was used for friction welding process

Table 1. Specification turning machine was used for friction welding

Spindle Speed	70 – 2000 rpm
Motor Spesifications	1,5 kW, 380 V, 3 HP
Dimenstion (*l* x *w* x *h*)	177 x 58 x 127 (cm)
Weight	655 kg

Methods

This experimental setup was designed and fabricated in order to accomplish friction welded joints mild steel. Thereafter, the effect of forging pressures and rotation speed on the mechanical properties of friction welded ST 42 steels, produced by mechanical joining, have been investigated. Samples were welded under friction pressure 10 MPa by different forging pressures 25 MPa and 35 MPa with different friction speed (rotation speed) 1095 rpm, 1200 rpm, and 1400 rpm. The weldments will determine and evaluate by Ultimate Tensile Machine (UTM).

Result and Discussion

This research was conducted to determine the effect of forging pressure and rotation speed on the tensile strength of weldments of mild steel as a result of friction welding. After the friction welding process, the weldments are turned into tensile test specimens then a tensile test is carried out. The process of friction is approved in Figure 4. The tensile test results of friction welding specimens as shown in Figure 5.

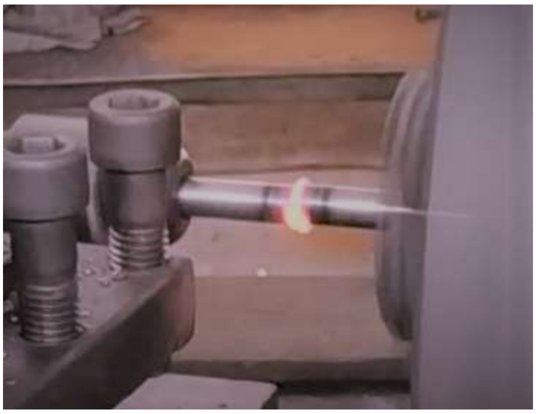


Figure 4. Friction welding processes

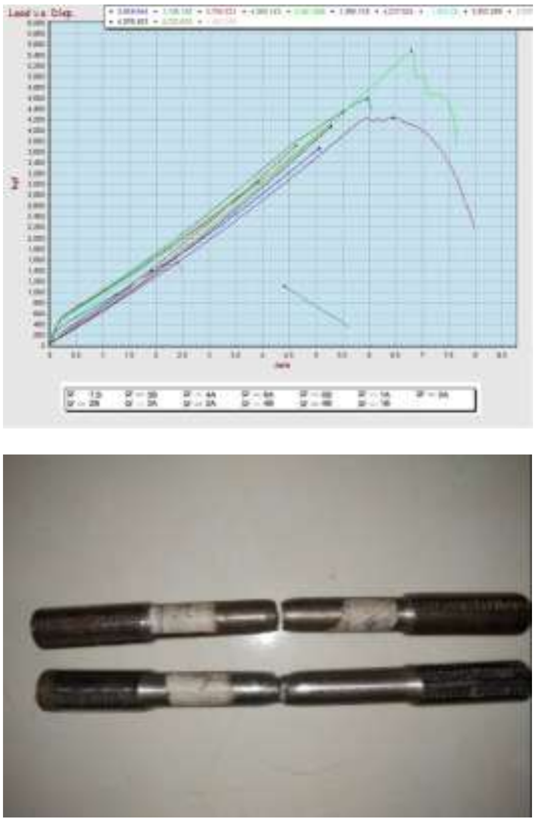
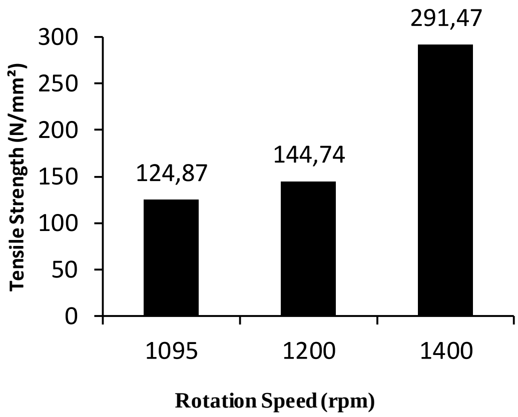


Figure 5. Diagram and specimens tensile test results

At friction welding under forging pressure 25 MPa, the tensile strength, yield strength, and elongation values are shown in Figure 6. And friction welding under forging pressure 35 MPa, the tensile strength, yield strength, and elongation values are shown in Figure 7.



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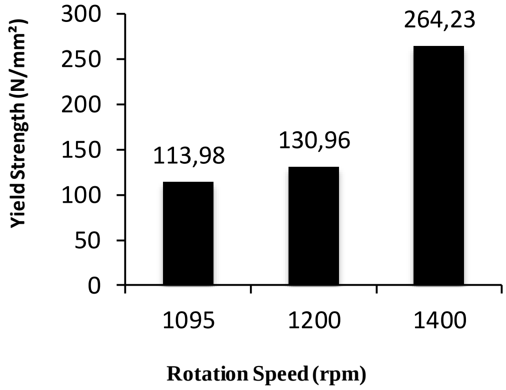

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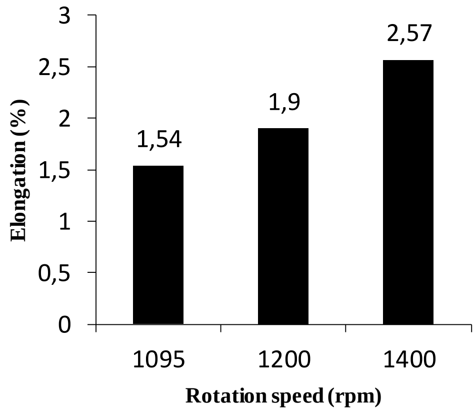
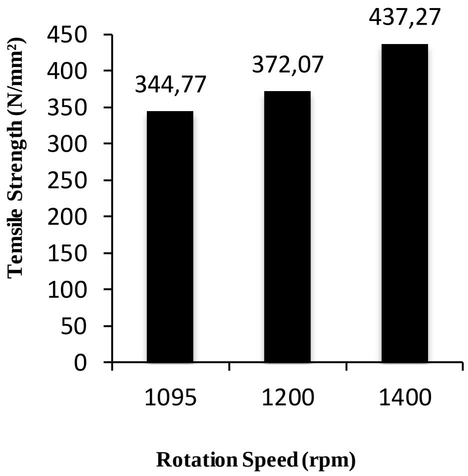


(c)

Figure 6. Mechanical properties UTS result of weldments under forging pressure 25 MPa. (a) Tensile Strength, (b) Yield Strength, (c) Elongation



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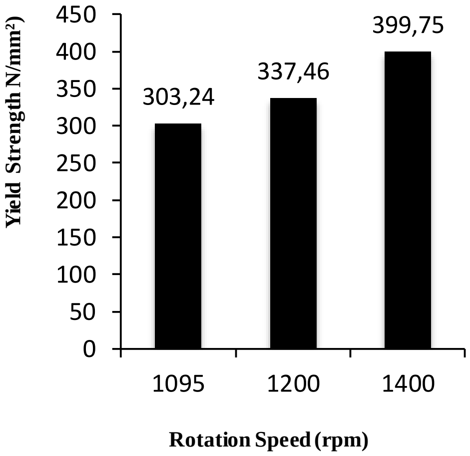

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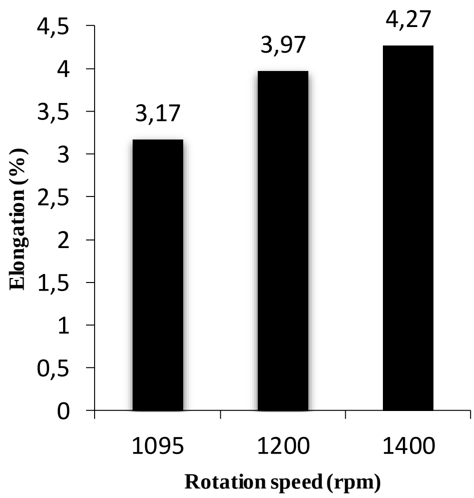
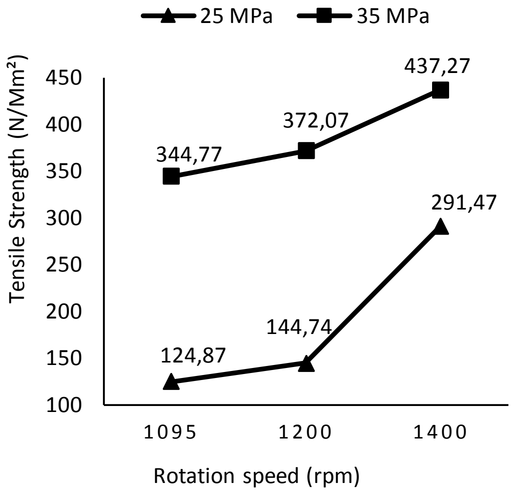
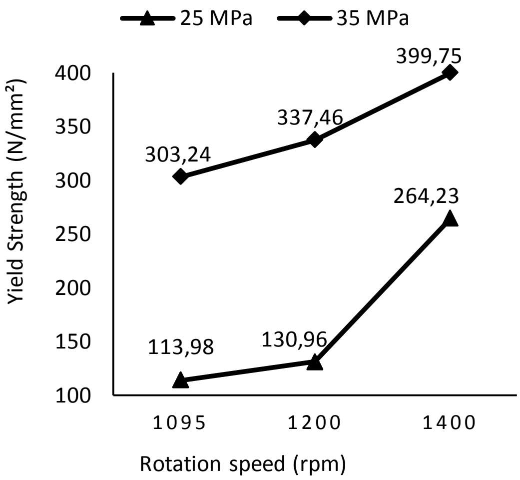


(c)

Figure 7. Mechanical properties UTS result of weldments under forging pressure 35 MPa. (a) Tensile Strength, (b) Yield Strength, (c) Elongation



(a)



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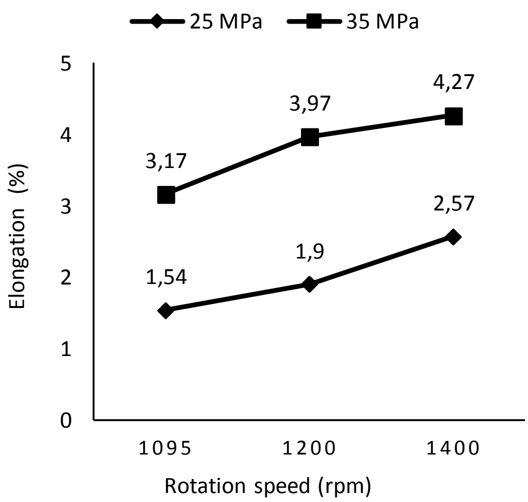

(c)

Figure 8. Comparasion mechanical properties of weldments under forging pressure 25 MPa and 35 MPa. (a) Tensile Strength, (b) Yield Strength, (c) Elongation

The top tensile strength value of the weldments under forging pressure 25 MPa were determined at 291 N/mm^2 (rotation speed 1400 rpm), and the lowest tensile strength value of the weldments under forging pressure 25 MPa were determined at 124,87 N/mm^2 (rotation speed 1095 rpm). Thereafter, the tensile strength value of the weldments under forging pressure 25 MPa were determined at 144,74 N/mm^2 at rotation speed 1200 rpm. The top tensile strength value of the weldments under forging pressure 35 MPa were determined at 437,27 N/mm^2 (rotation speed 1400 rpm), and the lowest tensile strength value of the weldments under forging pressure 35 MPa were determined at 344,77 N/mm^2 (rotation speed 1095 rpm). Thereafter, the tensile strength value of the weldments under forging pressure 35 MPa were determined at 372,07 N/mm^2 at rotation speed 1200 rpm.

The top yield strength value of the weldments under forging pressure 25 MPa were determined at 264,23 N/mm^2 (rotation speed 1400 rpm), and the lowest yield strength value of the weldments under forging pressure 25 MPa were determined at 113,98 N/mm^2 (rotation speed 1095 rpm). Thereafter, the yield strength value of the weldments under forging pressure 25 MPa were determined at 130,96 N/mm^2 at rotation speed 1200 rpm. The top yield strength value of the weldments under forging pressure 35 MPa were determined at 399,75 N/mm^2 (rotation speed 1400 rpm), and the lowest yield strength value of the weldments under forging pressure 35 MPa were determined at 303,24 N/mm^2 (rotation speed 1095 rpm). Thereafter, the yield strength value of the weldments under forging pressure 35 MPa were determined at 337,46 N/mm^2 at rotation speed 1200 rpm.

The maximum elongation of the weldments under forging pressure 25 MPa were determined at 2,57 % (rotation speed 1400 rpm), and the minimum elongation of the weldments under forging pressure 25 MPa were determined at 1,54 % (rotation speed 1095 rpm). Thereafter, the elongation of the weldments under forging pressure 25 MPa were determined at 1,9 % at rotation speed 1200 rpm. The maximum elongation of the weldments under forging pressure 35 MPa were determined at 4,27 % (rotation speed 1400 rpm), and the minimum elongation of the weldments under forging pressure 35 MPa were determined at 3,17 % (rotation speed 1095 rpm). Thereafter, the elongation of the weldments under forging pressure 35 MPa were determined at 3,97 % at rotation speed 1200 rpm.

On the overal, the best material properties of the weldments under pressure 35 MPa and rotation speed 1400 rpm, with maximum value of tensile strength 437,27 N/mm^2, maximum yield strength 399,75, and maximum elongation 4,27 %.

Conclusion

Friction welding has been successfully employed to weld mild steels. Strength of the joints also obtained was good. With the increase in forging pressure and rotation speed, the tensile strength increases. The maximum available tensile strength which was 437,27 N/mm^2, was available at pressure forging 35 MPa and rotation speed 1400 rpm.

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