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Performance Analysis of Flywheel Addition on Drive System of Rotary Friction Welding Machine

Yohanes [a*], Erikson Siregar [b], Anita Susilawati [a*] and Muftil Badri [c*]

[a)] *Laboratory of Production Technology, Department of Mechanical Engineering, Faculty of Engineering, Universitas Riau, Indonesia*
[b)] *Student of Department of Mechanical Engineering, Faculty of Engineering, Universitas Riau, Indonesia*
[c)] *Laboratory of Material Testing, Department of Mechanical Engineering, Faculty of Engineering, Universitas Riau, Indonesia*

*Corresponding author: yohanes_tmesin@yahoo.com, anitasusilawati@yahoo.com, muftilbadri@yahoo.com

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ABSTRACT

Friction welding is a solid-state welding without the use of filler metal by using pressure method where by two workpieces to be connected. It is placed in contact and regulated relative motion in pressure, so that on the contact surface being heat (close to the metal liquid point), which form the metal connection. A friction welding machine in the laboratory of technology production of the University of Riau has some disadvantages, namely the electric motor as a driver head stock stems that are often damaged due to overheating such as excessive during welding. Thus was interfering with the welding process due to damage to the electric motor. Therefore, this paper purpose is carried out the development of friction welding tool by using flywheel. The Flywheel stores energy during high engine speed, and passes it during low engine speeds to produce a steady turn. In this study used three flywheels with a diameter of 250 mm, which each thick of 10 mm, 20 mm and 30 mm. From the test is obtained the value of the average tensile strength on each flywheel that is 522.736 MPa, 510.648 MPa and 531.79 Mpa.

KEY WORDS: *Friction Welding, Flywheel, Tensile Test.*

NOMENCLATURE

σ	= Tensile strength (MPa)
F	= Maximum load at test time (N)
A_o	= Area of initial cross-section (mm^2)
l	= Extension (mm)
l_o	= Initial length (mm)
E	= Modulus of elasticity (N / mm^2)
σ	= Tensile strength (N / mm^2)
ε	= Strain (%)

1.0 INTRODUCTION

Friction welding includes solid state welding type, which the welding process is performed on solid phase. Heat welding is obtained from the direct conversion of mechanical energy into thermal energy through friction. It does not require a source of heat from electricity or combustion. The heat is generated from the inter-surface friction process that being increased the temperature of the object in the axial direction with a relatively very short distance. Connection occurs when surfaces reaching the temperatures below liquid temperatures. Welding occurs due to the effect of pressure on plastic metal mixing and diffusion mechanisms (Tiwan dan A. Ardian, 2005).

Based on observation and previous research at rotary friction welding machine in Laboratory of Production Technology, Department of Mechanical Engineering University of Riau, that was a final project by Khan, M.A. dan. R. Alhadi. 2014 and redesigned by Ricky, Yohanes, M. Badri 2016, it has some deficiencies so that the welding process is not optimal. It can be seen and verified to the field by running the rotary friction welding machine.

Based on investigation on their rotary friction welding machine was occurred a damaging on the electric motor twice due to excessive load when the welding process, then there was a peak load on the electric motor when given forging pressure, so that interfered with the welding process activities. Some causes of the damage electric motors were the overload, single phasing, bearing problem, problem in rotor, life time and others. The greatest cause of motor damage was cannot reach its intended lifetime that was the over-heating or excessive heat. One of the causes of over-heating is the load condition: misalignment coupling, overload load, abnormal load (Sudirman, A. et al 2009).

To optimize the rotary friction welding machine, it is better to add components to the motor connections and connecting shaft which aim to minimize damage to the electric motor. Sub-sequence, it is necessary to add flywheel in order to reduce the shock load that can occurs in the electric motor of the rotary friction welding machine. The advantages of optimization of rotary friction welding machine is to minimize damage for the motor, also it aims to get a more stable engine rotation. Therefore, it is necessary to do a research on rotary rod welding machine with the addition of flywheel.

2.0 FUNDAMENTAL THEORY

Friction welding includes solid state welding type, which the welding process is performed on solid phase. Heat welding is obtained from the direct conversion of mechanical energy into thermal energy through friction. It does not require a source of heat from electricity or combustion. Heat generated from the inter-surface friction process will increase the temperature of the object in the axial direction with a relatively very short distance. The connection occurs when the surface reaches a temperature below the liquid temperature. Welding occurs due to the effect of pressure on plastic metal mixing and diffusion mechanism.

Phenomenon of friction welding process is from heat generator through friction and abrasion. Further heat generated is stored in the material that is connected to raise the temperature. At certain temperatures the material is in perfect plastic properties and the press will be easily deformed and occurrence of chemical diffusion the process of grafting on metal surfaces that are connected (Tiwan and Ardian, 2005).

The success of friction welding is influenced by five factors, which are related to material properties and working conditions. The five factors are:

- Relative velocity between surfaces.
- Pressure imposed.
- Temperature formed on the surface.
- Bulk properties of the material.
- Surface conditions and the presence of a thin layer on the surface.

Some of the advantages of this friction welding are material savings, requiring fast time for connecting the same or different materials. Friction welding can also connect caterpillar material or not round. Whilst, the important process parameters are friction time, friction pressure, wrought time, wrought pressure and rotational speed (Yohanes et al, 2016).

2.1 Types of Friction Welding

Friction welds are divided into three types of processes:

1. Rotary Friction Welding (RFW), in this friction welding specimen is cylindrical, one of the specimen's moves rotation and the other is silent, and then is subjected to axial load, as shown in Figure 1.
2. Linear Friction Welding (LFW), this welding difference by welding rotary friction welding is, in this welding heat is generated from the linear motion of one workpiece against another workpiece, as shown in Figure 2.

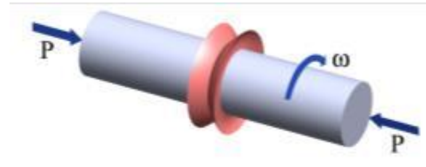

Figure 1: Rotary Friction Welding (RFW), (Li, et al, 2012)

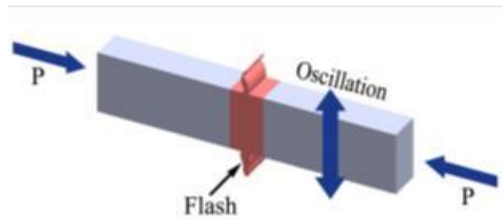

Figure 2: Linear Friction Welding Process, (Li, et al, 2012)

3. Friction Stir Welding (FSW), in this welding the heat used to melt the working metal is produced from the friction between a rotating object (pin) with a stationary object (workpiece), a sheet-shaped workpiece. The pin is rotated at a constant speed touched onto the gripped plate.

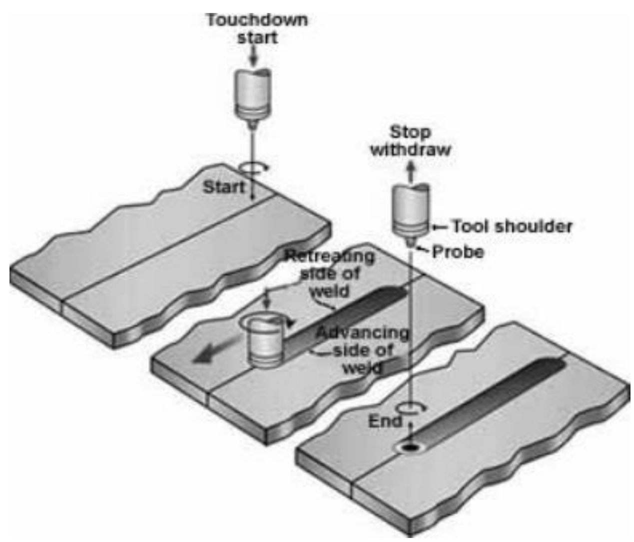

Figure 3: Friction Stir Welding Process (Narashima et al, 2011 in Khan, M.A. dan. R. Alhadi. 2014.)

2.2 Flywheel

The flywheel or commonly called the flywheel is a component of a machine capable of storing kinetic energy from the crankshaft rotation motion and aims to produce a stable engine rotation. Flywheel serves as an energy storage store, which stores energy as supply exceeds demand and releases it when supply is smaller than needs which is also useful as a control of the occurrence of a speed fluctuation and able to make the crankshaft rotate

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continuously and the engine can be operated with smooth (Rachmawan et al, 2014).

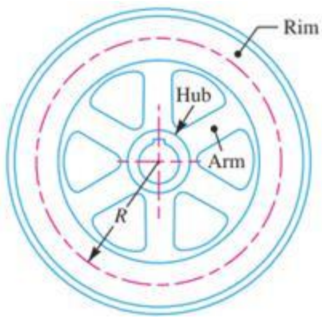


Figure 4: Flywheel (Khurmi, R.S. and J.K. Gupta. 2005)

2.3 Tensile Test

Tensile Test is one of the mechanical tests performed on a material by applying a tensile load to the material. So, that will be obtained the mechanical properties of the material. The experimental tool for this tensile test should have a strong grip. The curve in Figure 5 shows the relationship between the pulling force and the length change.

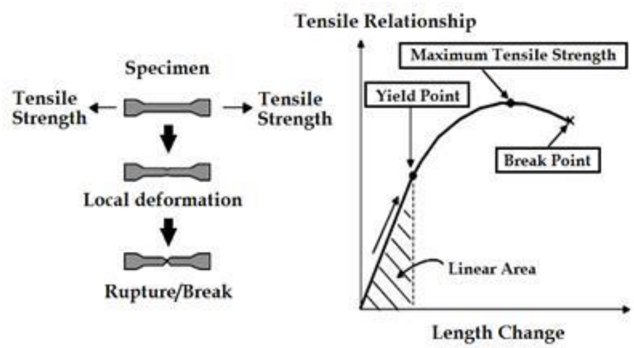


Figure 5: Curve of Tensile Relationship with Length Change (Rahayu, 2012).

Tensile tests performed on a material can provide a relatively complete explanation of the material's behavior to mechanical loading. The information is obtained in the tensile strength testing, which is continuously given and gradually increased, along with the observation of the extension experienced by the specimen. Then the voltage and strain curves can be generated.

The ultimate tensile strength is the maximum stress that the material can bear before the fracture. The maximum tensile strength value of σ uts is determined from the maximized Fmax load divided by the Ao cross-sectional area, as is shown in equation (1).

$$\sigma_{uts} = \frac{F_{maks}}{Ao} \quad (1)$$

3.0 METODOLOGY

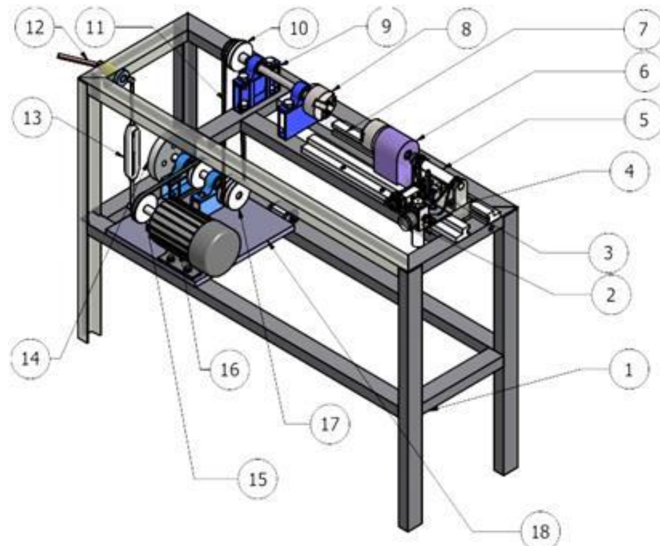
3.1 Research Tools

The equipment used in this research is:

a. Rotary friction welding Machine
b. Compressors
c. Flywheel
d. Arduino Uno
e. Computer
f. Steel Mild Steel

3.2 Concept of Rotary Engine Design

The design of rotary friction welding machine is shown in Figure 6.



Captions:

No	Part name	No	Part name
1	Tale	10	Upper Pulley
2	Pneumatic screen	11	V-Belt
3	Pneumatic position lock	12	Holder Belt
4	Pneumatic position	13	Iron holder Belt
5	Pneumatics	14	Flywheel
6	Tail Stock withChuck	15	Pulley
7	Rail Tail Stock	16	Motors
8	Chuck and transmission shaft	17	Big Pulley
9	Bearing stances and Bearing	18	Position of drive Motor

Figure 6: Rotary Fiction Welding Machine Design.

3.3 Flywheel Design

Flywheel is designed to be able to reduce the shock load that occurs on the electric motor rotary welding machine. Optimization of rotary welding machine is in addition the flywheel to minimize motor damage and to get a more stable engine rotation. In this study used three flywheels to determine the effect of adding each flywheel to the welding results.

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Dimensions of flywheel used:

- Flywheel 1: Diameter: 250 mm, Thickness: 10 mm

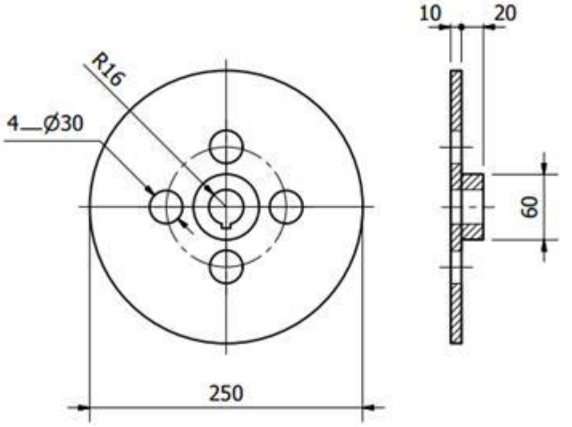

Figure 7: Flywheel 1

- Flywheel 2: Diameter: 250 mm, Thickness: 20 mm

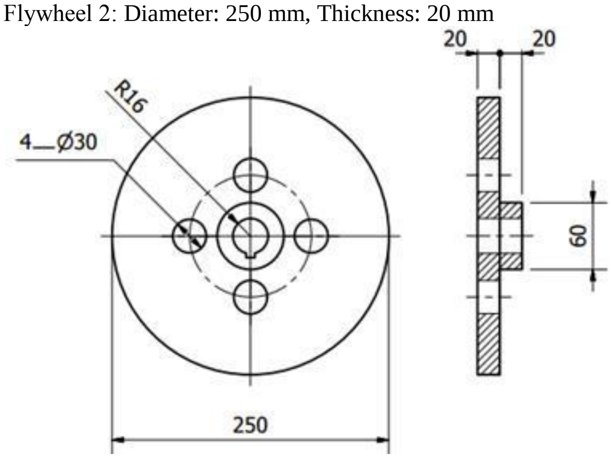

Figure 8: Flywheel 2

- Flywheel 3: Diameter: 250 mm, Thickness: 30 mm

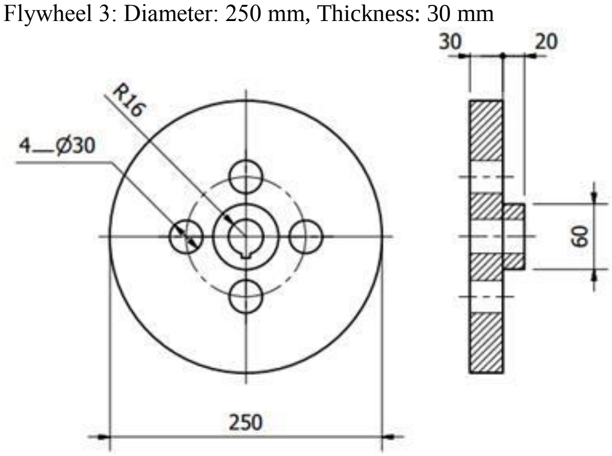

Figure 9: Flywheel 3

3.4 Testing

The test was performed by using flywheel 1, flywheel 2 and flywheel 3. Each flywheel was tested five times, which t using the mild steel material diameter of 8 mm by following some testing procedures. Data was taken at 4 bars of frictional pressure and forging pressure of 6 bars. In term of the preliminary data was obtained values of rotation of frictional pressure, rotation at wrought pressure, wrought time, time required flywheel stop when electric motor being off, time of welding specimen heat reduction and specimen length change.

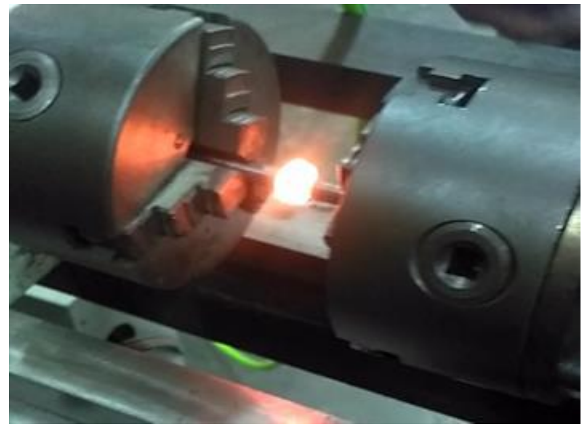

Figure 10: Testing Process

4.0 RESULT AND DISUSSION

4.1 Test Result

Graph of the average data of performance of the electric motor during the test is depicted in Figure 11.

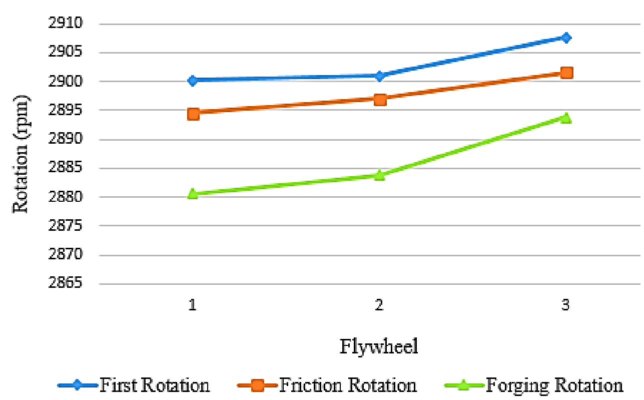

Figure 11: Graph of Average Motor Rotation

It can be seen in Figure 11, the initial rotation value of the electric motor at the time of testing with the highest average initial rotation value at flywheel 3 that was 2,907.6 rpm and the lowest on flywheel 1 of 2,900.2 rpm, For the highest average value of rotation when the highest friction was obtained at flywheel 3 with value of 2902 rpm and the lowest on flywheel 1 of 2895 rpm. The average motor rotation during the forging process was obtained the highest average rotation value on flywheel 3 that was 2,893.8 rpm and the lowest at flywheel 1 of 2,880.6 rpm. Figure 12 is a graph of friction time data on pneumatic pressure for 4 bars during testing.

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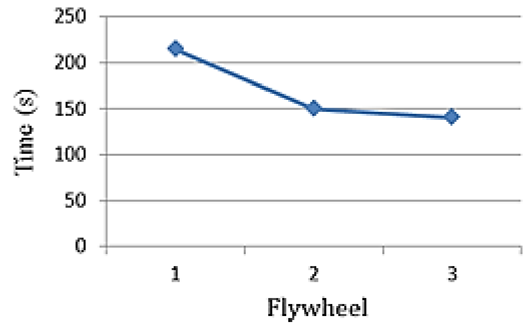

Figure 12: Graph of Average Friction Time

Figure 12 is depicted the fastest friction time on flywheel 3 with duration of 141 seconds friction and the average time of the longest friction on flywheel 1 that is 215 seconds. Then, Figure 13 is shown the graph of flywheel for time data stops after the electric motor is turned off.

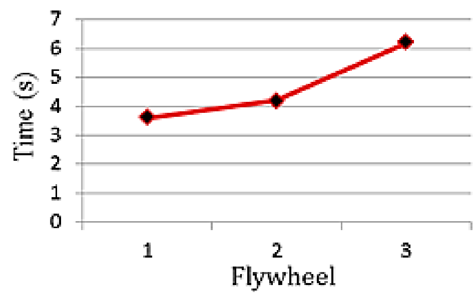

Figure 13: Graph of Stop Time of Flywheel

From the average flywheel stop graphs were obtained the flywheel 3 has a longer stop time of 6.2 seconds while the flywheel 1 was a fastest one with time of 3.6 seconds. Figure 14 is shown the graph of average data changes in length of specimen after welding on each flywheel.

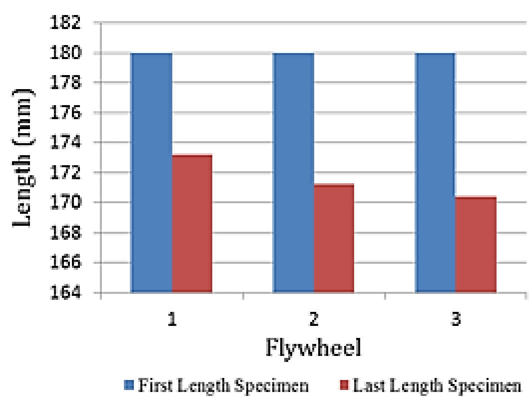

Figure 14: Graph of Change of Length Specimen

Figure 14 is depicted the graph of the initial specimen obtained for each flywheel of 180 mm. The welding is done each specimen that has a length change and the flywheel 3 has the most reduction in length, which is 9.6mm while the flywheel 1 with the reduction of the lowest length of 6.8 mm.

4.2 Test Result Pull Test

Figure 15 is shown graph of data of tensile test results from three flywheels, which each of them has five specimens.

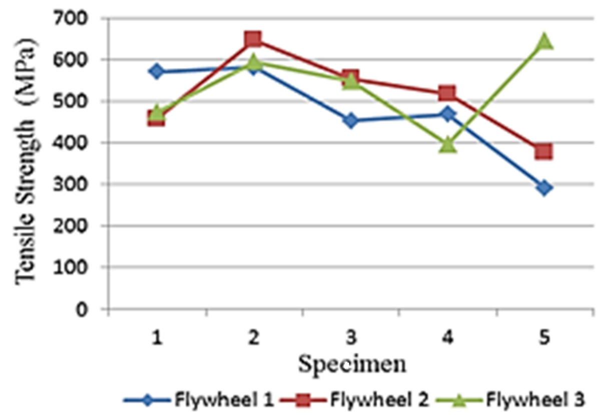

Figure 15: Graph of Tensile Strength

Figure 15 is shown the tensile strength graph, which obtained the lowest maximum tensile strength in specimen 5 for flywheel 1 of 291.13 MPa. The highest maximum tensile strength value was obtained on specimen 2 at the flywheel 2 with value of 647.07 MPa.

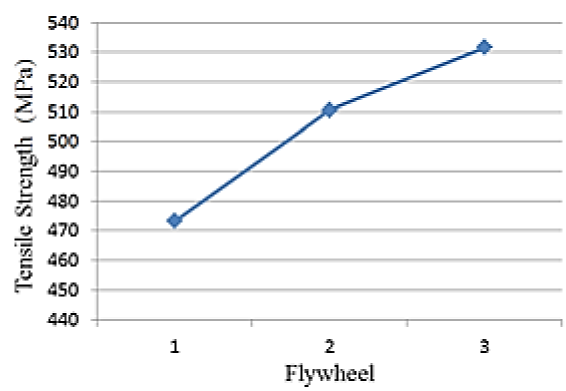

Figure 16: Graph of Average Tensile Strength

From the average graph of tensile strength (Figure 16) is known the lowest average maximum tensile strength value on flywheel 1 with a value of 473.112 MPa while the highest average maximum tensile strength is obtained at flywheel 3 with a value of 531.79 MPa.

5.0 CONCLUSION

This paper is investigated the performance of flywheel addition on drive system of rotary friction welding machine. Based development of the flywheel design and result of testing can be concluded the flywheel 3 has an average maximum tensile strength of 531.79 MPa, flywheel 2 with value of 510.648 MPa and flywheel 1 value of 473.112 MPa. From the test was obtained the flywheel 3 that has the values of the initial round, friction rotation, forging round, time friction, flywheel stop time were better than the flywheel 1 and flywheel 2. Therefore, from the test results were obtained the dimension and mass of the flywheel affect the process and welding outcome.

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REFERENCE

1. Khan, M.A. dan. R. Alhadi. 2014. *Perancangan dan Pembuatan Mesin Las Gesek Rotari*. Tugas Akhir. Fakultas Teknik Universitas Riau, Pekanbaru.
2. Khurmi, R.S. and J.K. Gupta. 2005. *A Textbook of Machine Design. Ed. 2*. Eurasia Publishing House (PVT) Ltd. Ram Nagar, New Delhi, India.
3. Li, W, S. Shi, F. Wan, Z. Zhang, T. Ma. and J. Li. 2012. *Numerical Simulation of Friction Welding Processes Based on ABAQUS Environment*. Journal Of Engineering Science And Technology. 5 (3):10-19.
4. Rachmawan, A.D, I.M. Ariana. dan I. Gerianto. 2014. *Analisa Pengaruh Flywheel dan Firing Order Terhadap Proses Kerja Mesin Diesel*. Jurnal Teknik Sistem Perkapalan Vol.1, No.1, 1-6. Institut Teknologi Sepuluh Nopember.
5. Rahayu, D. 2012. *Analisis Proses Friction Stir Welding (FSW) Pada Plat Tipis Aluminium*. Skripsi. Fakultas Teknik Universitas Indonesia, Depok.
6. Ricky, Yohanes, M. Badri 2016. *Redesign Alat Las Gesek Rotari Dengan Pendekatan Fault Tree Analysis (FTA) dan Design or Manufacture and Assembly (DFMA)*. JOM Fteknik Universitas Riau Volume 3 No.2.
7. Sudirman, A, A. Saepuloh dan Teguh. 2009. *Kajian Penyebab Kerusakan Motor Katup KLA23 AA01 pada Sistem VentilasiI RSG-GAS*. Seminar Nasional V SDM Teknologi Nuklir, ISSN 1978-0176. 5 November 2009, Yogyakarta, Indonesia.
8. Tiwan dan A. Ardian. 2005. *Penyambungan Baja AISI 1040 Batang Silinder Pejal dengan Friction Welding*. Laporan Penelitian. Universitas Negeri Yogyakarta.
9. Yohanes, P. Partomuan dan Sunaryo. 2016. *Pengaruh Bentuk Permukaan Forging Sambungan Las Gesek Rotary Terhadap Kekuatan Tarik Baja Mild steel*. Jurnal Simposium Nasional Teknologi Terapan. 4:509-517.