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Analysis Surface Fatigue Fracture On The Material Steel Astm A – 36

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Abstract:
The development of the construction sector in the industrial world regarding the need for technical materials is increasing rapidly, this can be seen by the increasing demand for technical materials which are classified as having higher quality, for example; in terms of capabilities (mechanical properties), the price is cheaper and widely sold on the market. In developing technology and processes such as; The fields of construction, production or manufacturing are closely related to the mechanical properties of a material, especially in the field of materials engineering, which is becoming increasingly difficult to meet with existing materials. In general, construction, including machine buildings, whether static (still) or dynamic (moving), in its operation always experiences dynamic loads, dynamic loads can be caused by factors that are difficult to avoid, such as gusts of wind, sea waves, uneven surfaces and so on. The cause of fatigue is the presence of cracks that originate in areas where the stress concentration is high. These areas include: indentations, holes in the material, rough surfaces, and cavities both inside and on the surface of the material. So, the occurrence of fatigue is a crack that continues to grow in length until the component no longer has the tolerance for higher stresses and strains, and finally a sudden static fracture occurs. The length of this crack will continue to increase due to continuous dynamic loading. In this research, fatigue testing using the repeated bending method was carried out, after testing the specimen, the fracture surface was analyzed using visual observation to see the macro structure and a scanning electron microscope test was carried out to see the structure. the micro

Key Word: *Analysis; Fatigue; Steel; ASTM A – 36; SEM*

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I. Introduction

The development of the construction sector in the industrial world regarding the need for engineering materials is increasing rapidly, this can be seen by the increasing demand for engineering materials which are classified as having higher quality, for example; in terms of capabilities (mechanical properties), the price is cheaper and widely sold on the market. In developing technology and processes such as; The fields of construction, production or manufacturing are closely related to the mechanical properties of a material, especially in the field of materials engineering, which is becoming increasingly difficult to meet with existing materials. In general, construction, including machine buildings, whether static (still) or dynamic (moving), in its operation always experiences dynamic loads, dynamic loads can be caused by factors that are difficult to avoid, such as gusts of wind, sea waves, uneven surfaces and so on. This dynamic loading causes damage to the material.

Damage due to dynamic loads is better understood as a material fatigue factor because the stress generated by dynamic loads is greater than the fatigue limit stress of the material. To avoid undetected accidents and greater losses, it is necessary to construct the fatigue factor.

Cracks are one of the factors that cause failure in a material. So it is an obligation for the industry to know the crack propagation mechanism to avoid losses. The resistance of materials to loads certainly varies, therefore the industry needs to classify the materials used, to increase the lifetime of a material in order to increase the effectiveness of using the material. Cracks are caused by two types of loads, namely static and dynamic loads.

II. Material And Methods

Loadings on a construction are generally in the form of static loads or dynamic loads. Static load is a loading system on a component with a constant load, while the load on a component with a load changes from maximum load to minimum load continuously. This changing load is often called fluctuating load. Under the same stress conditions, structural components that experience dynamic loading will have a shorter service life limit compared to components that experience static loading, because the component appears to be subjected to a sudden shock load. After several dynamic loading cycles, the component will fail (break). Fractures that occur due to repeated loads are called fatigue or fatigue fractures (Diharjo K, 1996). The cause of fatigue is the presence of cracks that originate in areas where the stress concentration is high. These areas include: indentations, holes in the material, rough surfaces, and cavities both inside and on the surface of the material.

So, the occurrence of fatigue is a crack that continues to grow in length until the component no longer has the tolerance for higher stresses and strains, and finally a sudden static fracture occurs. The length of this crack will continue to increase due to continuous dynamic loading. The greater the dynamic loading amplitude, the faster the crack propagates (Diharjo K, 1996). Damage due to repeated loads is called fatigue failures because these fractures generally occur after a fairly long period of use. Fatigue or fatigue according to (Sugiarto et al, 2013), is defined as a process of progressive localized permanent structural change in conditions that produce fluctuations in strain and stress below its tensile strength and at one point or many points which can culminate in a crack or fracture.) as a whole after certain fluctuations

Progressive means that the fatigue process occurs over a certain period of time or during use, since the component or structure is used. Localized means that the fatigue process operates in a local area that has high stress and strain due to the influence of external loads, changes in geometry, temperature differences, residual stresses and non-perfection.

According to (William D. Callister and Rethwisch, 2007) the stress applied can be axial (tension and compression tests), flexural, or torsional. In general, three different types of time-fluctuating voltages are possible. It is represented schematically by regular and sinusoidal time dependencies in Figure 1

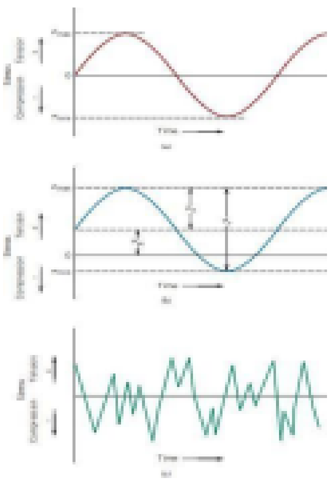

Figure 1 Voltage Variations (Callister and Rethwisch, 2008)

Baja Karbon

Carbon steel is an alloy steel that contains carbon elements with a small addition of alloying elements. The addition of these alloying elements aims to increase the strength of the steel without reducing its ductility. Carbon steel contains carbon elements between 0.1% – 1.7%. (Yuspian et al, 2017). Based on the carbon content it contains, carbon steel is classified as follows:

1. Low Carbon Steel, namely steel containing less than 0.3% carbon. In industry, low carbon steel is used to make plates, pipes, machine work, and so on.
2. Medium Carbon Steel, namely steel containing carbon between 0.3% – 0.6%. Medium carbon steel is usually used as tools, gears, crankshafts, and so on.
3. High Carbon Steel, namely steel containing carbon between 0.6% – 1.5%. This steel is usually used for construction tools that are associated with high temperatures, such as anvils, drills, ball bearings, and so on.

According to (Bambang Pratowo et al, 2019), the influence of alloying elements on the properties of carbon steel is as follows:

1. Carbon Element (C): increases heat resistance, toughness, hardness and friction. 2. Silicon element (Si): increases heat resistance and improves elasticity properties. 3. Phosphorus (P): can improve friction resistance properties.
4. Sulfur element (S): can improve scratch resistance properties.
5. Chromium element (Cr): can increase tensile strength, plasticity, wear, and improve resistance to heat and hardness.
6. Manganese element (Mn): improves properties against wear, increases hardness, strength and ductility. 7. Molybden element (Mo): increases the properties of heat resistance and hardness. 8. Tungsten element (W): forms a hard carbide, high temperature resistance, widely used in tool steel and fast cutting steel.
9. Cobalt (Co) element: improves wear and hardness properties.

ASTM A-36 Steel

ASTM A-36 steel is carbon steel which is included in low carbon steel. This type of carbon steel is often used in structural applications such as construction, ships, pressure vessels, etc. ASTM A-36 steel is generally also referred to as mild steel plate. The requirements for ASTM A-36 steel composition and mechanical properties are shown in tables 1 and 2.

Table 1. ASTM SA-36 Steel Chemical Composition Requirements (ASTM A-36, 2004)

Composition (%)				**Plate Thickness (mm)**		
		≤ 20	20-40	40-65	65-100	>100
Carbon Max	(C),	0.25	0.25	0.26	0.27	0.29
Mangan (Mn),				0.18-1.20	0.08-1.20	0.08-1.20
Fosfor Max	(P),	0.04	0.04	0.04	0.04	0.04
Sulfur Max	(S),	0.05	0.05	0.05	0.05	0.05
Silicon (Si),		0.40 Max	0.40 max	0.15-0.40	0.15-0. 40	0.15-0.40
Copper (Cu),		0.20	0.20	0.20	0.20	0.20

Table 2. Mechanical Properties ASTM A-36 (ASTM A-36, 2004)

Mechanical Properties	**Value**
***Ultimate Strength* (Mpa)** ***Yield Strength* (Mpa)**	400-500 250
***Elongation*, min (%)**	23

Test Method

In preparing the thesis, the research used the following testing methods:

Fatigue Testing Repeated Bending Method

Fatigue testing aims to obtain the fatigue resistance value of ASTM A-36 steel. This test was carried out at the Mechanical Engineering Materials Laboratory, Department of Mechanical Engineering, Sriwijaya University with the JIS Z 2202 testing standard using the Torsion and Bending Fatigue Machine shown in Figure 2.

Figure 2. Repeated Torsion and Bending Fatigue Testing Machine

Visual Observation

Visual observations of ASTM A-36 steel will be carried out by observing specimens that have been tested for fatigue. This aims to determine the type of fracture and crack propagation on the surface of the specimen which is marked by the presence of Beachmarks. When testing the fatigue test specimens, room temperature is used

Metallographic Examination

Metallographic testing was carried out to determine the microstructure of ASTM A-36 steel plate, which was carried out at the UPT Integrated Laboratory and Technology Innovation Center - Lampung University, Bandar Lampung City. The steps for metallographic testing are as follows:

1. Prepare the specimen to be tested.
2. Sand some of the surface of the specimen to be tested until the existing fibers are visible.
3. Cut the specimen to size on the SEM photo testing machine.
4. Coating the surface of the specimen to be tested with gold (Au).
5. Place the specimens that are ready to be tested into the SEM photo testing machine.
6. Carry out testing.

Figure 3. Scanning Electron Microscope (SEM)

Test Scanning Electron Microscope

SEM is an electron microscope designed to observe and analyze the surface of materials directly. An instrument for analyzing the surface of a material. The SEM test was carried out at one of the campuses in Bandar Lampung, namely the University of Lampung. The sample taken is 1 sample for each concentration. The device used is the Zeiss EVO 10 I Scanning Electron Microscope (SEM). The results can be seen in Figure 4-2. 4-3 and 4-4 with 5000x . magnification

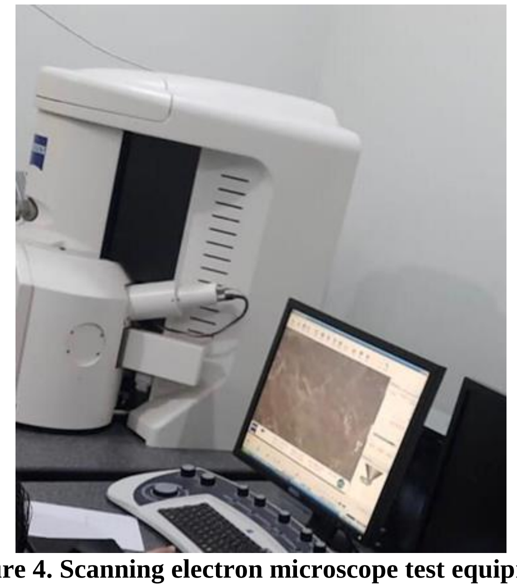

Figure 4. Scanning electron microscope test equipment

III. Result

Fatigue Test Result Data

Table 3. Fatigue Test Result Data

Sample	Deflection Angle	Fatigue Time (Seconds)
Sample 1	1°	2700
Sample 2	2°	1680
Sample 3	3°	600

Table 4. Fatigue Test Result Data ASTM A – 36 Steel

Angle	Time (detik)	Revs (rpm-rps)	Cycle	Stress (MPa)
1°	2700	3000-50	135000	7,84
2°	1680	3000-50	84000	15,69
3°	600	3000-50	30000	23,53

S-N Curve

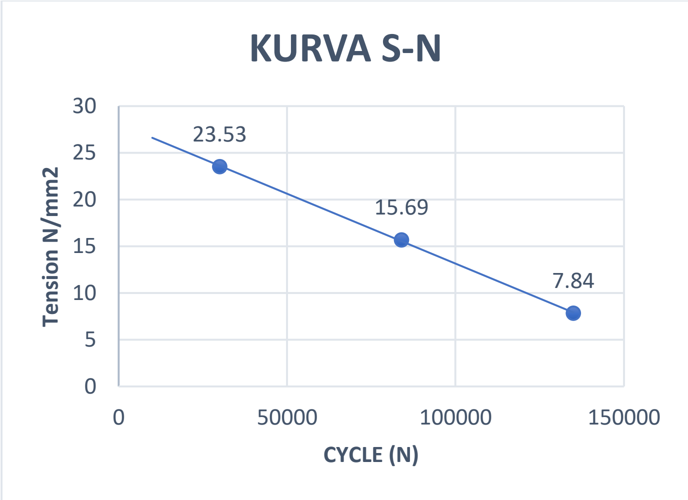

Figure 5. S-N Curve of ASTM A – 36 Specimen

Visual Observation of Fracture Surface Fatigue Testing

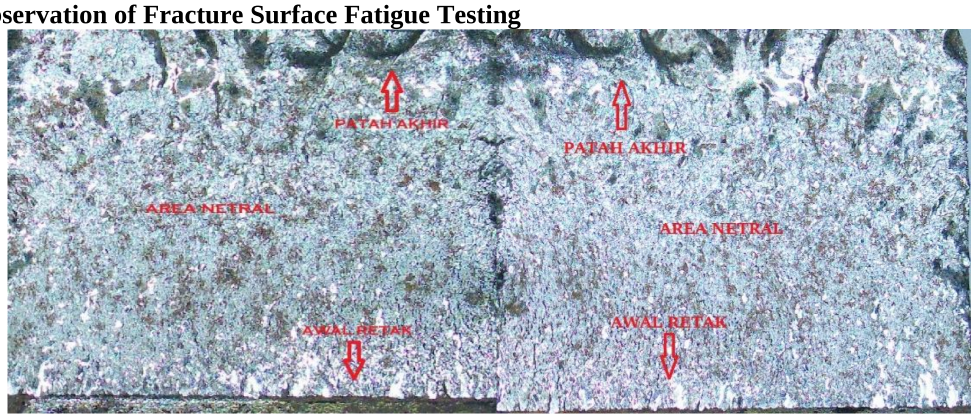

Figure 6. Macro observation results of the fracture surface of the test specimenfatigue with a loading angle of 1°

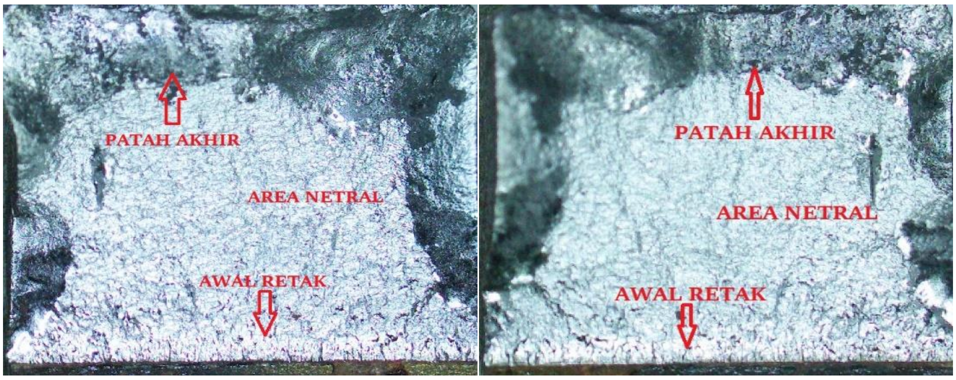

Figure 7. Macro observation results of the fracture surface of the test specimenfatigue with a loading angle of 2°

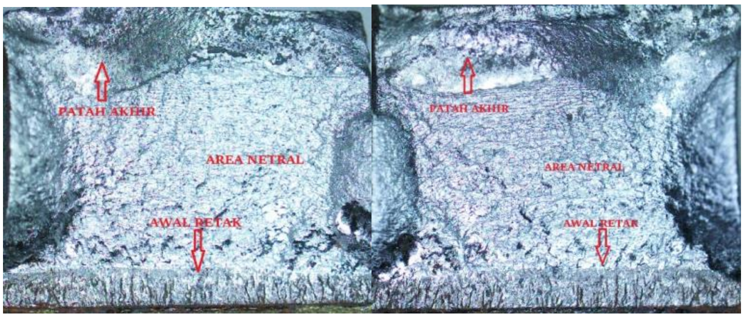

Figure 8. Macro observation results of the fracture surface of the test specimenfatigue with a loading angle of 3°

Metallography results onScanning Electron Microscope

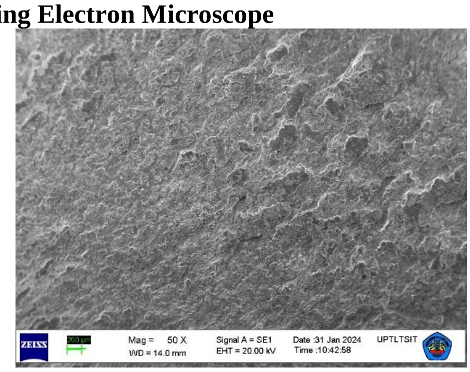

Figure 9. Test Results Scanning Electrin Microscope 50x magnification at initial crack on the specimen surface 1°

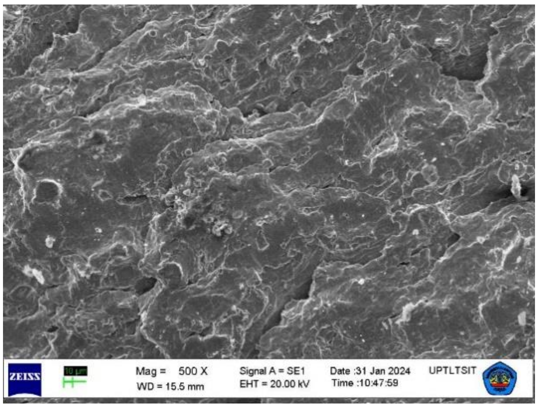

Figure 10. Test Results Scanning Electrin Microscope 500x magnification at initial crack on the specimen surface 1°

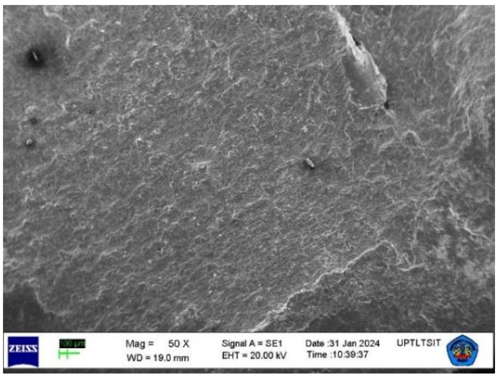

Figure 11. Test Results Scanning Electrin Microscope 50x magnification at initial crack on the specimen surface 2°

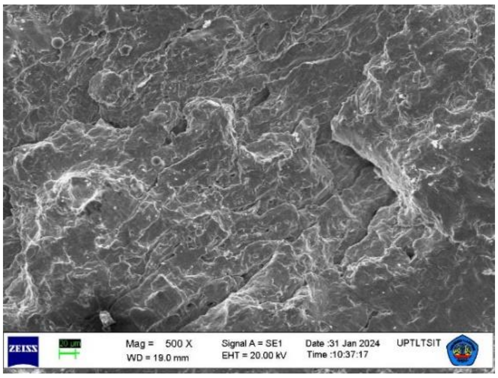

Figure 12. Test Results Scanning Electrin Microscope 500x magnification at initial crack on the specimen surface 2°

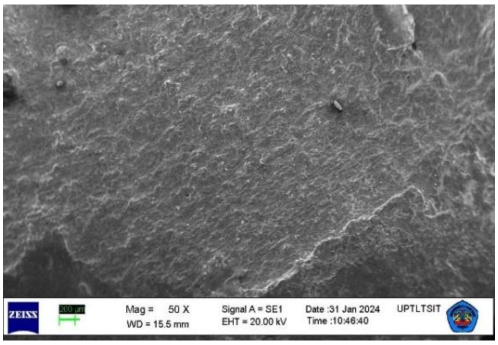

Figure 13. Test Results Scanning Electrin Microscope 50x magnification at initial crack on the specimen surface 3°

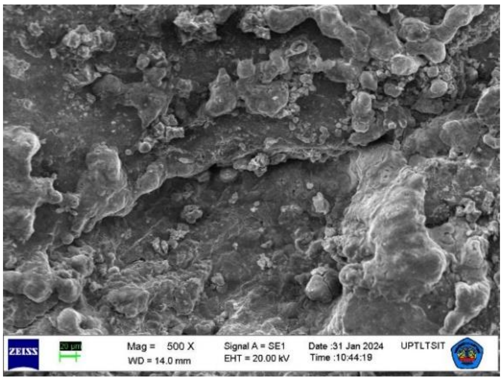

Figure 14. Test Results Scanning Electrin Microscope 500x magnification at initial crack on the specimen surface 3°

IV. Discussion

The results obtained from fatigue testing show that the greater the angular loading, the greater the cycle value obtained. This can be seen from the results of fatigue testing at a 1° angle loading which was fatigue broken within a time span of 45 minutes or 2700 seconds with a rotation speed of 3000 rpm which obtained a cycle of 135000 cycles and a stress of 7.84 MPa, whereas the specimen with a 2° angle which was broken fatigue in a time span of 28 minutes or 1680 seconds with a rotation speed of 3000 rpm getting a cycle of 84000 cycles and a stress of 15.69 MPa, and the lowest cycle value was found in a specimen with an angle of 3° which was fatigue broken in a time span of 10 minutes or 600 seconds with a speed of 3000 rpm rotation gets 30,000 cycles and a stress of 23.53 MPa.

From the results of macro observations on ASTM A – 36 steel specimens, the fracture patterns of the specimens at different angles of loading have different patterns. Starting from the beginning of the crack, the neutral area, and the final fracture. Differences occur at the beginning of the crack, the neutral area, and the final fracture where in the specimen with a loading angle of 1° the crack propagation area tends to be smaller than the final fracture area because at this loading the resulting cycle is the largest cycle. When compared with a specimen given an angle of 2°, the crack propagation area will be slightly smaller and the final fracture area will be slightly wider. So on at a loading angle of 3°. This is because at a greater angle the load and vibration received by the specimen will be greater which can cause the specimen to break more quickly.

V. Conclusion

Based on the research results of the tests and examinations carried out in this research, the following conclusions can be drawn:

1. The greater the angle of loading, the greater the resulting stress, while the resulting cycle will be smaller. It can be seen from the macro structure obtained, the pattern produced from each specimen has a different pattern.
2. After testing the ASTM A - 36 Steel specimen, the failure model that occurred was fatigue failure or the specimen experienced fatigue due to repeated dynamic load fluctuations, which was characterized by the presence of initial cracks, slow crack propagation and sudden fracture areas in the area. final fracture on scanning electron microscope observation.

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