Effect of Dynamic Imposition on Mechanical Properties

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Abstract

Bendig Rotary is one method applied to examine material. The aim of examination is to reveal the material ability, durability, capability and fatique due to dynamic loading. Therefore, we can identify what parameters affecting material property.

Optimal design on a component is very important. This is intended to avoid failure in operating conditions, because avoiding failure through excessive designs by using a large safety factor is a waste. Improper design is of course will cause premature failure.

The research is to apply an experimental method on a laboratory scale where the use of metal materials and alloys is certainly adapted to the condition of the material to be processed. The purpose of this research is to know the effect of loading time on tensile strength on some material types.

Keywords: Dynamic imposition, fatique strength, steel, brass, aluminum, material properties.

Introduction

Procurement of certain facilities and infrastructure, such as the presentation of the raw materials for a type of product in order to support the results of today's technology then needed raw materials adequate to serve the needs of various industries.

Fero and nonfero metals widely used in engineering should also consider other factors, ranging from manufacture factors, such as the ability to form, up to metallurgical factors which can be specified clearly (e.g. fatigue or wear resistance). Generally, the cause of failure in engineering components can be grouped into three sections:

1. Failure caused by wrong design or improper selection of materials
2. Failure due to incorrect processing
3. Failure due to wear and tear during usage

This study aims to determine the effect of loading on the tensile strength and to reveal the effect of loading time on the tensile strength.

Because of the many variables that influence the tensile strength of the author limits on several things, namely:

1. The material used is carbon steel, brass & aluminum.
2. Load 5 kg
3. Loading time are 4, 6 and 8 hours
4. Constant rotation
5. Testing rotary bending and tensile test

This study is expected to be useful in:

1. Industrial world as information in improving material quality
2. Information for academician in analyzing and comparing the effects of dynamic loading on medium carbon steel materials.

Literature Review

Metals are elements that have strong properties, clay, hard, brittle and conductor of electricity or heat. Because of these properties the metal is used by humans for various purposes so that life can not be separated from metal.

Mechanical Properties

The mechanical properties of the metal are rigidity and strength from pull loads, torsion, shear, pressure and scratch either on loading statically or dynamically at ordinary temperature or high temperature or temperatures below zero. While the physical properties of the metal are to have the density, melting point, specific heat, thermal conductivity, electrical resistance coefficients and electrical resistance.

Technological Properties

Technological properties of a material is defined as the ability of a material to be formed. These properties include weldability properties, capable of forging, capable of machine and the nature of the hot working or cold working.

Tensile Test

The test bar is a round rod, with large ends for the handler on a tensile test machine and in the middle of the trunk (smaller part) i.e., there is a measurement portion represented by two identifiers. L_O, length of the size of this area has a certain ratio, with the diameter of the test rod. As in the picture below:

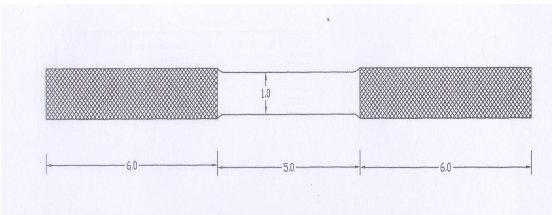


Figure 1 Tensile test specimens to standard DIN 50125

Test rod shape that is widely used in tensile testing is the ratio L_O/d_O = 5 or 10. For testing compilers the selected test is 10.

Aside from the size of the test bar mentioned above, there are still others. A rod that qualifies a fixed ratio called a proportional test rod. To carry out the tensile test, between two tug binding heads. By giving an increasingly large force will grow in length and grow smaller and eventually break up.

In order for the experiment to be comparable, the stress can be defined by the force of each unit area.

$$Stress = \frac{Force}{\text{The original cross-sectional area}}, \text{ or}$$

$$\sigma = \frac{F}{A_o} \qquad (\text{N/mm}^2)$$

Note that for the cross-sectional area the initial cross-sectional area is taken, the calculated stress is called the nominal stress. While strain is defined as an extension expressed in a percent.

To calculate the strain, the extension is divided by its original length and expressed in percent.

$$Strain = \frac{Extension}{Initial\ length} \times 100\ (\%)$$

$$\varepsilon = \frac{\Delta L}{L_O} = \frac{L_1 - L_O}{L_O} \times 100\ (\%)$$

In this experiment, the relationship between stress and strain can be illustrated in the diagram of stress-strain. This diagram is very important because it presents various properties of the material in question.

Elastic modulus

$$\text{Elastic modulus} = tg\,\alpha = \frac{\text{stress}}{\text{strain}}$$

$$E = tg\ \alpha = \frac{\sigma}{\varepsilon}$$

The magnitude of the angle α is a measure of elasticity. The elasticity modulus expressed in *E* which is equal to tg α (can be seen in this picture). In this case the extension expressed in percent.

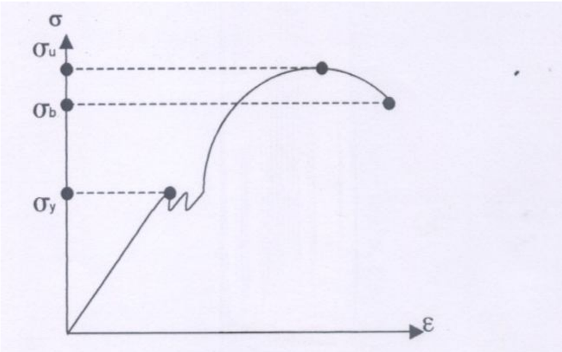


Figure 2 Stress-strain diagram

Yielding stress

$$\sigma_y = \frac{\text{yielding load}}{\text{initial cross-section}}$$

$$\sigma_y = \frac{P_y}{A_o}\ (\text{kgf/mm}^2)$$

Ultimate stress

$$\sigma_u = \frac{\text{Maksimum load}}{\text{initial cross-section}}$$

$$\sigma_u = \frac{P_u}{A_o}\ (\text{kgf/mm}^2)$$

Real tension when the rod broke we call fracture strength.

$$\text{Fracture strength} = \frac{\text{Force when rod broke}}{\text{Cross section when broke}}$$

$$\sigma_b = \frac{P_b}{A_o}\ (\text{kgf/mm}^2)$$

Strain Fracture

Extension rod on this experiment after dropping expressed as a percent of its original length and we call fracture strain

$$Strain = \frac{\text{Length after broke}}{\text{Initial length}} \times 100\ (\%)$$

$$\varepsilon \text{ or } A = \frac{L_u - L_O}{L_O} \times 100\ (\%)$$

This is equal to the number of permanent strain or the plastic strain.

Cross section reduction

Limited reduction of cross-sectional area after dropping is expressed in percentage of the original cross-sectional area. We call it *shearing*, *Z*.

$$Z = \frac{A_o - A_u}{A_O} \times 100\ (\%)$$

Metal fatique

Fatique failure is very dangerous, because it happened without any initial signs. Fatigue leads to fractures that look vulnerable, without deformation to the fracture. On a macroscopic scale, the fracture surface is usually known from the fracture shape, there is a subtle part due to friction occurring during crack propagation and coarse area. Fracture also occurs when the cross section can not accept the load. Often the development of cracks is characterized by a number of rings or beach marks, moving into the point where failure begins to occur.

There are three basic factors that are needed for fatique failure. These three things are:

1. The maximum tensile stress is high enough
2. Variations or large voltage fluctuations
3. The application cycle of the stress is large enough.

In addition, there are still a number of other variables, namely: stress concentrations, temperature corrosion, excess material, metallurgical structures, residual stress, and combination stress which tend to change fatigue conditions. Because it does not have a solid basic knowledge of the causes of fatigue in metals, it is necessary to discuss the above factors in terms of empirical. Because of the amount of data like this, there is only a possibility to illustrate the relationship of the above factors with fatigue.

Stress cycles

As a first step, a short definition of fluctuating stresses that may cause fatigue should be given.

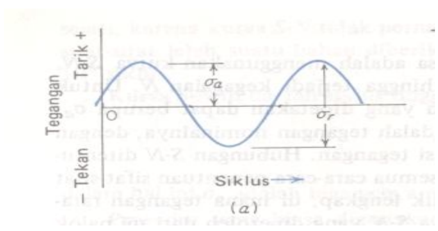


Figure 3 Fatique failure cycle

The picture above illustrates the types of stress cycles that can cause fatigue. Figure *a* illustrates a complete sinusoidal-shaped stress cycle. The image is the ideal state produced by the rotary beam machine. R.R. Moore is regarded as a spindle shaft with a constant speed with no more weights. For stress cycles, so the maximum and minimum stress are equal. Where the minimum stress is the lowest stress of algebra in a cycle. The tensile stress is considered positive, and the compressive stress is considered negative. Figure *b* illustrates a recurrent stress cycle with maximum stress σ_{max} and minimum stress σ_{min} are not equal. Both are tensile stresses.

RESEARCH METHODS

Tensile test specimen

Tensile test specimens were made according to Dutch Industrial Norm Standard (DIN 50125).

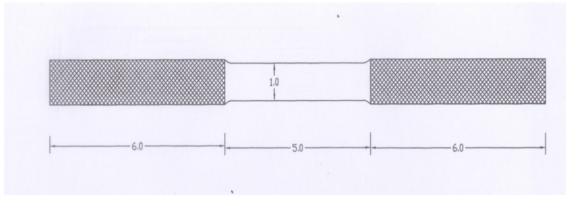


Figure 4 Tensile test specimen standard

Tensile test

Tensile test can be performed after rotary bending process with time variation. The purpose of tensile testing is to know the mechanical properties of steel, brass & aluminum.

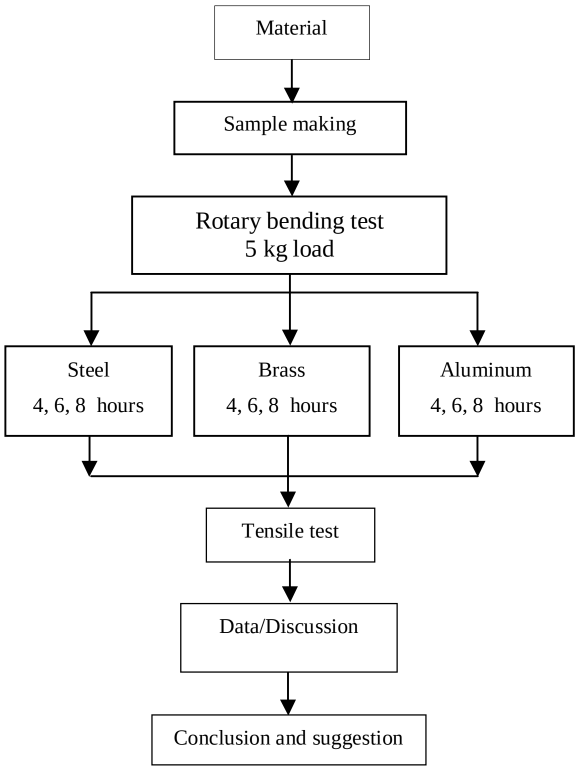


Figure 5 Flowchart of research

DATA ANALYSIS

Test data obtained from carbon steel material HQ 760, then processed and calculated on the basis of existing equations which can be further described as follows.

Rotary Bending Test

Prior to tensile testing, the first rotary bending test with the specified load and time is required. This test is conducted in order to provide a dynamic treatment or loading of the material. Data from the rotary bending test machine are as follows:

Motor power: 1 HP

Maximum spin (n): 1450 rpm

TENSILE TEST

Strength calculation

In calculating the strength of the material or the amount of stress that occurs due to withdrawal is used the following formula:

$$\sigma = \frac{P}{A}$$

where: P = Load (kgf)

A = The cross-sectional area burdened (mm^2).

In this case use $A = A_0$ = sectional area of the specimen as the cross-sectional area burdened.

$$\text{Yielding stress } (\sigma) = \frac{P_y}{A_0} \left[\frac{kg}{mm^2}\right]$$

$$\text{Maximum stress } (\sigma) = \frac{P_{\max}}{A_0} \left[\frac{kg}{mm^2}\right]$$

$$\text{Broken stress } (\sigma) = \frac{P_{patah}}{A_0} \left[\frac{kg}{mm^2}\right]$$

Example calculation for normal steel material.

$$\text{Strain } (\varepsilon) = \frac{\Delta L}{L_o} \times 100\,(\%)$$

$$= \frac{18.3}{50} \times 100\,(\%) = 36.59\%$$

Maximum pull stress (σ_m)

$$\sigma_m = \frac{P_{\max}}{A_0}$$

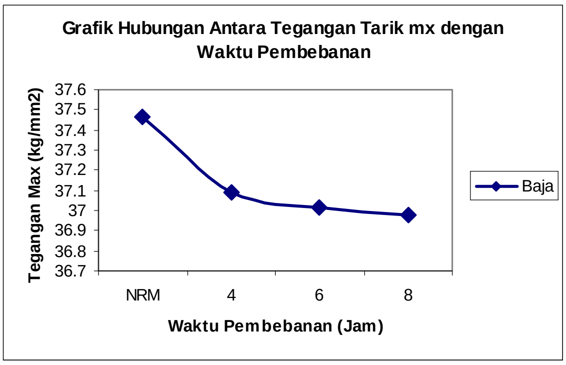
where: P_{max} = 2941.1316 kg

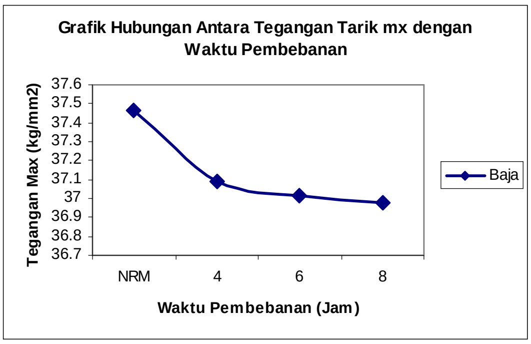
A_0 = 78.5 mm^2

$$\sigma_m = \frac{2941.1316 \text{ kg}}{78.5 \text{ mm}^2} = 37.47 \text{ kg/mm}^2$$

Table 4.1 Pull Test Result Data

NO	Force (kgf)	Distance (mm)	□m (kgf/mm²)	□ (%)	Note.
1	2941.1316	11.05317	37.4666	22.1063	Normal steel
2	2911.7203	18.1113	37.0920	36.2226	4 hours
3	2905.8380	18.0930	37.0170	36.1860	6 hours
4	2902.8969	18.0564	36.9796	36.1128	8 hours
5	95.3369	7.81770	1.2145	15.6354	Brass Normal
6	93.4302	7.4268	1.1902	14.8536	4 hours
7	91.5234	7.3486	1.1659	14.6972	6 hours
8	90.5701	7.6583	1.1538	15.3166	8 hours
9	33.0410	5.31120	0.4209	10.6224	Al Normal
10	33.0410	4.42600	0.4209	8.8520	4 hours
11	28.7476	4.20470	0.3662	8.4094	6 hours
12	26.4328	3.98340	0.3367	7.9668	8 hours





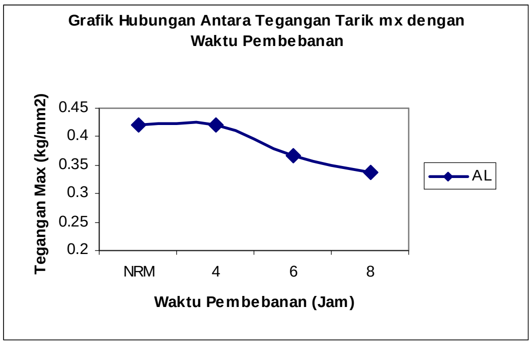


Figure 6 Relationship between stress and load time for (a) steel (b) brass and (c) aluminium

DISCUSSION

In general, from the results of the research, in this case the graph of the relationship between the maximum tensile stress and the loading time is seen a significant drop in tensile strength from normal conditions (without rotary bending test) compared to the material that has been loaded with rotary bending test for steel material HQ 760 and brass.

For 4 hours, the tensile strength decrease from normal condition is 0.3746 kg/mm^2, while the average decrease from 4 hours to 6 and 8 hours is 0.0562 kg/mm^2. However, the aluminum material from normal conditions to 4 hours, no change in tensile strength, while at the loading time of 4 to 8 hours, the average tensile strength decline of 0.421 kg/mm^2 decrease in tensile strength is very large due to the loading time. This occurs because of the long loading time that resulted in the material becomes tired resulting in a decrease in tensile strength.

Effect of loading time on maximum tensile strength

Based on the graphs, the effect of loading time on the maximum tensile strength for some material types is:

HQ760 Steel Material

The tensile strength under normal conditions of 37,6666 kg/mm^2 decreases to 37,0920 kg/mm^2 for a period of 6 hours. The tensile strength is relatively small at 37.0170, and for 8 hours the maximum tensile strength is 36.9796 kg/mm^2.

Material Brass

For brass material the decrease of tensile strength from normal condition up to 6 hours loading time is equal to 0.0243 kg/mm^2 and at 8 hours the drop strength is relatively small at 0.0121 kg/mm^2.

Aluminum Material

For aluminum material for normal condition and 4 hours loading time does not appear the change of tensile strength. Changes in tensile strength occur at 6 hours loading time. The tensile drop becomes 0.3662 kg/mm^2 and 8 hours down to 0.3362 kg/mm^2. The decrease in tensile strength of these three types of material is due to the deformation that occurs as a result of the loading given to the material.

CONCLUSION

From the results of research that has been done on various treatments on the material done with rotary bending treatment then continued with the test of tensile strength and based on the processing and discussion of the results of the research, the authors can draw the following conclusion:

1. As a result of the loading of the loading time of 4, 6 and 8 hours of the material, there will be a decrease in tensile strength and the magnitude of the drop in tensile strength depending on the amount of loading time given.
2. Of the three types of materials tested by steel, brass, and aluminum; aluminum

shows a very large drop in tensile strength.

5.2 SUGGESTIONS

1. This research can still be developed further because there are still many parameters that can be examined related to rotary bending testing process and tensile test.
2. The need for re-calibration of the rotary bending apparatus in order to condition the appliance in proper condition to ensure accuracy in the research results.

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