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Damage Analysis of Leaf Springs Dump Truck Hino Dutro 130 HD

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A R T I C L E I N F O

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A B S T R A C T

Leaf springs that have been used for a long time will experience a decrease in the quality of the mechanical properties due to the dynamic loads that occur on this component. A comparison of two leaf spring materials is carried out, this is expected to be a solution to increase the strength and toughness of the leaf springs that have been used, the strength and carrying capacity of the damp truck is 8 tons. Spring damage mechanical strength Tensile Strength of Indospring Materials. In a Hino Dutro 130 HD brand car. The average tensile stress is 44.8 (HRC) The average tensile stress is 1407.8 N/mm2 The hardness in specimen 1 is 1407 N/mm2 in specimen 2, the hardness is 1408 N/mm2 in specimen 3, the result is hardness 1409 N/mm2 on specimen 4 with a hardness of 1407 N/mm2 and on specimen 5 the force value of hardness is 1408 N/mm2 Bending test of Indospring Material that has been carried out on Bending test data of Indospring Material to analyze the mechanical strength of spring damage. Strength of Indospring Material. In a Hino Dutro 130 HD brand car. Tensile force Hardness average 1407.8 N/mm2 HOP Material Bend, Indospring. In a Hino Dutro 130 HD brand car. The average hardness force is 1407.8 N/mm2. So that the strength of this material is feasible and good for use while loading trucks. Which is flat paved, so the weight of the cargo transported is not known with certainty. However, it can be estimated based on the carrying capacity, the weight of the cargo ranges from 7-10 tons, for one transport

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INTRODUCTION

The development of technology today is very rapid, one of which is in the automotive sector. Driver comfort and safety are the main factors besides the reliability of the car engine itself. This encourages the automotive industries to compete to produce a quality automotive product. The comfort and safety of motorized vehicle drivers, especially four-wheeled vehicles, must be guaranteed either directly or indirectly. This is intended so that the driver does not experience interference that can result in injury or pain while driving the vehicle. One component that plays an important role in providing comfort to motorized vehicle drivers is the spring. Spring is a component that functions to receive dynamic loads and provide comfort in driving. Therefore, the spring material must have high elastic strength and also be balanced with high toughness. This is due to the loading conditions received by the spring.

One type of spring that is commonly used in four-wheeled motorized vehicles is leaf springs. Leaf springs that have been used for a long time will experience a decrease in the quality of the mechanical properties due to the dynamic loads that occur on this component. This decrease in the quality of mechanical properties causes the spring to be unfit for use because it will create uncomfortable conditions for the rider. Through this research a comparison of two leaf spring materials will be carried out, this is expected to be a solution to increase the strength and toughness of the leaf springs that have been used, the strength and carrying capacity of the damp truck of 8 Tons.

To find out the mechanical properties of the spring, Hardness and Bending Tests will be carried out. The effect of the leaf springs are the original leaf springs while the mechanical properties will be analyzed through the Hardness strength test and the Bending test. Maintenance and reduce spare parts costs. The problems and obstacles that are often encountered in the field where the public or consumers think that the original leaf spring is expensive and does not last long, while non-original factory products are much more expensive and do not last long compared to the manufacturer, so non-manufacturers often break or break in the leaf spring, therefore I, as a student, know the mechanical properties of the spring material, which are manufacturers and non-manufacturers, so that the material is able to meet the initial eligibility standards and have a relatively longer service life.

Formulation of the Problem

The formulation of the problem in this study is:

Analyzing the mechanical strength of damage to Indospring leaf springs. In a Hino Dutro 130 HD brand car.

Restricting the Problem

In order for the problems in this study to become clear and not deviate from the stated objectives, the authors need to limit the issues raised. The limitations of the problem in this study are:

1. The object of research is a leaf spring with a rectangular cross-section on the rear wheel suspension of a Hino Duro 130 HD car
2. Analysis of the mechanical strength of leaf springs with a rectangular cross-section on the rear wheel suspension of a Hino Duro 130 HD car

3. Leaf springs that often break or break on leaf springs in the order of 4 and 5 of this spring are examined and analyzed for their strength
4. Types will be observed through while the mechanical properties will be analyzed through hardness tests and Bending Tests

Research Purposes

Based on the problems above, the objectives of this research are:
a. General Purpose
1) To determine the mechanical strength characteristics of the indospring brand leaf springs
2) To find out the comparison of the characteristics of hardness strength and compressive strength
b. Special Purpose
1) To become a reference and input for consumers and companies that HOP leaf springs have different strengths and prices so that consumers trust HOP leaf springs
2) Making the basis for explaining to consumers that Leaf springs with HOP tend to be cheap and have much stronger mechanical strength so that consumers have more confidence and are able to increase company sales

Benefits of Research

1. Theoretical Benefits

Through this research, it is possible to apply the scientific application development of the Mechanics of Strength of Materials and related to the analysis of the strength of materials

2. Practical Benefits

1) Researchers can apply the science of Material Strength Mechanics related to stress analysis obtained during lectures, so that it can become real experience as an implementation of the theory they have learned.
2) For the University it can be input in order to know the prediction of the force on the leaf springs of the Hino Dutro 130 HD Dump Truck car, I am a student who is currently conducting education and research in the Department of Mechanical Engineering, Faculty of Engineering, University of Muhammadiyah Pontianak**.**

Research Methods

The research method used in this final project are:
1) Literature Method

This method is carried out by reading books related to spring materials, types of springs and their effects on changes in structure and mechanical properties, especially the properties of tensile and compressive tests.

2) Test method

This method is to carry out tests on predetermined samples, this test is in the form of mechanical strength testing and mechanical testing, namely tensile and compressive strength on the leaf springs of the Hino Dutro 130 HD Dump Truck car.

THEORETICAL REVIEW

1. General Things About Springs

1. Kinds of Springs

Springs can be classified on the basis of acceptable load types, as follows:
1. Comp g pull
3. Torsion ressed spring
2. Sprin
 spring
2. According to the pattern can be distinguished between:
(1,2,3) Threaded spring
4. Volute spring
5. Leaf spring
6. Plate spring
7. Ring spring
8. Spring rod punter
9. Spiral spring or clock spring

2. Leaf Springs

A leaf spring is a spring in the form of a flat plate with a certain width and is subjected to a lateral load which causes the plate to bend (Hidayat, 2012: 2). Leaf springs as a component of the suspension system function to absorb shock from the road and vibration from the wheels so that they are not transmitted directly to the vehicle body and increase the grip of the tires on the road surface and support the overall weight of the vehicle, including the weight of the body, engine, passengers, frame, accessories and other loads that are supported on it. According to Erjavec (2010: 1325) there are three basic types of leaf springs, namely multi leaf springs, mono leaf springs, and fiber composite leaf springs.

1) Multi Leaf Springs

Multi Leaf Springs consist of flat steel leaves that are held together and fastened using clips or using U-bolts placed in the center of the arrangement. Multi Leaf Springs consist of main leaves, extra fulllength leaves, and graduated leaves. The main leaf has an eye spring at each leaf tip. Extra full-length in addition to the main leaf with a leaf that is almost the same length as the main leaf and is placed between the main leaf and graduated leaves. Graduated leaves with a shorter length than the main leaf and extra full-length leaves are placed below the extrafull-length leaves.

Figure 1. Multi Leaf Springs

2) Mono Leaf Springs

Mono Leaf Springs or single leaf springs usually consist of a steel plate that has a curvature along the leaf. This type of leaf spring usually has low stiffness. This provides a smooth ride and good cargo handling. This type of leaf spring also does not have the static friction and disturbance characteristics of multi leaf springs.

3) Leaf Spring Material

The blades are usually made of steel, 55Si2 Mn 90, 50Cr1 or 50Cr1V23. The safety factor is based on yield strength, which is between 2 and 2.5 for car suspensions (Bhandari, 1994: 319). In its development, composites are widely used as a substitute for steel leaf spring materials because they have better strength with lighter weight. Gebremeskel, explained a good detailed procedure for making a single leaf spring prototype made from E-glass fiber epoxy resin material using the hand layup method for 40 layers of E-glass fiber material with a fiber thickness of 0.4 mm.

Carbon steel is classified into three basic classifications namely low carbon steel which has a carbon content of less than 0.30%, medium carbon steel which contains 0.30% − 0.50% carbon, and high carbon steel which has 0.50% − 0.95% carbon. Low carbon steel has relatively low strength, but has good formability. Medium carbon steel is used in most elements that have moderate to high strength requirements with moderate ductility and moderate hardness requirements. Whereas high carbon steel provides better wear properties suitable for applications requiring durable cutting edges and for surfaces subject to constant wear and tear (Mott, 2004:47).

Based on the provisions of AISI (American Iron and Steel Institute), carbon steel has a maximum weight content of 1.00% carbon element, 0.60% copper element, 1.65% manganese element, 0.40% phosphorus element, 0.60% silicon element, and 0.05% elemental sulfur. AISI makes a separate code for carbon steel. The code consists of a four-digit number. The first two digits indicate the grade of steel, while the last two digits indicate the amount of carbon contained in the alloy in hundredths of a percent (Efunda, 2014).

Table.1 Grades of Steel according to AISI

XX : 0,XX% jumlah kandungan karbon
AISI 10 60
10 : Nonresulfurized grades
11 : Resulfurized grades
12 : Resulfurized and rephosphorized grades
15 : Nonresulfurized grades; max kandungan Mn > 1%

(Source: Efunda, 2014)

4) Construction of Multi Leaf Springs

Construction of Multi Leaf Springs as shown in Figure 2.4 which is semi-elliptic in shape consisting of a series of flat plates. The leaf spring plates are fastened together using two U-bolts and a center clip. Rebound clips are installed to maintain the alignment and straightness of the leaf spring plates and prevent the leaf spring plates from shifting sideways during operation. The longest leaf spring is called the master leaf which is bent at both ends to form the spring eye. In the middle, the spring is tied to the axle of the vehicle (car). Multi leaf springs are equipped with one or two extra full-length leaves in addition to the master leaf. The extra full-length leaves are stacked between the master leaf and the graduated-length leaves. Construction of multi leaf springs as shown in Figure 2 below.

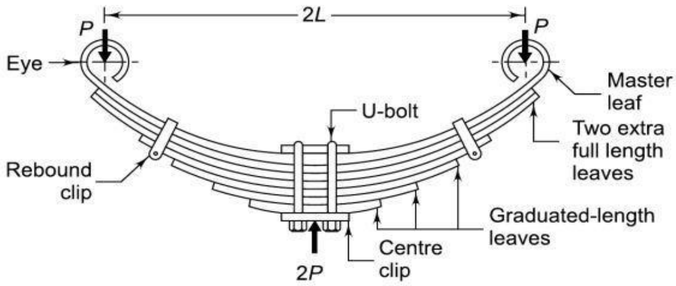

Figure 2. Construction of Multi Leaf Springs
(Source: Bhandari, 1994: 315)

According to Bhandari, (1994: 319), the standard dimensions of thickness and width of leaf springs for car suspensions are in accordance with Indian Standards 1135-1966 as shown in Table 2

Table 2. Dimensional Specifications for Indian Leaf Springs Standard 1135-1966

Thick (mm)	Wide (mm)
6,0	50
7,0	60
8,0	70
9,0	75
10,0	80
11,0	90

(Source: Efunda, 2014)

5) Leaf Spring Force Distribution

The distribution of forces on leaf springs is shown in Figure 2.5. In semi-elliptic leaf springs, the load or force distribution that occurs can be treated as a double cantilever. The load w received by the leaf spring is concentrated on the main leaf spring eye (master leaf). As a result of this load w, there is a moment of force in the center of each leaf against the load w of 2w.

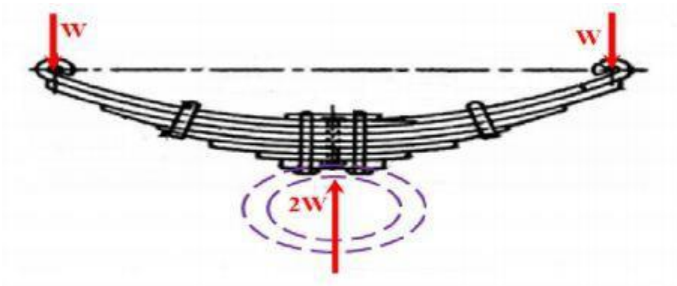

Figure 3. Load Distribution on Leaf Springs
(Source: Sudarsono and Yuspian, 2012: 253)

Leaf Spring

The leaf springs commonly used in automobiles are of a semi-elliptical shape as shown in Figure 1. These leaf springs are formed of a number of plates (shaped like leaves). These leaves usually have the characteristic of being curved so that the leaves will serve to bend and become straight due to the work of the load.

Material Testing

A metal has certain properties which are distinguished by physical, mechanical, thermal and corrosive properties. One of the most important of these properties is the mechanical properties. Mechanical properties consist of ductility, hardness, strength and toughness. Mechanical properties are one of the references for carrying out further processing of a material, for example for forming and machining processes. To determine the mechanical properties of a metal must be tested on the metal. One of the tests carried out is the tensile test.

In the manufacture of a construction required materials with specific specifications and properties in each part. For example in the construction of a bridge. It takes a strong material to accept the load on it. The material must also be elastic so that when standard or excessive loading occurs it does not break. One example of a material that is now widely used in building or general construction is metal.

Even though the mechanical properties of the metal have been predicted in the manufacturing process, we really need to know the absolute and accurate value of the mechanical properties of the metal. Therefore, currently many tests are carried out on samples of the material.

This test is intended so that we can find out the mechanical properties of the material, so that it can see its advantages and disadvantages. Materials with better mechanical properties can improve the mechanical properties of materials with poorer properties by alloying. This is done according to construction needs and orders.

Tensile test is a method used to test the strength of a material by providing an axial force load. The results obtained from tensile testing are very important for engineering and product design because they produce material strength data. Tensile testing is used to measure the resistance of a material to a static force that is given slowly. One way to determine the magnitude of the mechanical properties of a metal is to do a tensile test. The mechanical properties that can be known are the strength and elasticity of the metal. Tensile tests are mostly carried out to complete basic design information on the strength of a material and as supporting data for material specifications. The strength and elasticity values of the test material can be seen from the tensile test curve.

This tensile test is carried out to determine the mechanical properties of a material, especially metals. Among the mechanical properties that can be known from the results of the tensile test are as follows:
1) Tensile strength
2) Yield strength of the material
3) Tenacity of the material
4) Elastic modulus of the material
5) Resilience of a material
6) Toughness.

Tensile testing is mostly done to complete basic design information on the strength of a material and as supporting data for material specifications. Because with tensile testing it can be measured the resistance of a material to a static force that is given slowly. This tensile test is one of the important tests to be carried out, because this test can provide various information about the properties of metals.

In the industrial field, this tensile test is required to consider metallurgical factors and mechanical factors involved in the treatment process of finished metal, to fulfill the next process. Because of the importance of this tensile test, we as metallurgical students should know about this test.

With the stress-strain curve we can know the tensile strength, yield strength, ductility, modulus of elasticity, toughness, and others. In this tensile test we also have to know the impact of testing on the mechanical and physical properties of a metal. By knowing these parameters, we can get basic data about the strength of a material or metal.

Basic Metal Testing

The tensile test is a method used to test the strength of a material by providing an axial force load [Askeland, 1985]. The results obtained from tensile testing are very important for engineering and product design because they produce material strength data. Tensile testing is used to measure the resistance of a material to a static force that is applied slowly.

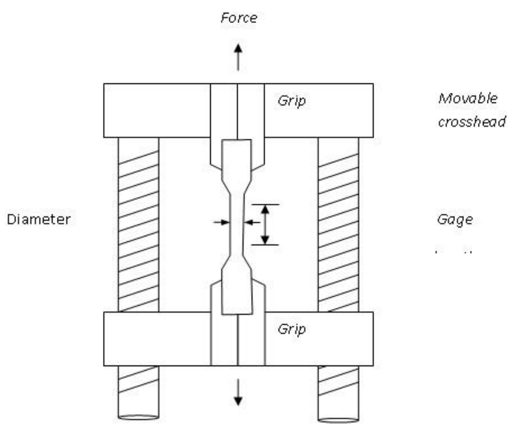

Figure 4. Tensile Testing Machines Are Equipped with Standard Size Specimens.

As shown in Figure 6, the object being tested in tension is loaded in both directions of its axis. Loading in both directions of the axis is given the same amount of load.

Tensile testing is the basis of the mechanical tests used on materials. Where the test specimens have been standardized, uniaxial loading is carried out so that the test specimens stretch and increase in length until they finally break. Tensile testing is relatively simple, inexpensive and highly standardized compared to other tests. The things that need to be considered so that the test produces a valid value are; shape and dimensions of test specimens, selection of grips and others.

1) Shape and Dimensions of the test specimen

The test specimen shall comply with the standards and specifications of ASTM E8 or D638. The shape of the specimen is important because we must avoid breaking or cracking the grip area or anything else. So the standardization of the shape of the test specimen is intended so that cracks and fractures occur in the gage length region.

2) Grip and Face Selection

Face and grip are important factors. By selecting an incorrect setting, the test specimen will slip or even break in the grip area (jaw break). This will produce invalid results. The face must always be covered over all surfaces in contact with the grip. So that the test specimen does not rub directly with the face.

The load exerted on the material being tested is transmitted to the handle of the material being tested. The dimensions and sizes of the test objects are adjusted to the standard standards for testing.

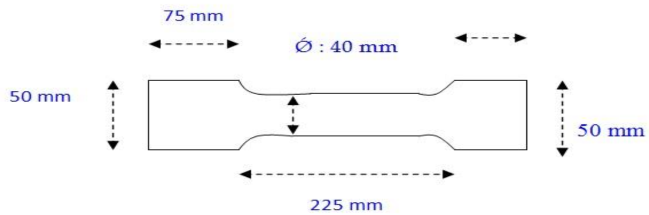

Figure 5. Dimensions And Sizes of Specimens for Tensile Tests

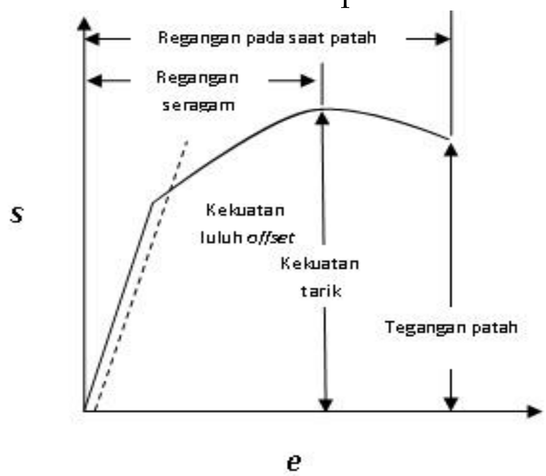

Figure 6. Example of A Tensile Test Curve

The stress used in the curve is the average longitudinal stress from the tensile test. The engineering stress is obtained by dividing the applied load divided by the initial cross-sectional area of the test object. Written as in the following equation 2.1:

s= P/A0 ……………………………………………………………..2.1

Information:

s : the magnitude of the stress (kg/mm2)

P : applied load (kg

A_0 : Initial cross-sectional area of the test object (mm2)

The strain used for the engineering stress-strain curve is the average linear strain, which is obtained by dividing the resulting elongation after the test is carried out by the initial length. Written as in the equation 2.2:

$$e = \frac{L - L_0}{L_0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. 2.2$$

Information ;

e : The amount of strain

L : Length of specimen after testing (mm)

σ : Initial length of the specimen (mm)

The shape and magnitude of the stress-strain curve of a metal depend on the composition, heat treatment, plastic deformation, strain rate, temperature and stress state which determines during the test. The parameters used to describe the stress-strain curve of a metal are tensile strength, yield strength or yield point, percent elongation and area reduction. And the first parameter is the strength parameter, while the last two represent the ductility of the material.

The shape of the stress-strain curve in the elastic region of stress is directly proportional to strain. Deformation does not change under loading, the area of loss that does not cause deformation when the load is removed is called the elastic region. If the load exceeds the value related to the yield strength, the object undergoes gross plastic deformation. Deformation in this area is permanent, even if the load is removed. The stress required to produce plastic deformation will increase with increasing plastic strain.

In the resulting stress and strain, the value of the modulus of elasticity can be known. The equations are written in equations 2.3;

$$E = \frac{\sigma}{\varepsilon} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. 2.3$$

Information ;

E : Large modulus of elasticity (kg/mm2)

e : strain

σ : Stress (kg/mm2)

Initially the strain hardening is greater than required to compensate for the decrease in the cross-sectional area of the test piece and the engineering stress (in proportion to the load F) which increases steadily with increasing strain. Eventually a point is reached where the reduction in cross-sectional area is greater than the increase in load deformation due to strain hardening. This state is reached for the first time at a point in the specimen that is slightly weaker than the no-load state. All subsequent plastic deformation is concentrated in this area and the specimen begins to narrow locally. Because the cross-sectional area decreases more rapidly than the deformation increases due to strain hardening, the actual load required to deform the test piece will decrease and so will the engineering stress in equation (1) decrease until fracture occurs.

From the tensile test curve obtained from the test results, several mechanical properties possessed by the test object will be obtained, these properties include [Dieter, 1993]:

1) Tensile strength
2) Yield strength of the material
3) Tenacity of the material
4) Elastic modulus of the material
5) Resilience of a material
6) Toughness

Mechanical Testing

1. **Hardness Testing**

Hardness is the resistance of a material to permanent deformation by the penetration of another, harder object. Hardness is a material property that is largely influenced by its alloying elements. The hardness of a material is an important property. Because it is the hardness of the material that determines the ease of processing and determines the wear resistance.

The carbon in the iron certainly affects the quality of the steel, and the required hardness can be achieved by heat treatment. From some research that has been done, the hardness of the material will change if it is cold worked.
Before carrying out the test, the surface of the workpiece must be smoothed so that it is smooth and shiny, and the work must not cause changes in the structure of the metal to be tested.

The most common form of hardness testing is to use a standard indenterthat is pressed against the surface of the specimen. The results of the indentation give the value of hardness.
The hardness value does not have an absolute standard or scale, because the hardness value of a type of test has its own scale, although there are some relationships from one scale to another.

To determine the hardness of a material can be done by several methods, namely:

1) Brinnel test
2) Vickers test
3) Rockwell Testing

The hardness testing method used in this study is the Vickers method. In the Vickers method, the identification of a pyramid-shaped gem is used with a square base and a special peak angle by applying a load to the metal (work piece) load f and the free diagonal of the emphasis is measured after the load is lifted. The Vickers hardness is a quotient obtained by dividing the applied load F by the stretch area on the indented surface of the workpiece.

Table 3. Hardness Calculation with Pivkers Method

NO	Symbol	Information	Unit
1	-	The peak angle of the pyramidal indenter = 1360 applied load	0
2	F	The average diameter obtained from	Kgf
3	d	Diagonals d1 and d2	mm
4	HV/DVH	Vickers violence= $\frac{the\ load\ imposed}{indentation\ area}$ $= \frac{2F sin\frac{136^o}{2}}{d^2}$=1,854$\frac{F}{d^2}$	

1. **Hardness**

Is one of the mechanical properties of a material. The hardness of a material must be known, especially for materials that will experience frictional forces and plastic deformation when used. Plastic deformation itself is a condition of a material when the material is given a force, the microstructure of the material cannot return to its original shape, meaning that the material cannot return to its original shape. In short, hardness is defined as the ability of a material to withstand indentation or penetration (stress) loads.

To find out how much a material has the ability to withstand indentation or penetration loads, testing is usually carried out, in the engineering world generally testing hardness uses 4 kinds of methods, namely:

2. **Brinnell (HB/BHN)**

Hardness testing with the Brinnel method aims to determine the hardness of a material in the form of the material's resistance to a steel ball (identor) which is emphasized on the surface of the test material (specimen). Ideally, the Brinnel test is intended for materials that have a rough surface with a strength test in the range of 500-3000 kgf. Identors (steel balls) are usually hardened and plated or made of tungsten carbide.

The brinnel hardness test is formulated by:

$$HB = \frac{2\,F}{\frac{\pi}{2}\,.\,D\,(D - \sqrt{D^2} - \,d^2)}$$

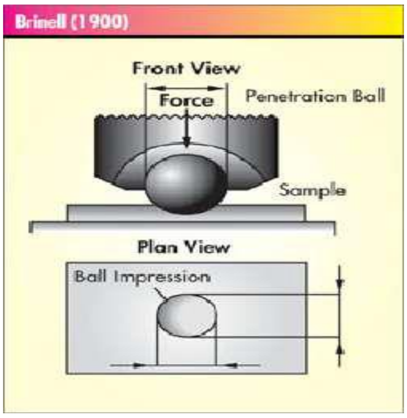

Figure 7. Brinell testing

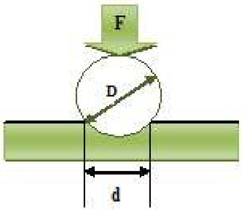

Figure 8. Formulation for Brinnel testing

3. **Rockwell (HR/RHN)**

Hardness testing using the Rockwell method aims to determine the hardness of a material in the form of the material's resistance to indenters in the form of steel balls or diamond cones which are emphasized on the surface of the test material.

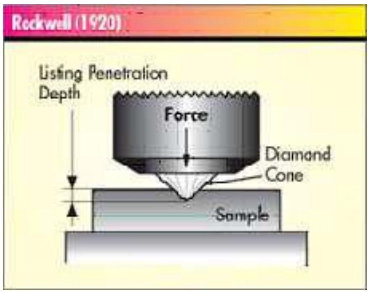

Figure 9. Rockwell Testing

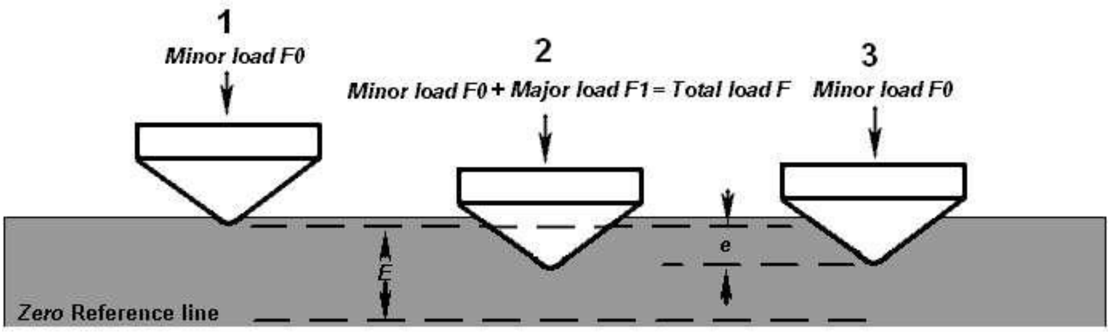

Figure 10. The working principle of the Rockwell hardness measurement method

To find the magnitude of the hardness value using the Rockwell method is explained in the figure, namely in step 1 the test object is pressed by the indenter with a minor load (Minor Load F0) after that it is pressed with a major load (major Load F1) in step 2, and in step 3 the major load is taken so that what remains is the minor load where in condition 3 the indenter is held like the condition at the time of the total load F shown in the picture.

The amount of minor load and major load depends on the type of material to be tested,

4. **Vickers (HV/VHN)**

Hardness testing with the Vickers method aims to determine the hardness of a material, namely the material's resistance to diamond indenters which are quite small and have a pyramidal geometric shape as shown in Figure 3. The load applied is also much smaller than the rockwell and brinel tests, namely between 1 and 1000 grams. The Vickers hardness number (HV) is defined as the quotient (coefficient) of the test load (F) by the pressure scar surface area (stamping) of the indenter (its diagonal) (A) multiplied by sin (136°/2).

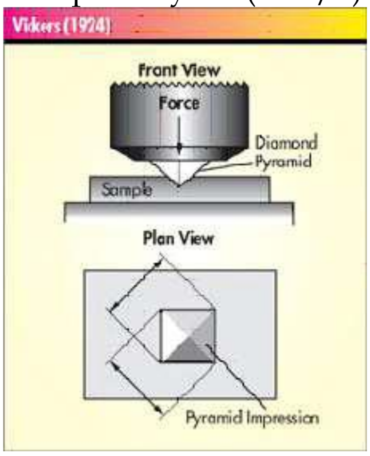

Figure 11. Vickers Testing

Figure 12. Vickers indenter shape

The formula for determining the magnitude of the hardness value with the vikers method is:

$$HV = \frac{F}{A}\ x\ Sin\ \frac{136^0}{2} \text{ or}$$

$$HV = \frac{F\ .\ Sin\frac{136^0}{2}}{\frac{d^2}{2}} \text{ or}$$

$$HV = 1{,}854\ .\frac{F}{d^2}$$

Where :
HV = Vickers hardness number
F = Load (kgf)
d = diagonals (mm)

5. **Micro Hardness (Knoop Hardness)**

Microhardness tests, often referred to as knoop hardness testing, are tests that are suitable for testing materials with low hardness values. Knoop is usually used to measure brittle materials such as ceramics.

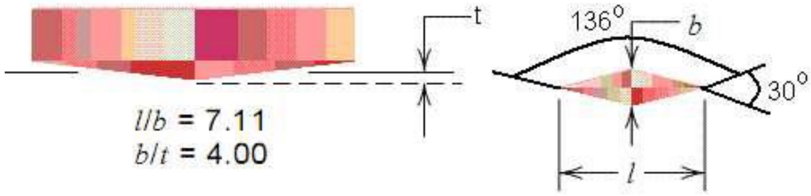

Figure 13. Knoop indenter shape

$$HK = 14{,}2\ \frac{F}{l^2}$$

Where :
HK = Knoop hardness number
F = Load (kgf)
l = Length of indenter (mm)

Yield Strength

One of the strengths that is usually known from a tensile test result is the yield strength. Yield strength is the point that shows the change from elastic deformation to plastic deformation [Dieter, 1993]. The magnitude of the yield stress is written as in the equation 2.4:

$$Y_s \frac{P_y}{A_0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..2.4$$

Information ;
Ys : The amount of yield stress (kg/mm²)
Py : The amount of load at the yield point (kg)
Ao : Initial cross-sectional area of the test object (mm²)

The stress at which plastic deformation or yield limit begins is observed depending on the sensitivity of the strain measurement. Most materials experience a gradual change in their properties from elastic to plastic, and the point at which plastic deformation begins to occur is difficult to determine accurately.

The yield strength is the stress required to produce a specified small amount of plastic deformation. The definition often used for this property is that the yield strength is determined by the stress associated with the intersection of the stress-strain curve and a line parallel to the elastic offset of the curve by a given strain. In the United States the offset is usually specified as 0.2 or 0.1 percent strain (e = 0.002 or 0.001)

A good way to observe the offset yield strength is after the specimen is loaded up to 0.2% of the offset yield strength and then when the load is removed the specimen will increase in length by 0.1 to 0.2%, longer than when the load is removed. shut up. The offset stress in the UK is often expressed as the proff stress, where the offset value is 0.1% or 0.5%. The yield strength obtained by the offset method is usually used for design and specification purposes, because this method avoids the difficulty of measuring elastic or proportional limits.

Measurement of Toughness (tenacity)

Tenacity is the ability of a material to withstand loads when given penetration and will return to its original shape. In general, ductility measurements are carried out to fulfill the interests of three things [Dieter, 1993]: To indicate the elongation at which a metal can be deformed without fracturing in a metal forming process, such as rolling and extrusion.

To give the designer a general indication of the ability of a metal to flow elastically before fracture.

As an indication of a change in surface purity or processing conditions:

Elasticity Modulus

Modulus of Elasticity is a measure of the strength of a material to its elasticity. The greater the modulus, the smaller the elastic strain produced due to the application of stress. The elastic modulus is determined by the binding forces between atoms, because these forces cannot be changed without a fundamental change in the properties of the material. So the modulus of elasticity is one of the mechanical properties that cannot be changed. These properties are only slightly altered by alloying addition, heat treatment, or cold working.

Mathematically the elastic modulus equation can be written as follows:

$$M_0 = \frac{\sigma}{e} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ 2.5$$

Where,

s = voltage

ε = strain

Table 4. The value of the modulus of elasticity at various temperatures [Askeland, 1985]

Bahan	Modulus elastisitas, psi x 10^6				
	Suhu kamar	400^0 F	800^0 F	1000^0 F	1200^0 F
Baja karbon	30,0	27,0	22,5	19,5	18,0
Baja tahan karat austenit	28,0	25,5	23,0	22,5	21,0
Paduan titanium	16,5	14,0	10,7	10,1	
Paduan aluminium	10,5	9,5	7,8		

Resilience

Resilience is the ability of a material to absorb energy when deformed elastically and return to its initial shape when the load is removed [Dieter, 1993]. Resilience is usually expressed as the modulus of resilience, which is the strain energy per unit volume required to compress the material from zero stress to the yield stress σo. The strain energy per unit volume for a one-axis tensile load is:

$$Uo = ½\, \sigma_x e_x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ 2.6$$

From the definition above, the modulus of resilience is:

$$U_x = 1/2S_e\varepsilon_e = 1/2S_0\frac{S_0}{E} = \frac{S_0^2}{2E}$$

This equation shows that the ideal material to withstand energy loads in applications where the material does not experience permanent deformation, such as mechanical springs, is a material that has a high yield stress and a low modulus of elasticity.

Toughness

Toughness is the ability to absorb energy in the plastic area. In general, resilience uses concepts that are difficult to prove or define. One way to express toughness is to consider the total area under the stress-strain curve. This area indicates the amount of energy per unit volume that can be applied to the material without causing it to break. Toughness (S0) is the ratio between strength and ductility. Equation as follows.

$$UT \approx su\,ef$$

For brittle materials

$$U_T = \frac{S_0 + S_0}{2} e_f \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 2.7$$

Information; UT : Number of volume units

The true fracture stress is the load at fracture divided by the cross-sectional area. This stress shall be corrected for the triaxial stress state that occurs in the tensile test piece at fracture. Because the data required for correction are often not obtained, the true fracture stress is often an incorrect value.

Definition of Bending Test

Bending test is a form of testing to visually determine the quality of a material. In addition, the bending test is used to measure the strength of the material due to loading and the elasticity of the results of welded joints in both weld metal and HAZ. In applying the load and determining the dimensions of the mandrel there are several factors that must be considered, namely:

1. Tensile Strength
2. Chemical composition and microstructure, especially the content of Mn and C.
3. Yield stress.

Based on the position of taking the specimen, the bending test is divided into 2, namely transverse bending and longitudinal bending.

Types of Bending Tests

1. Transverse Bending

In this transverse bending, taking the specimen is perpendicular to the welding direction. Based on the direction of loading and the location of the observation, the transverse bending test is divided into three:

a. Face Bend (Bending on the Welding Surface)

It is said Face Bend if bending is done so that the surface of the weld is subjected to tensile stress and the base of the weld is subjected to compressive stress. Observations were made on the weld surface experiencing tensile stress.

Is there a crack or not. If a crack appears, where is it located, is it on the weld metal, HAZ or on the fusion line (border line of WM and HAZ).

b. Root Bend (Bending on the Root of the Weld)

It is said Rote Bend if bending is done so that the root of the weld experiences tensile stress and the base of the weld experiences compressive stress. Observations were made on the roots of the welds that were experiencing tensile stress, whether cracks appeared or not. If a crack appears where is it located, is it in the weld metal. HAZ or diffusion line (WM and HAZ border line)

c. Side Bend (Bending on the Welding Side)

It is said to be Side Bend if the bending is done so that the side is welded. This test is carried out if the thickness of the material being welded is greater than 3/8 inch. Observations were made on the weld side, whether cracks appeared or not. If a crack appears, where is it located, whether on Weld metal, HAZ or on the fusion line (border line of WM and HAZ).

2. Longitudinal Bending

In this longitudinal bending, taking specimens in the same direction as the direction of welding based on the direction of loading and the location of the observation, the longitudinal bending test is divided into two:

a. Face Bend (Bending on the Welding Surface)

It is said Face Bend if bending is done so that the weld surface experiences tensile stress and the weld base experiences compressive stress (figure 5.4). Observations were made on the surface of the weld that was experiencing tensile stress, whether cracks appeared or not. If a crack appears, where is it located, whether in Weld metal, HAZ or on the fusion line (WM and HAZ border line).

b. Root Bend (Bending on the Root of the Weld)

It is said Root Bend if bending is done so that the root of the weld is subjected to tensile stress and the base of the weld is subjected to compressive stress. Observations were made on the root of the weld which was subjected to tensile stress, whether cracks appeared or not. If a crack appears, where is it located, whether in Weld metal, HAZ or diffusion line (WM and HAZ border line).

3. Criteria for Passing the Bending Test

To be able to pass the bending test, the test results must meet ASME standards as follows:

1) In the area of Weld metal and HAZ the size does not exceed 1/8 inch (±3.2 mm) measured from all directions of the surface.

2) In the coating area the maximum defect size is 1.6 mm

3) Defects at angles are neglected except for SI (Slag Inclusion) and IF (Incomplate Fusion) and Internal Discontinuities

METHODOLOGY

Research Object In this study an investigation will be carried out on leaf springs on trucks that experience failure in the form of fractures, where these vehicles routinely operate up to six days a week. The route taken varies, ranging from flat dirt roads and sometimes potholes, especially at sand collection locations, to flat paved roads, so the weight of the cargo being transported is not known for certain. However, it can be estimated based on the carrying capacity, the weight of the cargo ranges from 7-10 tons, for one transport.

The broken leaf springs are in the first order of the leaf spring arrangement on the truck, while the dimensions of the leaf springs are shown in the figure below.

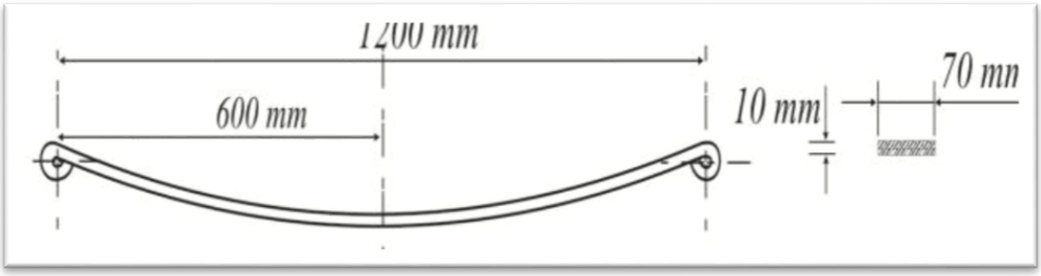

Figure 14. Broken spring dimensions

Hino Dutro 130 Hd Dump Truck Specification Data

A. Performance

1) Maximum Speed : 103 (km/h)
2) Gradeability (tan Ø): 39.6
3) Machine Models
4) Model: W04D - TR
5) Type: Inline 4 Stroke Diesel Engine; direct injection; Turbo Charge Intercooler
6) Maximum Power (PS/rpm): 130 / 2,700
7) Maximum Torque (Kgm/rpm): 38 / 1,800
8) Number of Cylinders: 4
9) Diameter x Piston Step (mm): 104 x 118
10) Cylinder Fill (cc): 4,009

B. Clutch

11) Type: Single Dry Plate; Hydraulic Operations
12) Disc Diameter: 300 mm

C. Transmission

13) Type: M550
14) Tooth Comparison: -

C : -
1st: 4,981
2nd: 2,911
3rd: 1.556
4th: 1,000
5th: 0.738
6th: -
7th: -

8th: -
Backward 4,625
D. Steering
1) Type: Recirculating Ball Screw
2) Minimum Turning Radius: 6.7 m
E. Axis
3) Rear: Full Floating Type, Single Reduction, Single Speed by Hypoid Gear
4) Front: Reverse Elliot, I-Section Beam
5) Final Tooth Comparison: 6.428
6) Drive System: Rear, 4 x 2
F. Brakes
7) Main Brake: Vacuum Servo with Dual Circuit; Equipped with Boosters
8) Slow Brake: With Exhaust Pipe
9) Parking Brake: Internal Expanding; Out Shaft Transmission
G. Wheels & Tires
10) Rim Size: 16 x 6.00GS-127
11) Tire Size: 7.50-16-14PR
12) Number of Tires: 6 (+1)
H. Suspension
13) Front & Rear: Rigid Axle with Semi Elliptic Leaf Springs
14) Accu Electrical System
15) Accu: 12V-60Ah x2
I. Dimensions
16) Diesel Tank
17) Capacity : 100 lt
J. Dimension(mm)
18) Wheelbase: 3380
19) Cabin to End: 2,900
20) Total Length: 6,026
21) Total Width: 1,945
22) Total Height: 2,165
23) Front Trail Width: 1,455
24) Rear Trail Width: 1,480
25) Forwards: 1,066
26) Rear Passage: 1,580
K. Chassis Weight (kg)
27) Front: 1,419
28) Rear: 936
29) Empty Weight: 2.355
30) GVWR / GCWR: 8250
L. Mechanical Specification
1) As for the engine, the Hino Dutro130 HD product is a 4-stroke inline diesel engine with a maximum power of 130/2,700 ps/rpm equipped with a turbo charge intercooler so it is more powerful but more fuel efficient.
2) The frame of the Hino Dutro 130 DH is made very strong, thick, equipped with inner reinforcement, rivet reinforcement and a new cross member design without holes, adding to the robustness of the frame.

3) This truck has an extra strong leaf spring suspension system, suitable for heavy and tough off road transport.
4) Hino Dutro 130 HD has a cabin that can be tipped over to make it easier to maintain the vehicle.

Specification Of Leaf Spring

1) Dumptruck specification data as follows:
2) Vehicle Brand: Hino Dutro 130 HD
3) Dumptruck net weight: 12,600 kg
4) Dumptruck payload weight: 17,400 kg, Chassis Length:
5) 7.025 m, Chassis Width 1.256 m
6) Dump Length: 5m,.
7) Long dimension of leaf spring
8) Dumptrucks:
9) Spring No. 1:1.58m,
10) Spring No. 2:1.58m,
11) Spring No. 3:1.15m
12) Spring No. 4:1.01m,
13) Spring No. 5:0.86m,
14) Spring No. 6:0.72m
15) Spring No. 7:0.56m,
16) Spring No. 8:0.44m,
17) Spring No. 9:0.32m
18) Dumptruck Leaf Spring Width: 0.086 m,
19) Dumptruck Leaf Spring Thickness: 0.018 m
20) Spring Material: DIN 17222 Steel,
21) Modulus of elasticity (E): 20.6.1010 N/m2
22) Allowable stress (σB): 67.109–2.16.109 N/m2,
23) Density (ρ): 7850 Kg/m3
24) Poisson number (v): 0.34

Research Flowchart

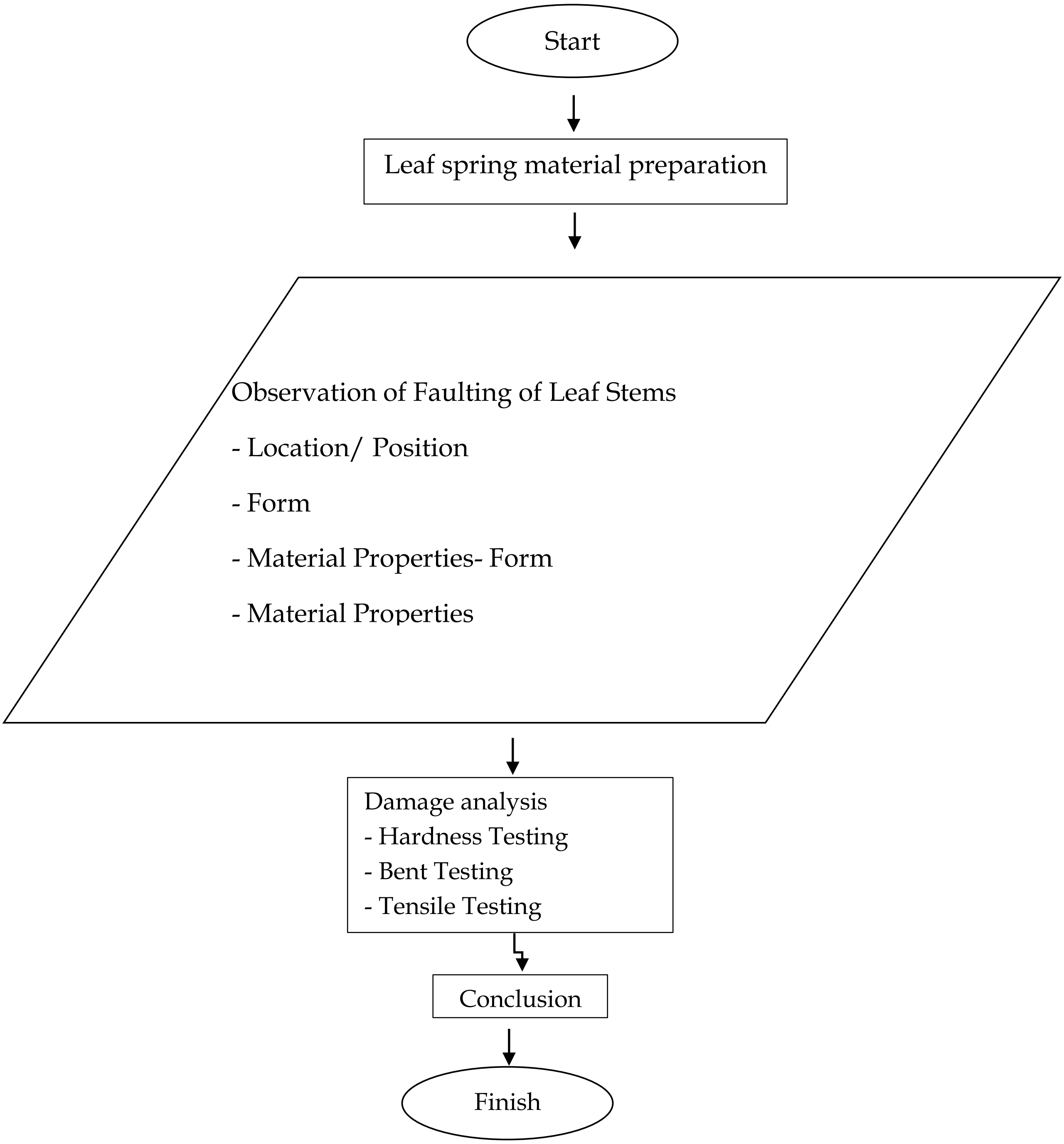

Figure 15. Research Methodology Flowchart

Materials and tools

Test Materials Used

In this research, the test material used was the Dutro 135 HD hino dump truck leaf spring with a size of 200 mm × 40 mm × 8 mm in a total of 3 (three)

Figure 16. Broken Leaf Springs

Test Equipment Used

The equipment used in this test are as follows:

a. Saw

The saw is used to cut the plate (workpiece) according to the desired size.

b. grinding

Grinder is used to smooth the sides of the plate after cutting (so the edges are not sharp).

c. Tensile Test Equipment

The test equipment used is the Universal Tensile Testing Machine Model Testing Machine Brand GALDABINI Made In Italy.

Figure 17. Tensile Test Equipment

Tensile Test Objects

The forming stage of the tensile test object was made using ZBK 22007-88 type scrap machine made in Taiwan. For the weld area, it is ground until it is flush with the base metal and then sizes are made for tensile testing. The size of the tensile test object can be seen below.

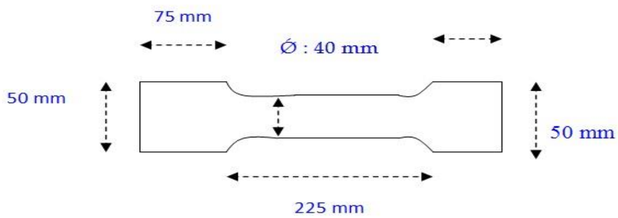

Figure 18. JIZ D4313 Standard Tensile Test Piece

Testing

Tensile Testing

Tensile testing aims to determine the tensile strength of the base metal after experiencing the welding process. Tensile testing is carried out by applying a tensile load to the test rod slowly until the test object breaks or breaks. The equipment used for tensile testing is a tensile tester and calipers. The machine used in this test is the test equipment used is the Universal tensile testing machine model Testing Machine Brand GALDABINI Made In Italy.

Tensile Testing Steps

1) Marking workpieces and electric welding
2) Determine the load used, namely 10000 N, then determine the total length and width of the object
3) Turn on the main power switch so the indicator light is on
4) Make sure the handle load control is in the stop position
5) Place the tool on the surface of the test equipment and the support plate
6) Make sure the pointer is in the zero position
7) Make sure the clamp is on the lower crosshead and raise the lower crosshead by pressing the up crosshead button so that it can grip the tensile test object properly
8) Set loading speed
9) The load indicator needle will continue to move until it reaches the max load point of the specimen under test and then the workpiece decreases and breaks
10) Record the loading and increase in length
11) Then remove the test object from the gripper.

Bending Test

Bending test (bending test) is a form of testing to visually determine the quality of a material. In addition, the bending test is used to measure the strength of the material due to loading and the elasticity of the welded joints in both weld metal and HAZ. In applying the load and determining the dimensions of the mandrel there are several factors that must be considered, namely:

1) Tensile Strength
2) Chemical composition and microstructure, especially the content of Mn and C
3) Yield stress (yield)
4) Based on the position of taking the specimen, the bending test is divided into 2, namely transverse bending and longitudinal bending.

Bending Test Equipment

The test equipment used is the Universal Tensile Testing Machine Model Testing Machine Brand GALDABINI Made In Italy.

Figure 19. Face Bend in Transversal Bending

Bending Test Objects

The Bending test object at the forming stage was made with a Type Ds D 9201 Grinding machine, the Metabo Brand, made in Germany. The size of the bending test object can be seen below.

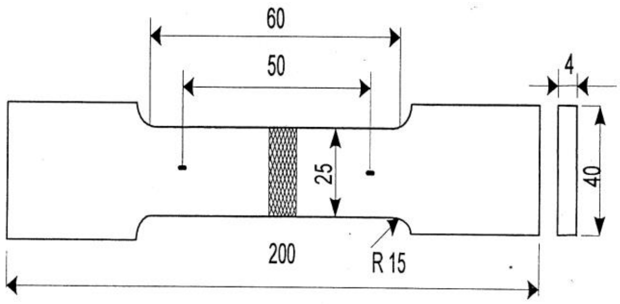

Figure 20. JIZ D4313 Standard Tensile Test Piece

Bending Test Steps

The stages of bending testing are carried out in accordance with the following steps:

1) Measure the dimensions of the specimen including length, width, and thickness according to JIZ D4313 standard.
2) Labeling each specimen that has been measured to avoid reading errors.
3) Turn on the bending machine to perform bending tests.
4) Place the test specimen right in the middle of the two supports and make sure the indicator is right in the middle of the two supports.
5) Installation of dial indicators by recalibrating at 0 mm position which is used to calculate the amount of deflection (1 revolution = 1 mm) on the specimen.
6) Record the amount of deflection every 1mm for 1 rotation at a constant speed in each additional load until failure occurs.
7) After obtaining the data from the test results, proceed with the calculation of the bending strength.

Transverse Bending

In this transverse bending, taking the specimen is perpendicular to the welding direction. Based on the direction of loading and the location of the observation, transverse bending test.

Bending on the Welding Surface (Face Bend)

It is said Face Bend if bending is done so that the weld surface experiences tensile stress and the weld base experiences compressive stress (figure 3.7). Observations were made on the surface of the weld experiencing tensile stress. Is there a crack or not. If a crack appears, where is it located, is it on the weld metal, HAZ or on the fusion line (border line of WM and HAZ).

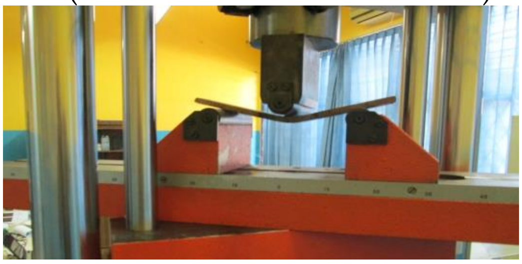

Figure 21. Face Bend pada transversal Bending

Test Result Data

Table 5. Hardness Test Results Data

No	Spring Variation	Style (N/mm²)			Mark Average
		Sampel I	Sampel II	Sampel III	
1	4	....	....	....	
2	5	....	....	....	
3	6	....	....	....	

Table 6. Bent Test Result Data

No	Spring Variation	Style (N/mm²)			Mark Average
		Sampel I	Sampel II	Sampel III	
1	6	....	....	....	
2	6	....	....	....	
3	6	....	....	....	

Table 7. Tensile Test Result Data

No	Spring Variation	Style (N/mm²)			Mark Average
		Sampel I	Sampel II	Sampel III	
1	6	....	....	....	
2	6	....	....	....	
3	6	....	....	....	

RESULTS

In this chapter, we will discuss the effect of immersing in seawater within a certain time on the mechanical properties in analyzing the mechanical strength of damage to Indospring leaf springs. In a Hino Dutro 130 HD car.

This research is an experimental research. As for what is meant by experiments, namely deliberately and systematically conducting treatments or observing actions carried out by researchers to see the effects that occur in these actions (Suharsimi Arikunto, 1993: 189). In this research, analyzing the mechanical strength of damage to Indospring leaf springs will be carried out. In a Hino Dutro 130 HD brand car. After analyzing the mechanical strength of damage to Indospring leaf springs. In the Hino Dutro 130 HD brand car, material testing was carried out. As for material testing, three and four types of tests were taken, namely: 1) Tensile Testing 2). Hardness Testing, and 3). Bent Testing.

Tensile Test Results

The purpose of doing a tensile test is to get the tensile stress value of the test material. In this test the specimen of the test material is the leaf spring of the Hino Dutro 130 HD car brand.

To calculate the tensile stress of the material from various treatments, the following equation is used.

$$\sigma_t = \frac{F_{maks}}{A_0}$$

Where:

σ_t: Tensile stress

Fmax: Maximum load

A_o: The initial cross-section

As an analysis sample for the basis of calculating the tensile stress of all samples, one sample was taken, namely the treatment specification. In this study, an analysis of the mechanical strength of the damage to the Indospring leaf spring was carried out. In a Hino Dutro 130 HD brand car. The calculation results are obtained as follows:

Data on the Results of Hop Material Hardness and Tensile Strength Tests

In testing the spring material for the dump car, the Hino Dutro 130 HD brand truck, the spring is first determined by the number of trifles and the size of the spring material so that testing is carried out, the test results are displayed in tables and graphs so that it makes it easier to read the test results.

Table 8. Results of Hardness Testing and Tensile Testing

No	Test Item Name	Rockwell Violence C (HRC)	Tensile Stress (σtk) (N/mm²)
1.	Hop_1	39	1227
2.	Hop_2	39	1227
3.	Hop_3	40	1230
4.	Hop_4	40	1230
5.	Hop_5	39	1227
Mark Average		39,4	1228,2

Analysis of the tensile strength and hardness of the Hop brand leaf spring. From the results of the tensile tests that have been carried out on 5 specimens, an average tensile stress of 1228.2 N/mm2 is obtained.

Analysis of the Hardness Strength of the Hop Brand Leaf Springs

From the results of the hardness test that has been carried out on the hardness test results data to analyze the mechanical strength of the damage to the Hop leaf spring. In a Hino Dutro 130 HD brand car. The average tensile stress is 39.4, (HRC) Hardness in specimen 1 39 HRC in specimen 2, hardness 39 HRC in specimen 3, the result is a tensile force of 40 HRC in specimen 4 with a hardness of 40 HRC and in specimen 5, the hardness value is 39 HRC. We can describe the test results for each specimen in the average value in table 8 and the results of the Hardness Test for the Tensile Strength Test Results for Hop Materials. Can be seen in the graph below:

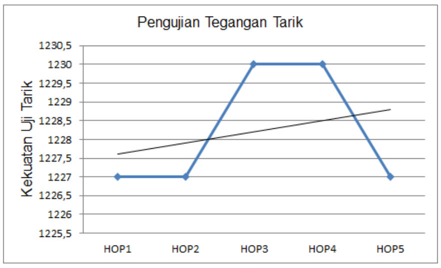

Figure 22. Tensile Test Results graphical data

Tensile Testing Analysis

From the data above, graphs can be formed for all test specimens. From the results of the tensile tests that have been carried out on the data from the hardness tests and tensile tests to analyze the mechanical strength of the damage to the Hop leaf springs. In a Hino Dutro 130 HD brand car. The average tensile stress is 39.4, (HRC) Hardness in specimen 1 39 HRC in specimen 2, hardness 39 HRC in specimen 3, the result is a tensile force of 40 HRC in specimen 4 with a hardness of 40 HRC and in specimen 5, the hardness value is 39 HRC Test results for each specimen, the average value can be described in a graphic image. 22

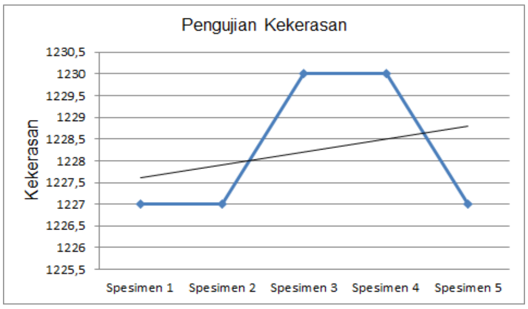

Figure 23. Graph of Material Tensile Testing

Indospring Material Tensile Strength Hardness Test Results

The purpose of doing hardness testing is to get the hardness value of the test material. In this test the specimen of the test material is in the form of a ship deck plate with the hardness testing method with the Vickers method aiming to determine an internal material, namely the material's resistance to diamond indenters which are quite small and have a pyramidal geometric shape.

The Vickers hardness (HV) is defined as the quotient (coefficient) of the test load (F) by the surface area of the pressure scar (stamping) of the indenter

(its diagonal) (A) multiplied by sin (136°/2). The formula for determining the hardness value with the vikers method is:
HV = Vickers hardness number
F = Load (kgf)
d = diagonals (mm)

Table 9 . Data on Hardness and Tensile Strength Test Results for Indospring Materials

No	Test Item Name	Rockwell Violence C (HRC)	Tensile Stress (otk) (N/mm^2)
1.	Indospring 1	44	1407
2.	Indospring 2	45	1408
3.	Indospring 3	46	1409
4.	Indospring 4	44	1407
5.	Indospring 5	45	1408
Average value		44,8	1407,8

Analysis of the results of the tensile test that has been carried out on the tensile test data to analyze the mechanical strength of spring damage Tensile Strength of Indospring Materials. In a Hino Dutro 130 HD brand car. The average tensile stress is 44 .8 (HRC) The hardness in specimen 1 is 44 HRC in specimen 2, the hardness is 45 HRC in specimen 3, the result is a tensile force of 46 HRC in specimen 4 with a hardness of 44 HRC and in specimen 5, the hardness value is 45 HRC We can describe the test results for each specimen with an average value in table 4.3

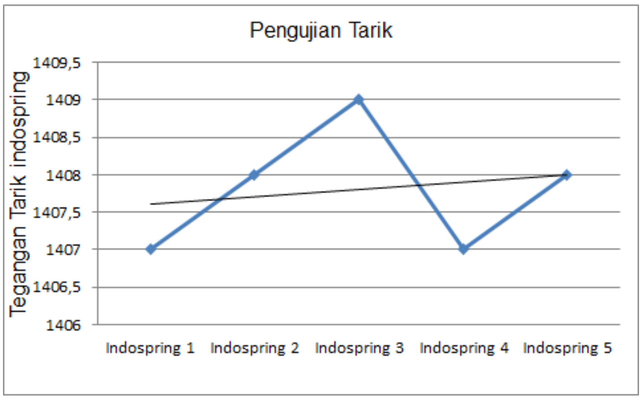

Figure 24. Graph of Tensile Strength Test Results

Analysis of the results of the tensile test that has been carried out on the hardness test data to analyze the mechanical strength of the spring damage Hardness Strength of Indospring Materials. In a Hino Dutro 130 HD brand car. The average hardness force is 1407.8 N/mm2 The hardness in specimen 1 is 1407 N/mm2 in specimen 2, the hardness is 1408 N/mm2 in specimen 3, the result is a hardness of 1409 N/mm2 in specimen 4, with a hardness of 1407 N/mm2 and in the specimen 5 force Hardness value of 1408 N/mm2 The test results on each specimen the average value can be described in table 10

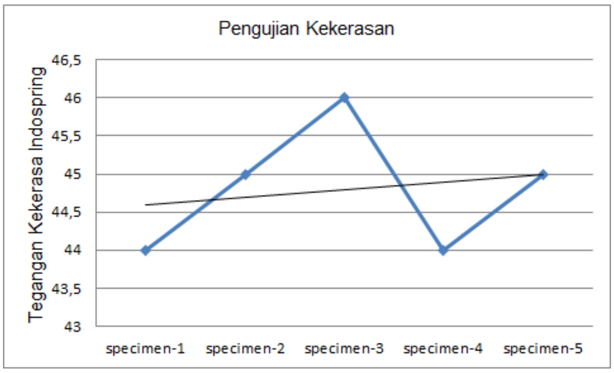

Figure 25. Graphical data Results of the average value of Indospring Material Hardness Test Results

Indospring Material Bending Test

Table 10. Data on Bent Test Results for Indospring Materials

No	Test Item Name	Prisoner Moment (Wp) (mm³)	fulcrum distance (L) (mm)	Crooked Style (F) (N)	Bending Voltage (σb) (N/mm²)
1	Indospring 1	826,83	200	41800,00	10110,91
2	Indospring 2	826,83	200	41800,00	10110.91
3	Indospring 3	826,83	200	42200,00	10207,66
4	Indospring 4	826,83	200	42110,00	10180,45
5	Indospring 5	826,83	200	42110,00	10180,45
Average value				42002,20	10158,07

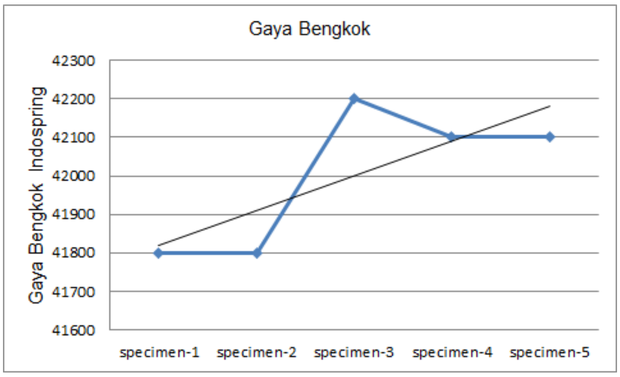

Figure 26. Graph of Bent Test Results

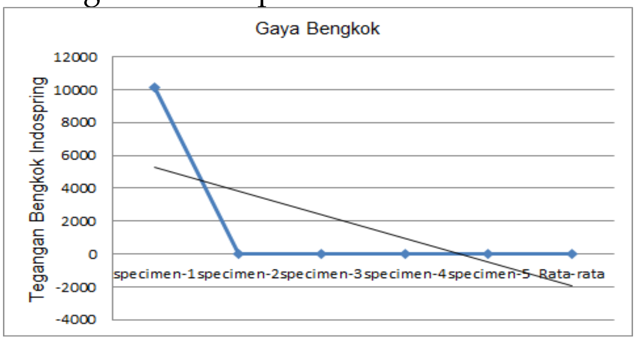

Figure 27. Bending Stress Test chart

Bending Test Analysis of Indospring Materials

Tests for Bending of Indospring Materials that have been carried out on the data for Bending of Indospring Materials to be carried out Analyze the mechanical strength of spring damage. Strength of Indospring Materials. In a Hino Dutro 130 HD brand car. The average hardness force is 1407.8 N/mm2 Bending stress of the Indospring material in specimen 1 with a bending stress of 10110.91 N/mm2 in specimen 2 Bending of the Indospring material 10110.91 N/mm2 in specimen 3 the result of the Bend test of the Indospring material is 10207, 66 N/mm2 in specimen 4 with Bent Indospring Material 10180.45N/mm2 and in specimen 5 the value of Bending Indospring Material is 10180.45 N/mm2 So that the use of this indospring spring. The route that is traversed varies, ranging from flat dirt roads and sometimes potholes, especially at sand collection locations, to flat paved roads, so the weight of the cargo being transported is not known for sure. However, it can be estimated based on the carrying capacity, the weight of the cargo ranges from 7-10 tons, for one transport. We can describe the test results for each specimen with an average value in table 10.

HOP Material Bending Test

Table 11. Data from Hop Material Bending Test Results

No	Name of Test Object	Prisoner Moment (Wp) (mm^3)	fulcrum distance (L) (mm)	Crooked Style (F) (N)	Bending Voltage (σb) (N/mm^2)
1	Hop	826,83	200	38750,00	9723,06
2	Hop	826,83	200	37122,43	9143,22
3	Hop	826,83	200	37122,43	9143,22
4	Hop	826,83	200	39231,33	9955,10
5	Hop	826,83	200	39231,33	9955,10
Average value				38291,50	9583,94

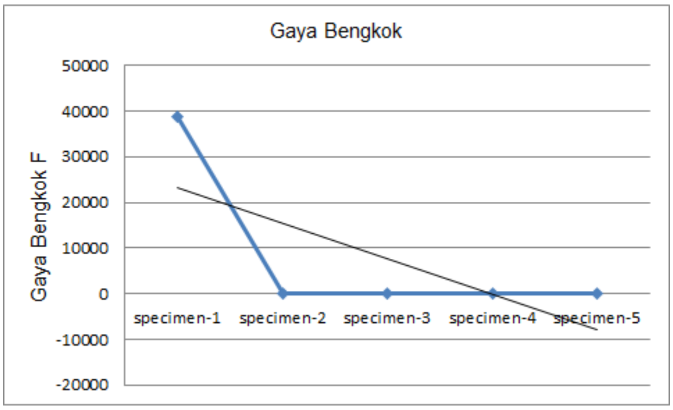

Figure 28. Bending Force Testing chart

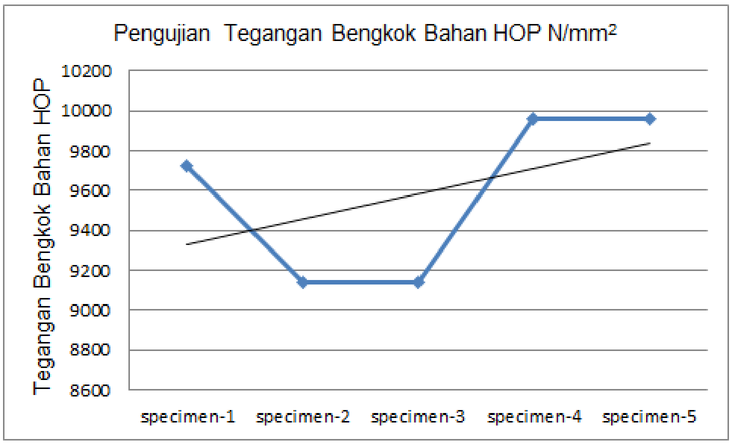

Figure 29. Bending Stress Test Graph

HOP Material Bending Test Analysis

Tests for Bending of Indospring Materials that have been carried out on the data for Bending of Indospring Materials to be carried out Analyze the mechanical strength of spring damage. Strength of Indospring Materials. In a Hino Dutro 130 HD brand car. The average hardness stress is 1407.8 N/mm2 Bending stress of the Indospring material in specimen 1 with a bending stress of 9583.94 N/mm2 in the specimen, 2 Bending of the Indospring material 9143.22 N/mm2 in the specimen, 3 results of the Bent test of the Indospring material 9143.22 N/mm2 in the specimen, 4 with the Indospring Material Bending 9955.10N/mm2 and in the specimen, 5 the bending force of the Indospring Material is 9955.10 N/mm2.

So that the strength of this material is feasible and good for use while the load of dump trucks. The road routes traversed vary, ranging from uneven dirt roads and sometimes potholes, especially at sand collection locations, to flat paved roads, so the weight of the cargo being transported is not known for certain. However, it can be estimated based on the carrying capacity, the weight of the cargo ranges from 7-10 tons, for one transport. We can describe the test results for each specimen with an average value in table 11.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

From the analysis process of leaf spring testing how much influence the Data Hardness Test Results on mechanical properties (Tensile and Twist) Hardness obtained the following results:

1) The average tensile strength is 39.4, (HRC) Violence stress in specimen 1 39 HRC in specimen 2, hardness 39 HRC in specimen 3 results in a tensile force of 40 HRC in specimen 4 with a hardness of 40 HRC and in specimen 5 the value of Hardness of 39 HRC

2) The average tensile strength is 39.4, (HRC) Violence stress in specimen 1 39 HRC in specimen 2, hardness 39 HRC in specimen 3 results in a tensile force of 40 HRC in specimen 4 with a hardness of 40 HRC and in specimen 5 the value of Hardness of 39 HRC

3) The average tensile stress is 44 .8 (HRC) The hardness in specimen 1 is 44 HRC in specimen 2, the hardness is 45 HRC in specimen 3, the result is a tensile force

of 46 HRC in specimen 4 with a hardness of 44 HRC and in specimen 5, the hardness value is 45 HRC

4) The average force of hardness is 1407.8 N/mm2 The hardness of specimen 1 is 1407 N/mm2 in specimen 2, the hardness is 1408 N/mm2 in specimen 3, the result is a hardness of 1409 N/mm2 in specimen 4 with a hardness of 1407 N/mm2 and on specimen 5 force the Hardness value is 1408 N/mm2

5) Indospring Material Strength. In a Hino Dutro 130 HD brand car. The average hardness force is 1407.8 N/mm2 Bending stress of the Indospring material in specimen 1 with a bending stress of 10110.91 N/mm2 in specimen 2 Bending of the Indospring material 10110.91 N/mm2 in specimen 3 the result of the Bend test of the Indospring material is 10207, 66 N/mm2 in specimen 4 with Bent Indospring Material 10180.45N/mm2 and in specimen 5 the force value of Indospring Material Bending is 10180.45 N/mm2

Suggestion

We recommend that in research the Test Result Data for this leaf spring material use standard sizes and samples that exist in several brands of leaf springs so that it becomes a reference for companies in recommending leaf springs for companies from dump truck cars in procuring and using leaf springs. Subsequent research should carry out microstructure testing and chemical testing on each brand of pagas leaf used for research.

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Ismail thamrin, analisa tegangan-regangan struktur pegas daun akibat modifikasi penekanan, jurusan teknik mesin fakultas teknik, universitas sriwijaya jl. Raya palembang – prabumulih km 32, inderalaya

Bayu Janoko1, Triyono2, Eko Prasetya Budiana2,MEKANIKA Volume 12 Nomor 2, Maret 2014 108 ANALISA KEGAGALAN PEGAS ULIR PADA BOGIE TIPE NT 11 (K5) UNTUK GERBONG KERETA EKONOMI (K3) 1Program Sarjana Jurusan Teknik Mesin – Universitas Sebelas Maret
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