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Strength Characteristics of Go-Kart Rear Axle on Mechanical Properties

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Abstract:- Shaft failures often occur due to incidents. Incidents occur because the components used by the Go-Kart shaft must use lightweight materials so that the shaft works faster. The purpose of this study is to determine the strength characteristics of the Go-Kart rear wheel shaft on mechanical properties with ASTM A414 Grade A steel material after bending test and impact test. whether there is an effect of Go-Kart rear wheel shaft temperature with ASTM A414 Grade A steel material on toughness and curvature after going through the normalizing process and tempering process. The method was carried out using the heat treatment process method, three-point bending testing, and the Charpy Impact Test method. The lowest impact price value is obtained in the normalizing process of 800 ° C and the tempering process of 250°C, namely in the specimen (A3) which is 0.059 joules / mm2. The lowest three-point bending test results obtained by Specimen C3 with a normalizing process of 900°C and a tempering process of 350°C, amounting to 2059.26 N/mm2. The highest impact price value is obtained in the 850°C normalizing process and 300°C tempering process, namely in specimen (B2), which is 1.153 joules/mm2. The results of bending tests with a normalizing process of 800°C and a tempering process of 250°C (A1) and a normalizing process of 850°C and a tempering process of 300°C (B1), have the largest bending strength value, which is 2647.62 N/mm2.

Keywords:- *ASTM A414 Grade A, Heat Treatment, Three-Point Bending, Charpy Method Impact Test.*

I. INTRODUCTION

Go-Kart is one of the mechanically designed transportation that uses a motor vehicle engine as the main drive. Go-Kart has components such as frame, steering system, rear wheel axle, and other components. The wheel axle is very important in a vehicle, as well as the Go-Kart which is designed in groups, only need to adjust its shape, size, and position so that it can function properly.[1]

Despite this, shaft failures still occur frequently caused by incidents. Incidents occur because the components used by the Go-Kart shaft must use lightweight materials so that the shaft works faster, but another impact is that if a high speed occurs it can damage the Go-Kart shaft components themselves. The incident can cause economic losses. Therefore, incidents can be prevented by improving manufacturing procedures and normalizing and tempering processes.[2]

Improved axle characteristics can have a significant impact on the overall stability of the Go-kart.

Based on the description above, the authors took the title "Strength Characteristics of Go-Kart Rear Wheel Shafts Against Mechanical Properties". .

The purpose of this study is to determine the strength characteristics of the Go-Kart rear wheel shaft on mechanical properties, which will be tried with ASTM A414 Grade A steel material after bending test and impact test. And see if there is an effect of Go-Kart rear wheel shaft temperature with ASTM A414 Grade A steel material on toughness and curvature after going through the normalizing process and tempering process.

II. MATERIAL AND METHODS

Technological advances in this era have been extraordinary, especially in the automotive field. Many things have been innovated so that time and budget efficiency and product quality are better. So in this context, what methods and materials will be used to create the Go-Kart wheel axle.

The shaft that will be prioritized in this test is the Axle shaft. This shaft is usually mounted on the wheels of freight trains, so it does not get a torsional load, sometimes the axle shaft may not rotate.[3] The materials and methods used are.

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➢ *Material :*

- *Carbon Steel Material.:-*

Axle shafts usually use carbon steel. The carbon steel material used is ASTM A414 Grade A which is also a low carbon steel with a carbon content of less than 0.3% C iron structure.

Table 1 Composition of ASTM A414 Grade A Steel

Unsur kimia	Satuan	wt %
Besi	Fe	99.12
Carbon	C	0.156
Mangan	Mn	0.0023
Fosfor	P	<0.0010
Sulfur	S	<0.0050
Silikon	Si	0.028

Table 2 Astm A414 Grade A Steel Material

Properties	Unit	Value
Tensile Strength	Mpa	310
Yeild Strength	Mpa	170
Elongation at break	%	26%
Hardness	HB	110
Elastic Modulus	GPa	190
Bulk Modulus	GPa	140
Shear Modulus	GPa	73
Physical Properties ASTM A414 GRADE A		
Density	X1000 Kg/m3	7.85
Melting Point	°C	1432

- *Bending Test Equipment:-*

This tool is used to measure the strength and mechanical characteristics of a material or structure. It works by applying a load to a sample material and observing the material's response to the pressure.

- *Charpy Impact Test Equipment:-*

This tool is used to determine the strength of materials and determine the toughness of metals due to shock loading under certain conditions.

- *Maple Furnance:-*

This tool is used to heat the specimen.

➢ *Methods :*

The method carried out also uses the heat treatment process method. Heat treatment aims to change the properties of materials to make them softer, more ductile and eliminate stresses. In the process of heat treatment of materials can produce durable materials. The heat treatment process is a combination of heating and cooling of a metal to obtain a better material. The existence of that process is:

- *Normalizing:-*

Normalizing is the process of heat treatment or heating steel until it reaches austenite. After that, the austenite microstructure is obtained which is then cooled in the open air to room temperature. From this process, changes in structure and material will occur, resulting in ductility and hardness in the material.[9]

In this process the steel carbon is heated above the critical temperature (800 - 900°C), then after reaching the critical temperature the steel is held at that temperature, and finally the steel is cooled. The cooling is in accordance with room temperature, the length of this cooling which greatly affects the mechanical properties of the steel. The faster the cooling, it will produce steel with melanin properties in the form of higher strength and hardness. Conversely, if the cooling is long, the opposite will occur.

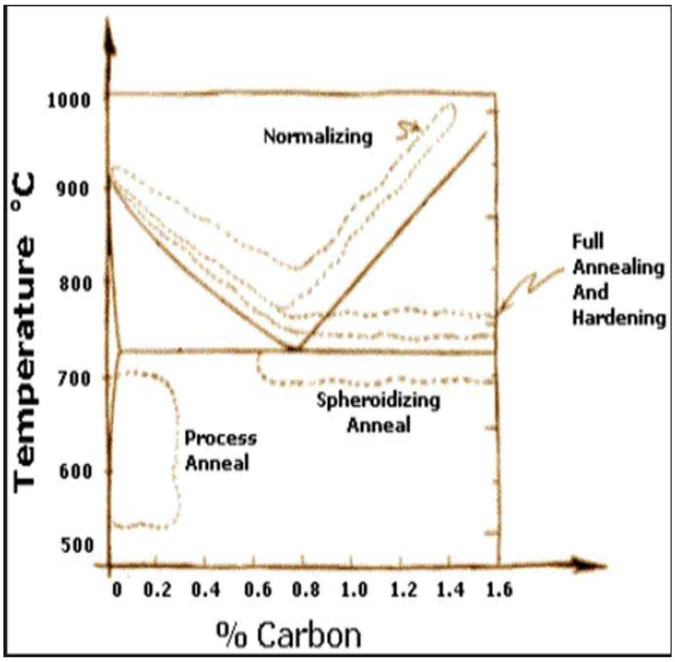

Fig 1 Normalizing Process

- *Tempering:-*

This process is the reheating of a metal that has been hardened through the normalizing process at a temperature below its critical temperature for a certain time and cooled slowly. The goal is to reduce residual stress, reduce hardness, increase metal ductility and toughness so as to obtain the right combination of metal hardness and ductility.[11]

- *Fe3C Phase Diagram:-*

This diagram is to determine the relationship between temperature and phase changes during the cooling process with carbon content (%C).

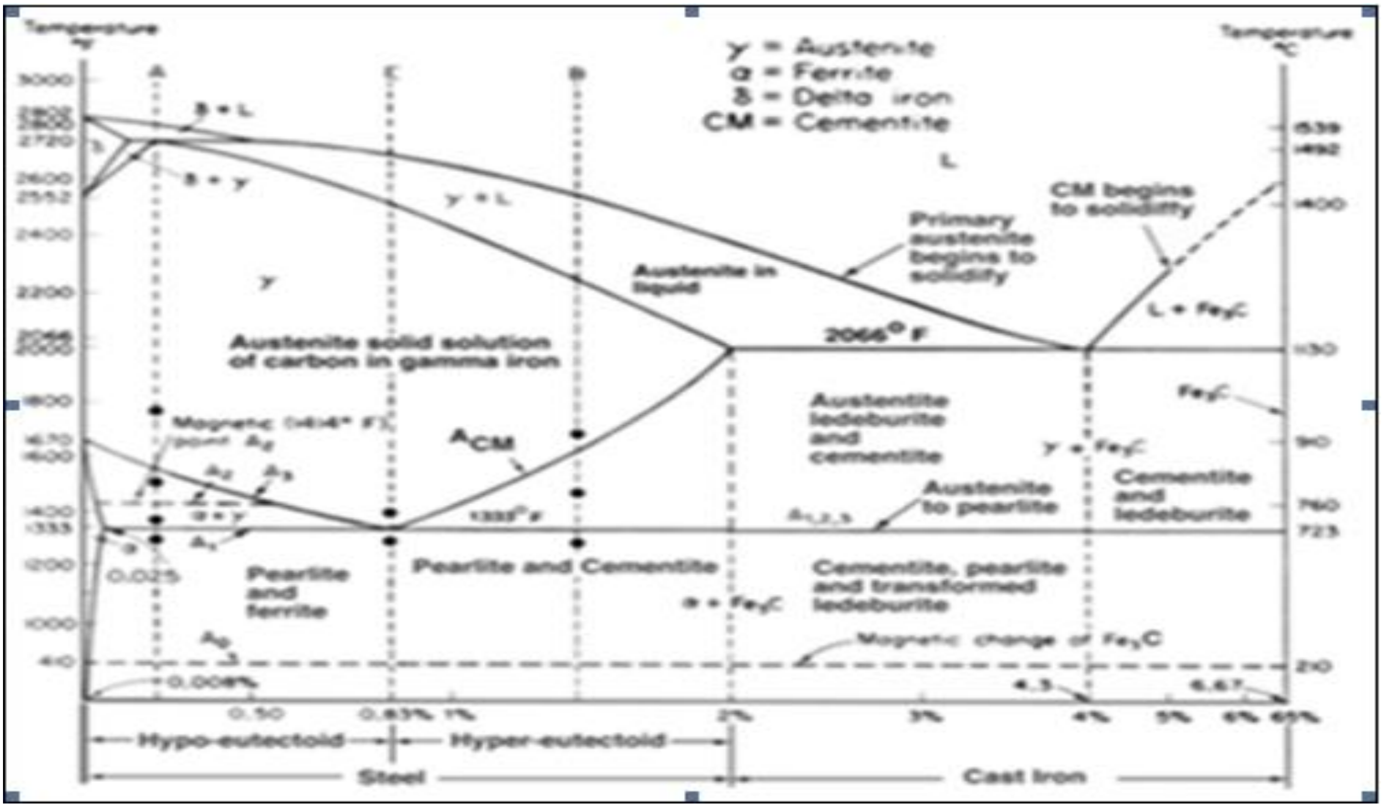

Fig 2 Fe3C Phase Diagram

- *Three-Point Bending Test:-*

Three-point bending testing is a way of testing that uses 2 supports and 1 emphasis. The specimen is given a load at one point, namely the center of the rod (0.5 L). This method must be right at the center point of 0.5L so that the moment obtained is the maximum moment.[5]

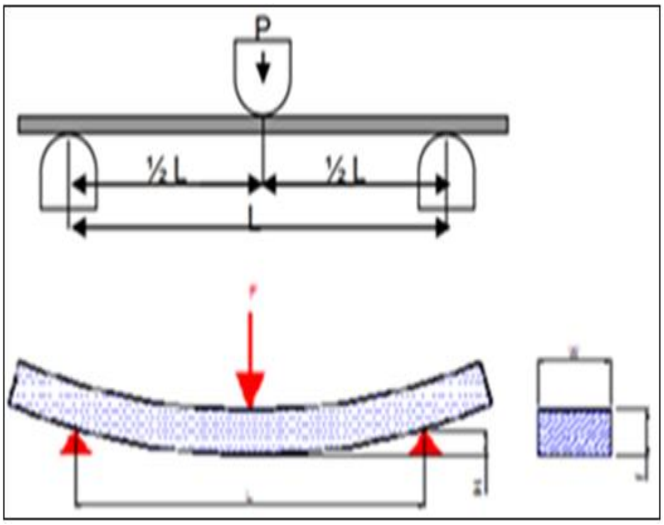

Fig 3 Schematic of Three-Point Bending Test

With the equation used:

$$\sigma = \frac{3\,x\,P\,x\,L}{2\,x\,W\,x\,T^2}$$

Where :

σ = Bending Strength (N/mm2)
P = Press Load or Force (N)
L = Distance of two fulcrums (mm)
W = Specimen width (mm)
T = Thickness of specimen (mm)

- *Charpy Method Impact Test:-*

This test is commonly referred to as the Charpy V-notch test which is a standard high strain rate test that determines the amount of energy absorbed by the material during fracture. The energy absorbed depends on the ductile-brittle transition temperature. In addition, this test is also used to determine the strength of the material.[7]

- *Impact Test Formula :-*

$$HI = \frac{GxD(\cos\beta - \cos\alpha).L}{A} \quad \text{(joule/mm}^2\text{)}$$

Where:

D = 0.6345 m
G = 26.12 kg
L = 0.75m
cos λ = initial position angle of the pendulum

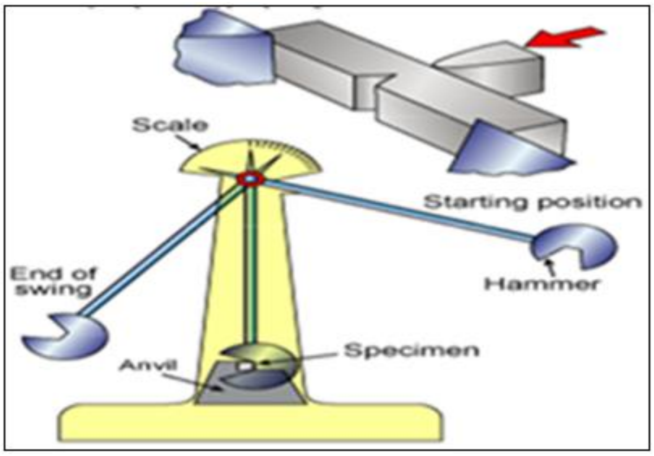

Fig 4 Schematic Illustration of Impact Testing

III. RESULTS AND DISCUSSION

A. Impact Testing Results

The results obtained from testing with the Impact testing method are as follows :

➢ *The Formula used :*

$$HI == \frac{G \; x \; D \; (coscos \; \beta - coscos \; \alpha) \; x \; L}{A} = (Joule/mm^2)$$

Where :

G = 26.12 kg
D = 0.6345 m
L = 0.75 m

Table 3 Then the Results of Impact Testing with a Normalizing Process of 800°C and a Tempering Process of 250°C are :

Specimen	**A1**	**A2**	**A3**
Long (mm)	55	55	55
Width (mm)	10	10	10
Thick (mm)	2	2	2
Cross sectional area	20	20	20
Corner α (°)	144	144	144
Corner β (°)	83	107	106
Pendulum Axis Distance to center of weight (m)	0.6345	0.6345	0.6345
Lever length (m)	0.75	0.75	0.75
Pendulum weight (kg)	26.12	26.12	26.12
Impact Energy (Joule/mm²)	0.386	0.069	0.115

Table 4 Then the Results with Impact Testing with Normalizing Process 850°C and Tempering Process 300°C

Specimen	**B1**	**B2**	**B3**
Long (mm)	55	55	55
Width (mm)	10	10	10
Thick (mm)	2	2	2
Cross sectional area	20	20	20
Corner α (°)	144	144	144
Corner β (°)	74	85	93
Pendulum Axis Distance to center of weight (m)	0.6345	0.6345	0.6345
Lever length (m)	0.75	0.75	0.75
Pelundum Weight (kg)	26.12	26.12	26.12
Impact Energy (Joule/mm²)	0.435	1.153	0.344

Table 5 Then the Results with Impact Testing with 900°C Normalizing Process and 350°C Tempering Process

Specimen	**C1**	**C2**	**C3**
Long (mm)	55	55	55
Width (mm)	10	10	10
Thick (mm)	2	2	2
Cross Sectional area	20	20	20
Corner α (°)	144	144	144
Corner β (°)	81	87	83
Pendulum Axis Distance to center of weight (m)	0.6345	0.6345	0.6345
Lever length (m)	0.75	0.75	0.75
Pelundum Weight (kg)	26.12	26.12	26.12
Impact Energy (Joule/mm²)	0.059	0.187	0.386

➢ *Then the Comparison Obtained from Each Test Result is :*

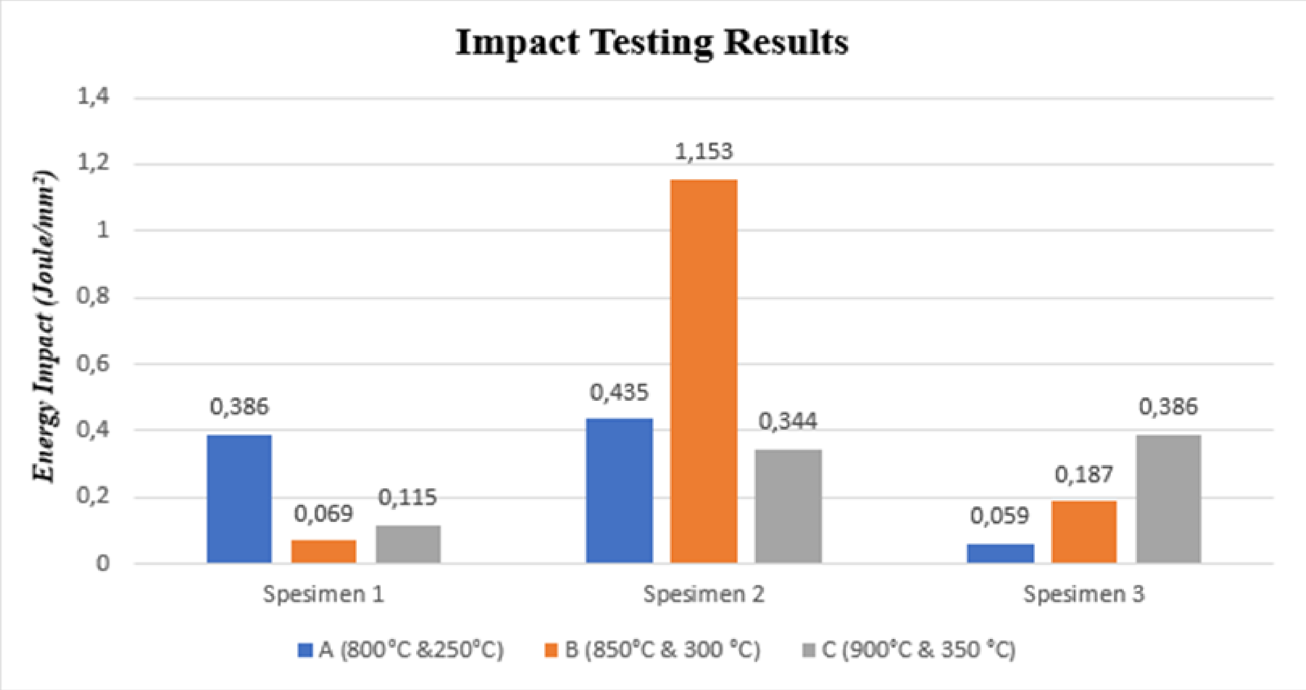

Fig 5. Comparison Results of Each Impact Test

Based on the results of the graph above, the highest Impact value is obtained in the normalizing process of 850 ° C and the tempering process of 300 ° C, namely in specimen B2 which is 1.153 joules/mm^2 . While the lowest Impact value is in specimen A3 with normalizing 800 ° C and tempering 250 ° C which is 0.059 joules / mm $^{2.}$. This shows that the material with the strongest structure is obtained by specimen B2.

B. Bending Test Results

➢ *The Formula used is:*

$$\sigma = \frac{3\,x\,P\,x\,L}{2\,x\,W\,x\,T^2}$$

Where:

σ = Bending Strength (N/mm^2)
P = Press Load or Force (N)
L = Distance of two fulcrums (mm)
W = Specimen width (mm)
T = Thickness of specimen (mm)

Table 6. Then the Results of Bending Test Testing with Normalizing Process 800°C and Tempering Process 250°C are :

Specimen	**A1**	**A2**	**A3**
Long (mm)	250	250	250
Width (mm)	25	25	25
Thick (mm)	2	2	2
Force (kgf)	90	80	80
Force (N)	882.54	784.48	784.48
Distance between two fulcrums (mm)	200	200	200
Bending strength (N/mm^2)	2647.62	2353.44	2353.44

Table 7. Then the Results of Bending Test Testing with 850°C Normalizing Process and 300°C Tempering Process are :

Specimen	**B1**	**B2**	**B3**
Long (mm)	250	250	250
Width (mm)	25	25	25
Thick (mm)	2	2	2
Force (kgf)	90	85	82
Force (N)	882.54	833.51	804.092
Distance between two fulcrums (mm)	200	200	200
Bending strength (N/mm^2)	2647.62	2500.53	2412.276

Table 8. Then the Results of Bending Test Testing with 900°C Normalizing Process and 350°C Tempering Process are :

Specimen	**C1**	**C2**	**C3**
Long (mm)	250	250	250
Width (mm)	25	25	25
Thick (mm)	2	2	2
Force (kgf)	85	75	70
Force (N)	883.51	735.45	686.42
Distance between two fulcrums (mm)	200	200	200
Bending Strength (N/mm^2)	2500.53	2206.35	2059.26

Then the comparison obtained from each Bending Test test result is:

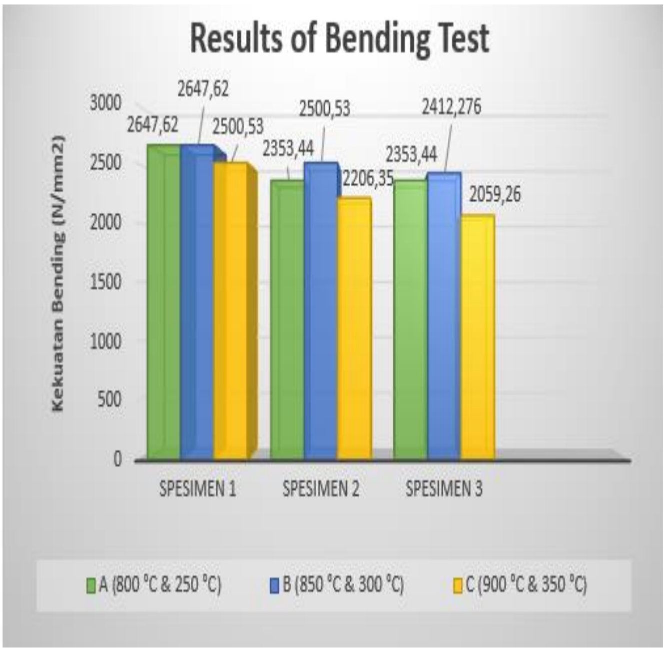

Fig 6 Results of Bending Test

Based on the results of the graph above, the value obtained with the largest bending value is Specimen B1 with a normalizing process of 800 ° C and a tempering process of 300 ° C which produces a value of 2647.62 N/mm^2. While the lowest results were obtained by Specimen C3 with a normalizing process of 900 ° C and a tempering process of 350 ° C which produced a value of 2059.26 N/mm^2.

IV. CONCLUSION

In the Impact test, it was found that specimen B2 which went through the 850°C normalizing process and the 300°C tempering process experienced an increase in impact force, where the impact force was 1.153 $joules/mm^2$. Specimen A3 which has gone through the normalizing process of 800 ° C and the tempering process of 250 ° C has decreased the impact force, which is 0.059 joules / mm^2.

In the Bending test, it was found that specimen A1 which went through the normalizing process of 800°C and the tempering process of 250°C and specimen B1 which went through the normalizing process of 850°C and the tempering process of 300°C experienced the greatest bending strength of 2647.62 N/mm^2. Specimen C3 which went through the normalizing process of 900 ° C and the tempering process of 350 ° C experienced the lowest bending strength of 2059.26 N/mm^2.

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