JMM: Journal of Mechanical and Manufacture
Vol. 3 No 1, October 2023 , pp. 22-29
DOI: 10.31949/jmm.v3i1.6520
e-ISSN: 2829-4424

ANALYSIS OF THE EFFECT OF VARIATION OF ELECTRIC CURRENT AND HOLDING TIME ON THE TEMPERING PROCESS TO IMPROVE MECHANICAL PROPERTIES OF AUTOMATIC TRANSMISSION SPREAD SHAFTS OF SUPRA X150 MOTORCYCLE

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ABSTRACT
A study has been carried out on the transmission shaft or main shaft used on the Supra x150 motorcycle vehicle. The material used for the main shaft component is made of SCr420 steel, which is an alloy steel similar to SAE 4118 or JIS SCM 420. The research carried out is the Temper Process with the aim of reducing hardness but increasing other mechanical properties, namely the more ductile nature of the material by how to vary the tempering temperature with the electric current used. This tempering process uses an induction furnace. The electric current used starts from 79 A, 80 A and 81 A with a holding time of 15 s, 20 s and 25 s for each Ampere. Tempering process with the required temperature and time is very influential on the hardness of the material. The lower the temperature and the shorter the Tempering process time, the higher the hardness of the material, and vice versa, the higher the temperature and the longer the Tempering process, the lower the hardness of the material.
From the results of the tests that have been carried out, it is obtained that some cannot be applied, but if seen from the electric current used, the efficient one is test number 4 because it uses a current of 79 Amperes

Keywords: Tempering, Current Strength, Supra X150 Motor, SAE 4118 Steel

Submitted: yyyy-mm-dd	Revised: yyyy-mm-dd	Accepted: yyyy-mm-dd

Introduction

The processing of steel materials in the process of making motorized vehicle parts cannot be separated from the hot working process and other processes so that the material can be shaped as desired, but the impact of the hot working process and a series of other processes will change the structure and mechanical properties of the material. steel, therefore the process of improving the structure and mechanical properties of the steel must be carried out. The process of improving the structure and mechanical properties is done by means of heat treatment (Heat Treatment).
Changes in properties obtained from heat treatment of steel are mechanical properties such as hardness, ductility, toughness, etc. which are the properties that most often change with heat treatment. Some common heat treatments carried out on steel are annealing, normalizing, quenching, and tempering. Tempering is heating the metal to below a critical temperature which is carried out after the hardening, cold forming and welding processes, then cooled at sufficient speed, in order to improve the desired properties. . Tempering heat treatment aims to reduce residual stresses, increase the toughness and ductility of martensite-hardened steel.

Carbon Steel

Steel material is superior in terms of strength, stiffness and ductility, so it's no wonder that in every project and building construction, steel is always found in the manufacture of motor vehicle materials, although of course the volume doesn't have to dominate.
The review in terms of strength, stiffness and ductility is very suitable for evaluating structures that are given a load. But keep in mind that besides these conditions there will be environmental influences that affect the survival of the building structure. So in certain conditions, a building can even be damaged even without being given a load (not yet functioning). So the resistance of construction materials to the surrounding environment is important to know so that they can be properly anticipated.

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Heat Treatment

Heat treatment is a process of heating and cooling metal in the solid state to change its mechanical properties. Steel can be hardened to increase wear resistance and cutability or can be softened to facilitate further machining. Through proper heat treatment, internal stress can be removed, grain size can be enlarged or reduced. In addition, the toughness is increased or a hard surface can be produced around the ductile core. To enable proper heat treatment, the chemical composition of steel must be known because changes in chemical composition, especially carbon can result in changes in physical properties. (Ainie, 2007).

Tempering

Tempering is the heating of metal to below a critical temperature which is carried out after hardening, cold forming and welding, and then cooling to a sufficient rate, in order to improve the desired properties.

Tempering heat treatment aims to reduce residual stresses, increase the toughness and ductility of martensite-hardened steel. During the tempering process, the hardness and strength will decrease. However, the ductility will increase followed by a decrease in brittleness. The residual stresses formed during the formation of the martensite phase are also reduced. The reduction of residual stress becomes very important in reducing the brittleness of steel. During tempering, there will be a transformation of the phases formed during the quenching process. The phase transformation mechanism in the tempering process occurs in four stages. Stages and mechanism of martensite phase decomposition

1. In the first stage, at a temperature of 100 – 250 Celsius, a carbon-rich phase is deposited, namely the epsilon-carbide phase. The formation of this phase causes the carbon content in the martensite phase to decrease.
2. The second stage, at a temperature of 200 – 300 Celsius, the austenite phase decomposes into bainite.
3. The third stage, at a temperature of 200 – 300 Celsius, there is a change or decomposition of epsilon – kabida into cementite and marsentite into cementite and ferrite.
4. The fourth stage, at temperatures above 350 Celsius there is a continuous change and spheroidization of the cementite phases occurs.

Hardness Testing

The hardness test is the most effective test because with this test we can easily find out the description of the mechanical properties of a material. Even though measurements are only made at a certain point or area, the hardness value is valid enough to express the strength of a material. By carrying out the hardness test, the material can easily be classified as ductile or brittle. Hardness (hardness) of rubber is the resistance of the rubber surface to the penetration of a load with a certain weight and the tip is shaped like a ball or cone. The spherical shape is called IHRD (International Rubber Hardness Degrees) and the conical Shore Hardness Degrees. The unit for hardness is degrees and ranges from 0 to 100. 0 (nul) is absolute soft and 100 is very hard.

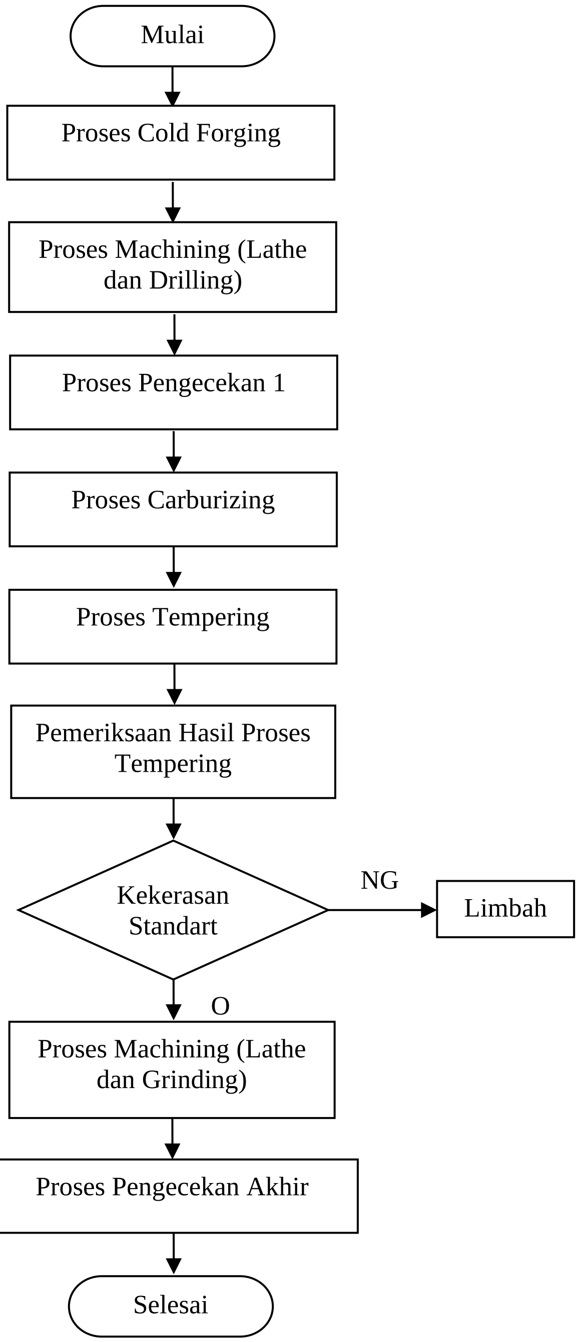
Hardness is one of the mechanical properties of a material. The hardness of a material must be known, especially for materials that will experience friction (frictoinal force) in use. In this case, the scientific field that plays an important role in studying it is Metallurgy Engineering. Hardness is defined as the ability of a material to withstand indentation or penetration (stress) loads. In the world of engineering, hardness testing generally uses 4 kinds of hardness testing methods, namely:

1. Brinell (HB / HBN)
2. Rockwell (HR/RHN)
3. Vickers (HV / HVN)
4. Micro Hardness / Knoop Hardness (H / HN)

Research Method

Automatic Transmission Shaft Manufacturing Flow Chart

The steps for making an Automatic Transmission Shaft based on the flow chart are as follows:



Specimen preparation In this research process, the basic material used was AISI 1037 plate with a thickness of 5 mm, the shape of the material is shown in the figure below.

Welding Machine Image

Results and Discussion

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Research Implementation Experimental Materials

SCr420 steel material has high strength and hardenability, in water the critical hardening diameter reaches 4 to 22 mm, in oil the critical hardening diameter reaches 11 to 40 mm, but the toughness of this type of steel in the carburizing process has grains, direct cooling at SCr420 steel has a large impact on toughness, so it is necessary to do a cooling process twice and a process to increase its toughness, with the addition of a normalization process or a tempering process will strengthen the toughness of SCr420 steel. The composition of the SCr420 steel material is:

SCr420 steel material composition table

C	Si	Mn	Cr	Ni	Cu	P	S	Nb
0.18 –0.24	0.17 – 0.37	0.5 – 0.8	0.7 – 1	≤ 0.03	≤ 0.03	≤ 0.035	≤ 0.035	19

Figure Main Shaft process materials

Electrical Ampere Data and Testing Time

Table Electric amperage data and test time

No	Arus listrik (A)	Waktu (s)
1	79	15
2	80	15
3	81	15
4	79	20
5	80	20
6	81	20
7	79	25
8	80	25
9	81	25

Tempering Machine
The equipment used in this research is an induction type Tempering machine which has the following specifications
Machine name : Main & Secondary Shaft Tempering Equipment
Serial Number : 102-72217 (AP77-236)
Year made : February 2003
Supply : 3Ø 200V 10kVA 50Hz
Transistor : Inverter type LTG-100-20
Inputs : 28 kVA, 200V, 50Hz
Manufacturer : Denki Kogyo Co., Ltd


Figure Tempering Machine

Figure Jig Tempering process

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Figure Components of conductors or heating elements

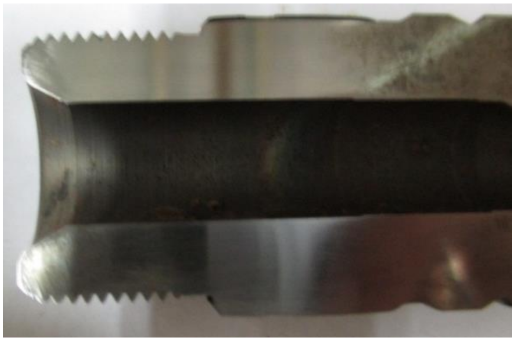

Figure Pieces of material for measurement

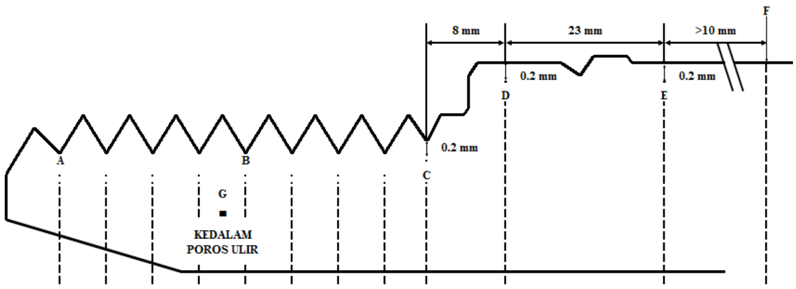

Figure Area of measurement of hardness in the material

Table Measurement results of the normal Tempering process

Area	Standart	Hasil								
ABC	HV 300~434	424	409	411	415	417	411	409	411	420
D	HV 302~513	472								
E	HV 471~746	690								
F	HRC 58~62	62								

G	HRC 20~30	28								

From the measurement results above, the tempering process with a current of 80 amperes and a time of 20 seconds is stated to be standard.

Data Analysis

The results of the analysis of the measurement results above are as follows

1. The Tempering process with an electric current of 79 Amperes and a time of 15 seconds produces a heating temperature of 643 ºC (lower than the normal process) and a machine time of 26.1 seconds (shorter than the normal process) produces a high hardness value in the areas A B C D F and G (NG), while the E area is included in the standard.
2. The Tempering process with an electric current of 80 Amperes and a time of 15 seconds produces a heating temperature of 637 ºC (lower than the normal process) and a machine time of 26.1 seconds (shorter than the normal process) results in a high hardness value in areas A B C D F and G (NG), while the E area is included in the standard.
3. The Tempering process with an electric current of 81 Amperes and a time of 15 seconds produces a heating temperature of 645 ºC (lower than the normal process) and a machine time of 26.1 seconds (shorter than the normal process) produces a hardness value that is still high in areas A B C F and G (NG), while areas D and E are included in the standard.
4. The Tempering process with an electric current of 79 Amperes and a time of 20 seconds produces a heating temperature of 689 ºC (lower than the normal process) and a machine time of 34.1 seconds (the same as the normal process) produces a hardness value that is still within standards in the area A to G. (OK)
5. The normal process of Tempering with an electric current of 80 Amperes and a time of 20 seconds produces a heating temperature of 713 ºC and a machine time of 34.1 seconds produces a standard hardness value in the area A to G. (OK)
6. The Tempering process with an electric current of 81 Amperes and a time of 20 seconds produces a heating temperature of 731 ºC (higher than the normal process) and a machine time of 34.1 seconds (same as the normal process) resulting in a hardness value that is still within the standards in the area A to G. (OK)
7. The Tempering process with an electric current of 79 Amperes and a time of 25 seconds produces a heating temperature of 760 ºC (higher than the normal process) and a machine time of 41.1 seconds (longer than the normal process) results in a hardness value still within the standard in the area A to G .(OK)
8. The Tempering process with an electric current of 80 Amperes and a time of 25 seconds produces a heating temperature of 751 ºC (higher than the normal process) and a machine time of 41.1 seconds (longer than the normal process) produces a hardness value that is still within the standard in the area A to G .(OK)
9. The Tempering process with an electric current of 81 Amperes and a time of 25 seconds produces a heating temperature of 747 ºC (higher than the normal process) and a machine time of 41.1 seconds (longer than the normal process) results in a hardness value still within the standard in the area A to G .(OK)

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Conclusion

1. The Tempering process with the required temperature and time greatly affects the hardness of the material. The lower the temperature and the shorter the Tempering process time, the higher the hardness of the material, and vice versa, the higher the temperature and the longer the Tempering process, the lower the hardness of the material.

2. From the results of the tests that have been carried out, some cannot be applied, namely tests number 1, 2, and 3 because there are measurement results outside the standard (NG). While testing numbers 7, 8, and 9 the results of measuring the hardness of the material are in standard (OK) but the time needed for the Tempering process is longer than the normal process, which is around 7 seconds for each process. Then the tests that can be applied are tests number 4 and 6, because both of them produce hardness that is still in standard (OK) and the same time, namely 34.1 seconds, but when viewed from the electric current used, the efficient one is test number 4 because using a current of 79 Amperes.

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