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GREENATION Research

Comparative Analysis Of 95MXC and SS420 Coatings Using Wire Arc Spray Method On Hardness and Microstructure Result

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Abstract: Material coating technology is a method that is often applied to improve the mechanical properties and characteristics of a material. The materials often used in the coating process are metal materials, including medium carbon steel such as AISI 1045, which is often used as machine parts, light pressure gears, pinion forming dies, hydraulic shafts, pump shafts, piston rods. Coating materials vary greatly, this is adjusted to suit needs, such as the SS420 and 95MXC materials used because they have quite high wear resistance and corrosion resistance properties. The composition of the coating material and the strong current in the coating process can affect the quality of the coating results formed on the material. In this research, we will determine the wire with the best results using the wire arc spray method as a coating method to increase the mechanical properties of the PLTU boiler using 95 MXC and SS 420 wire. The highest hardness results were obtained for 95MXC wire with a value of 45.98 HRC. Meanwhile, the hardness value for SS420 wire is 33.11 HRC and the results of microstructure observations also show an increase in thickness of the 95MXC layer with a value of 297.99 µm in line with the increase in hardness of the coating layer, because in a thicker coating layer the coating material particles will spread evenly and denser, thereby increasing the hardness value

Keyword: Wire Arc Spray, Coating Process, Hardness Test, Microstructure Test

INTRODUCTION

Material coating technology or what is called coating, is a method that is often used to improve the mechanical properties and characteristics of a material so that it meets the desired specifications. In its implementation, the method most often used is the thermal spray coating method. In simple terms, the thermal spray coating process uses a heat source at a high temperature to melt the coating material so that it can coat the substrate. In this research, Ni-Al was used as a bond coat and a mixture of 95 mxc and SS400 as a top coat to coat a medium carbon substrate using the wire arc spray method. In simple terms, the thermal spray coating process uses a heat source at a high temperature to melt the coating material so that it can coat the substrate. In thermal spray coating itself, there are several types of methods that can be used, including flame spray, wire arc spray, high-velocity oxy-fuel spray (HVOF) and plasma spray which have different variations and detailed specifications but the basic principles used are the same.

The use of two different materials aims to increase the service life of the material against corrosion and environmental factors and determine the best coating in terms of hardness and microstructure properties for application to boilers at PT. Nuscaco Hasteloy Turbine Service. This process procedure is carried out by observing the microstructure of the Ni-Al coating system and 95 mxc and ss400 alloy with AISI 1045 steel substrate and the resulting hardness values.

METHOD

This research began by searching for literature that was used as supporting research material and as a reference for determining the standards used when testing took place. After carrying out sufficient material literacy, the research continued by looking for a research location. then the coating process is carried out. After the coating process is complete, the research continues with the formation of test specimens based on standard sizes for hardness and metallographic testing. After the process of forming the test specimen is complete, the research continues by carrying out hardness testing and metallographic testing, the results of which will be processed and analyzed in order to obtain conclusions from the research results.

In this research, the method that will be used is the experimental method. The coating method that will be used in this research is wire arc spray coating using 95 MXC and SS 420 wire and Ni-Al as coating materials and using a substrate in the form of AISI 1045 steel plate. The coating process also applies a current strength of 300A and a voltage of 30A.

In the research flow diagram, the research procedure is divided into several stages, namely: 1) Sample preparation including substrate and coating material process coating with method wire arcSpray; 2) Hardness test process; 3) Metallographic test; 4) Analyze the results.

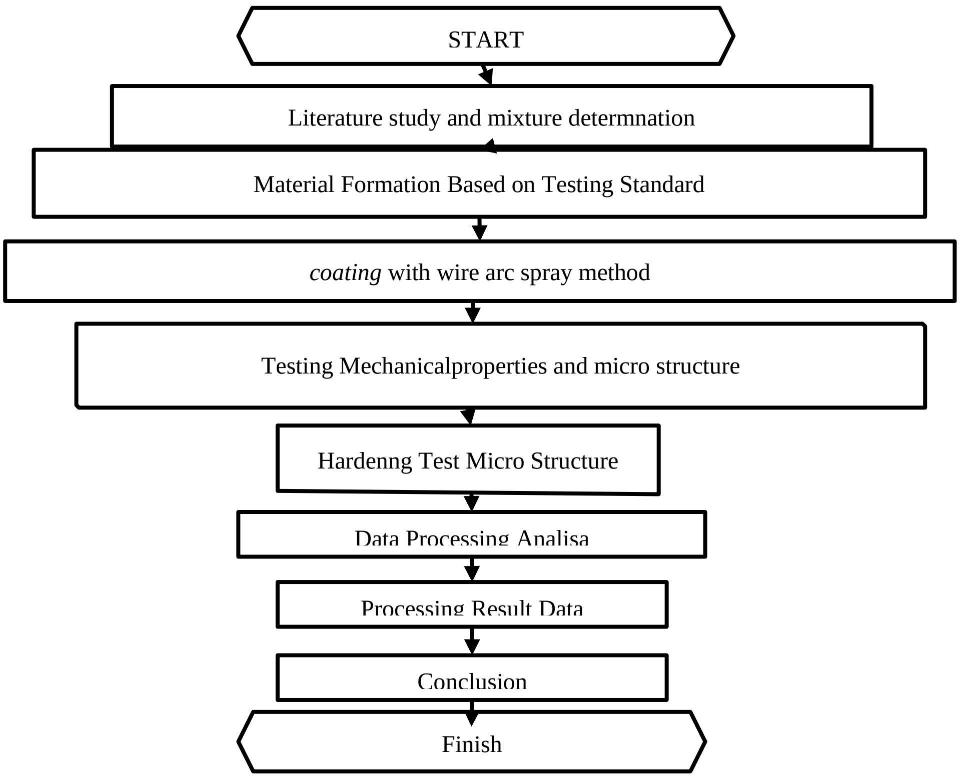

Image 1. Flow Diagram

The materials used for this research using the SS 420 and 95 Mxc wire coating process and Ni-Al board coat using the wire arc spray method include:

1. Steel AISI 1045

In this research, alloy steel is used at high temperatures, namely AISI 1045. AISI 1045 steel is a medium alloy steel containing 0.25% Cr and belongs to the medium carbon steel group.

element	presentase
S	0,42 – 0,50
Mn	0,50 – 0,80
S	0,035 maks
Si	0,17 – 0,37
Ni	1 0,25 maks
Cr	0,025 maks.
P	0,035 maks.

2. Coating (Top Coat)

The wire coating material used is one of the commercial coating materials for the metal coating process on tubes in boiler packages or in other combustion chamber areas that contain high levels of sulfur and carbon. In this research, the final layer uses an iron-chrome metal alloy with the trademarks 95 MXC and SS420. The chemical composition of this final layer can be seen from the table below.

Table 1. Chemical composition of 95MXC wire

Element	Presentase (%)
iron	50 – 75
Chromium	20 – 50
silicon	1 - 5
mangnese	1 - 5
boron	1 - 5

Table 2. Chemical composition of SS420MXC wire

element	Presentase (%)
Cr	13.0
si	1.0
Mn	1.0
C	0.32
Fe	Balance

3. Ni-Al (Bond coat)

The intermediate coating material in this test is a commercial coating which is often used in spraying metal coating applications for adhesive coatings (bond coats). The chemical composition of this final layer can be seen from the table below.

Table 3.Chemical composition Ni-Al

element	Presentase (%)
Ni	95
Al	5

4. Wire Arc Spray

This machine is used to apply the process of coating wire-shaped material onto substrate material, where to melt the two wires on the cathode and anode sides using electrical power and compressed air to push the droplets. The parameters for using the wire arc spray tool using the soup are as follows:

Table 4. Parameter

Mode	Persentase
amphere	300 A
Voltage	30 A
range	Konstant
pressure	3Bar

Hardness Test

Hardness testing was carried out on all coating samples and for each test 5 different test points were taken. Rockwell hardness testing is carried out by pressing applying a preliminary load (minor load), then adding a main load (major load), then the main load is released while the minor load is still maintained on the surface of the specimen (test object) with an indenter. The pressure of the indenter into the test object is carried out by.

Micro Structure Test

Microstructure observations were carried out using an Olympus DSX-HRS optical microscope with 150x and 750x magnification. The observations focused on the observation method of the coating layer with the substrate and were adjusted to the ASTM E3 standard.

Collection and Data Processing

The coating method used in this coating process is the wire arc spray method, using two wires as the bond coat and top coat. In this research, we used 95MXC and SS400 wire and Ni-Al as a bond coat using a current strength of 300A and a voltage of 30A with a constant distance of 3 bar, then observed the resulting hardness and microstructure values. The results of the material after the sand blasting and coating process are in the image below.

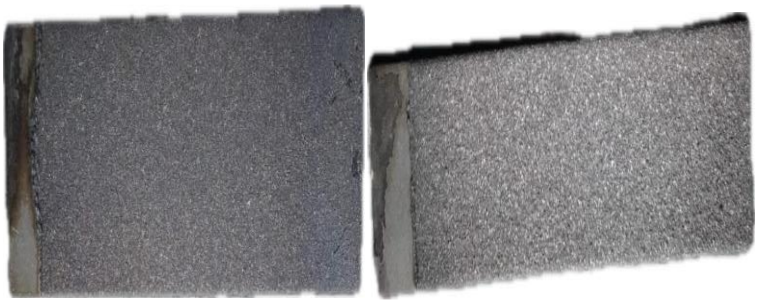

Image 2. Coating 95 MXC (top), coating SS420 (below)

RESULTS AND DISCUSSION

Hardness Test Results

The following is a table of hardness test results for the AISI 1045 steel plate substrate which has been coated using NiAl wire with 95 MXC and SS420 wire with a current strength of 300 A and a voltage of 30A.

Table 5. Coating Hardness

Coating uji	H1	H2	H3	H4	H5	Average (HRC)
95 MXC	43,01	44,57	47,27	46,58	48,20	45,98
SS 420	32,11	29,58	34,33	37,33	32,19	33,11

In table 1. It can be seen that the value of the 95 MXC w'ire hardness results is very precise

using the wire arc spray method. It is said to be very appropriate because the 95 MXC coating layer with a result of 45.98 HRC shows an increase in strength compared to SS 420 wire with a result of 33.11 HRB. This is because the coating material alloy with the addition of CR elements further increases the layer hardness value and the layer structure. it is not homogeneous because the unmelted particles and porosity reduce the density between particles and result in a low hardness value in a layer. Chromium provides resistance to high temperature oxidation and corrosion and increases the hardness of the coating by forming very hard deposits (Gonzalez, et al., 2007). The hardness value required by the company is 43.00 HRC, it can be concluded that 95 MXC wire with a strength value of 45.98 HRC has exceeded the company's standard value and is suitable for use as a coating material according to the company's needs.

Micro Structure Observation

Microstructure observation tests were carried out to see the condition between the coating layer and the substrate formed on the AISI 1045 plate sample after the coating process using 95 MXC and SS420 wire with a current strength of 300A and a voltage of 30A using a constant distance of 3 bar. The focus of observing the microstructure of the specimen is in the crooss section area which will show the boundaries of layers with a certain thickness which will later be used as a reference in selecting wire

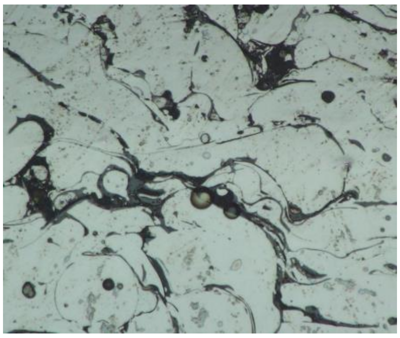

Image 3. Coating 95 MXC

In the picture is the result of coating 95 MXC wire. The results of observations using an optical microscope show that the coating material particles have been deposited perfectly, where it can be seen that the two coating materials, namely the bond coat and top coat, have spread and adhered to the substrate surface. Porosity cavities still form but are not too large

Image 4. Coating SS420

The image shows that the coating material particles have been deposited perfectly, however, there is also an increase in porosity compared to 95MXC wire. This is due to several factors that can influence the appearance of porosity, namely that the powder does not melt completely during the coating process due to differences in particle size and imperfect composition content in the wire product. To determine the thickness value of the 95 MXC and SS 420 coating layers, you can observe using 3 lines drawn from the end of the interface to the end of the coating surface and then take the average of these values. The thickness values for each layer are as follows.

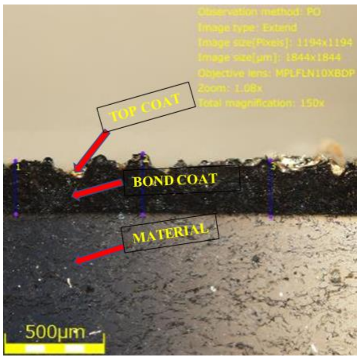

Image 5. SS420 coating thickness

In the picture, it can be seen that the thickness of the SS420 wire layer has been deposited and adhered to the sample, but it is not very even, there are empty cavities in the material that has been coated with SS42O wire

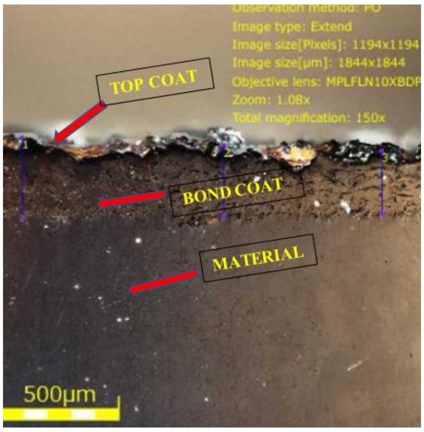

Image 6. Layer thickness 95 MXC

In Figure 4 you can see the results of the thickness of the coating being more uniform and thicker on 95 MXC wire compared to SS420. This happens because the coating particles melt completely and there are fewer voids formed between the particles. It can be seen in these two pictures that the arc spray wire coating with a current strength of 300A and a voltage of 30A uses 95 MXC and SS420 wire. The thickness results obtained are that the 95 MXC coating layer looks slightly thicker and more even.

Table 5. Coating layer thickness table

No	Coating uji	1 Distance	2 Distance	3 Distance	Rata-rata
1	95 MXC	331,64	297,988	264,335	297,99
2	SS 420	269,985	331,207	286,483	289,225

In this table it can be seen that the increase in hardness value is in line with the increase in thickness of the coating layer, because in a thicker coating layer the coating material particles will be spread evenly and denser, thereby increasing the hardness value. However, there is a decrease in the hardness value in the SS420 layer with a thickness of 289.225 µm. In the observations there was a decrease in the hardness value, this occurred because the percentage of unmelted particles increased due to solidification of the particles so that porosity was formed in the layer. This porosity will reduce the hardness value of a layer. By reducing the porosity of the coating layer, the size of the coating will become thinner because there are fewer cavities in the coating layer which causes the coating layer to become denser. It can be seen that the arc spray wire coating with a current strength of 300A and a voltage of 30A using 95 MXC and SS420 wire, the thickness results obtained are that the 95 MXC coating layer looks thicker and more even.

Steel AISI 1045

AISI 1045 carbon steel is a type of medium carbon steel (0,43-0,50% C by weight) which is widely used on the market because is has many advantages. This steel has the characteristics: good machinability, good wear resistance, and medium mechanical properties. Steel with medium carbon content is capable of forging, cold drawing, machining, heat treatment (including flame hardening) and has good wear resistance through flame treatment or induction hardening. AISI 1045 steel has the characteristics of mechanical properties that are capable of welding, machining, as well as a good level of hardness and wear resistance, and absorbs impact loads quite well. AISI 1045 steel has a fairly wide range of applications. The application of AISI 1045 steel tends to be for making components or tools that must have good wear resistance due to the function of the object being made so that it can withstand abrasion against reduction in dimensions due to friction on the object.

Coating

The basic concept of coating is to limit the influence on the environment of the substrate, so that this coating process can increase the useful life of the substrate. The mechanism of the spray coating method is to spray precursor powder/liquid onto the substrate using air pressure at a certain temperature which causes the precursor material to hit the substrate and deposition to form a coating layer. The functional purpose in question is to increase or improve the surface properties of the substrate to be coated, for example corrosion resistance, high temperature resistance, wear resistance and increasing material hardness. With this aim, it is hoped that the coating process can increase the durability and economic value of a material. A good coating can be characterized by having good adhesion, compatibility with the substrate, and low porosity. The coating must provide a continuous barrier to the substrate, because imperfections in the coating can cause degradation and corrosion of the substrate. Coatings come in several types. Among them:

1. Primer coating

Primer coating is the base layer or base on which other coating systems are placed. Primer is the key to the adhesion of the entire coating system. The primer must adhere firmly to the metal of the overlying coating system

2. Intermediate Coating

Intermediate coating or bondcoat functions as additional protection. Also called a body coat to add thickness and durability. This body coat must adhere firmly to the primer and also to the top coat. The function of the intermediate coating, namely, increases the thickness of the coating system, has strong chemical resistance, is resistant to water vapor, has strong cohesion, has a strong bond between the primer coating and the top coating.

3. Top coating

Topcoat is a layer of insulating resin on top of the bondcoat and primer coating. functions as the first barrier in the coating system. The top coat is denser than the intermediate coat because the amount of pigment is smaller.

Wire Arc Spray Method

Wire Arc Spraying is a method of coating metal surfaces that uses coating material in the form of wire. The wire is melted using a high electric current arc. After the wire melts (droplets), it is then pressed using inert gas, but the temperature drops drastically after passing through the wire tip. Liquid spray particles form splats when they hit the substrate surface due to the effects of temperature and high kinetic energy. The liquid spray particles flatten, break, spread and quench in a short time span of around 10-8s and 1-6s. In the Wire arc spray proces there is a thin oxide layer that spreads and is trapped between the lamellar coating structure which is often called oxide inclusions (stringers).

The wire arc spray process can be carried out only for materials that have good electrical conductivity, especially for coating materials. In the arc spraying tool, there is a single wire (singlemwire) which is connected to an arc ignition (arc burning), and between the two tools there is a non-consumable electrode which acts as a nozzle for the gas atomization process. Wire Arc Spray is a coating process in which two metal wires are fed into a spray gun. These wires are then charged and an arc is generated between them. The heat from this arc can melt the incoming wire, which is then blown away in a jet of air from the gun.

Coating Material

The coating process using the wire arc spray method is divided into two stages, namely the first stage of coating using Ni-Al (Nickel Aluminide) wire as a bondcoat and the second stage as a top coat using stainless steel wire and 95 mxc. The layers used are as follows:

Nikel Aumina Coating (Ni-Al) - Bond Coat

Bond coat is the base or base on which other coating systems are placed. The primer coat is the key to the adhesion of the entire coating system on a material. In this research, the bond coat used was NiAl in the form of wire. Nickel and aluminum are two elements that are able to provide protection to alloys exposed to high temperatures.

SS420

Top coat is a layer of insulating resin (a resinous seal) on top of the intermediate and primer. This layer is the first defense against aggressive chemical reactions, water or the environment, which functions as the first barrier in the coating system. The top coat is denser than the layers below (intermediate and primary coat) because the amount of pigment is smaller. SS420's resistance to high oxidation in air at ambient temperatures is usually achieved due to the addition of a minimum of 13% (by weight) chromium.

95 MXC

Fe-Cr-B-Mn-Si This type of coating produces an amorphous phase that is erosion resistant and corrosion resistant. The monocrystalline amorphous phase has high values of wear resistance, erosion resistance, and corrosion resistance. This type of coating produces an amorphous phase that is erosion resistant and corrosion resistant. The monocrystalline amorphous phase has high values of wear resistance, erosion resistance, and corrosion resistance. The amorphous nanocrystalline phase is formed due to the presence of a Fe-Cr coating metallic matrix and several types of borides. The matrix consists of an amorphous phase and nanocrystalline grains.

Material

The application of AISI 1045 steel tends to be for making components or tools that must have good wear resistance due to the function of the object being made so that it can withstand abrasion against reduction in dimensions due to friction on the object. Substrates that have high impurities will influence the deformation of the first layer of particles being deposited, thus affecting the cohesion between the first and subsequent layers. Medium carbon steel with a carbon content of 0.3-0.5% (medium carbon steel). Its strength is higher than low carbon steel. It is difficult to bend, weld and cut. It is used for building construction, materials for machine components, machetes, knives and others.

Hardening Test

Hardenss testing using the Rockwell method aim to determine the hardness value of a material in the form of the material's resistance to an indenter in the form of a steel ball or diamond cone which is pressed on the surface of the test material. Rockwell hardness testing is carried out by pressing the surface of the specimen (test object) with an identer. The pressure of the identer into the test object is carried out by applying a preliminary load (minor load), then adding the main load (major load), then the main load is released while the minor load is still maintained. In the Rockwell method hardeness testing process, two stages of the loading process are given to the test sample specimen. Minor load and major load stages. The maximum size for minor loads is 10kg, while for major loads it is adjusted according to the hardness scale used.

Micro Structure Test

Microstructure is a structure that can only be observed through a microscope, be it an optical microscope or an electron microscope. Information that can be obtained from the microstructure includes identification of the phases present, phase percentages, phase distribution, inclusions (impurities), precipitates and grain size. Changes in the structure of a metal mixing system will only occur if the mixture is cooled slowly. Microstructure testing aims to determine the structure before heat treatment and after heat treatment of a material. The microscopes that can be used are optical microscopes and electron microscopes. Before viewing with a microscope, the metal surface must be cleaned first, then react with a chemical reagent to make observation easier.

CONCLUSION

Based on the research data and analysis that has been carried out, several conclusions can be drawn as follows:

The 95MXC and SS400 wire layers use the wire arc method with a current strength of 300A and a voltage of 30A to produce a coating layer with the highest hardness value, namely 45.98 HRC and the SS420 layer has a value of 33.11 HRC. Increasing the hardness value of 95MXC wire with a value of 45.98 HRC, this is because the coating material alloy with the addition of CR elements further increases the hardness value of the coating and the coating structure is not homogeneous due to unmelted particles and porosity which reduces the density between particles and results in low hardness value of a layer.

The results of observations of the microstructure of the 95MXC and SS400 wire layers using the wire arc method with a current strength of 300A and a voltage of 30A show the interfaces formed in the top coat, bond coat and substrate layers. The coating layer on 95MXC wire looks slightly thicker than the coating layer on SS420 wire. because in a thicker coating layer the coating material particles will be spread evenly and denser, thereby increasing the hardness value. The increase in thickness of the 95MXC layer with a value of 297.99 μm is in line with the increase in hardness of the coating layer, because in a thicker coating layer the coating material particles will be spread evenly and denser, thereby increasing the hardness value.

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