

EFFECT OF NICKEL ELECTROPLATING TIME ON CORRUGATED METAL GASKETS PERFORMANCE

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ABSTRACT

Metal gaskets is an alternative to asbestor gaskets, but it still have many weaknesses. The main focus of this research is to find the optimal electroplating time to prevent leakage. This research was started with forming the gasket material, and then followed by coating process. The methode that used in coating proses was electroplating with nickel solution. The gasket material used SUS 304 sheet with 1,5 mm of thickness. Water pressure test was used to test leakage with 2 MPa, 4 MPa, 6 MPa, and 8 MPa presurre for 5 minute test duration. The result this research are (1) electroplating are effected by time, the longer time applied more nickel attached to the gasket, (2) the best performance on nickel electroplated gasket was on 32 minute and 45 second plating time, (3) electroplated nickel gasket performance was better than the original to prevent leakage from 2 to 8 MPa water pressure.

Keywords: corrugated metal gasket; SUS 304; electroplating; performance.

1. INTRODUCTION

Gasket is a layer that fills between two or more sufaces to prevent leakage from joint due to pressure. Gaskets makes “less-than-perfect” or imperfect machining surface due to machining used so leakage can be prevented. Gaskets work by filling the imperfections surface by tightening the fixing bolts on both flanges. Gasket that chosen usually based on the suitability of the gasket material with the fuild, the ability with the system pressure, work temperature and also gasket’s life.

In spesific application, such as high pressure heating systems usually made of asbestos material, this material can withstand high

temperatures and chemical effect. As in the JIS B2220 flange with a diameter of B2404 25A, this flange has a surface roughness of 1.6-3.2 μ m or equivalent with N7. With 1.6-3.2 μ m surface roughness, gasket must be able to fill the micro ruggedness. With asbestos gaskets, this micro ruggedness is easy to achieve because its more flexble and easier to follow the shape of the pressed surface with also tends to be cheaper than other materials.

The use of asbestos material has been banned in various countries including indonesia [1]. Due to risk of asbestos materials, it can cause various healts problems and serous illnesses [2]. Material to replace asbestos in gasket has been carried out including graphite, fiber glass,

ceramic fiber and fluorocarbon resin which more expensive and still have problem with its short life times. However, the performance of these materials is still far from asbestos gasket.

Metal flat gasket are one of the alternative to asbestos gaskets. It can withstand with high pressures, extreme temperatures and resistant to chemicals, but they still have many disadvantages [3]. The new 25A sized corrugated metal gasket has metal spring effect and produces high local contact stress to create sealing line with flanges for increasing the contact stress and contact width [3]. Even with increased contact stress and contact width this new metal gasket still has limitations on contact width and contact stress with surface roughness [4]. This affects leakage, it will increased with greater surface roughness.

Metal gaskets usually made of combination of metal with certain shapes and sizes. One of the metal that can be used as a base material for gaskets is stainless steel SUS304. Stainless steel SUS304 has corrosion resistance due to the presence of the carbon and chromium with the addition of silicon in its content, also this metals has advantage of easy to form, weldable, has good quality for deep drawing and has high durability.

To improve the metal gasket performance gasket coated with nickel. Corrugated SUS304 metal gaskets can be coated with any material when treated with nickel strike plating. Nickel is a hard metal but can stretch because of its flexibility, beside its unique characteristics such as resistance to oxidation and the ability to maintain its properties in extreme temperatures. Nickel plating is a method that has many advantages, namely: preventing corrosion, increasing hardness and strength, increasing wear resistance and giving the product aesthetic appearance [5]. Nickel coating can be done with various type of electrolyte solutions, some of which are watt's bath, all sulfate bath, all chloride bath, chloride sulfate nickel bath, and allfluoroborate. Thickness and mass of the layers

will be depended on electric current and electroplating time.

Coated gaskets with nickel and copper tested with 40kN, 60kN, 80kN and 100kN bolt tightening and thickness variation 20µm and 30µm, leakage indicates that the gasket with layer of nickel or copper are better than standard (non-coated) gaskets [9]. In addition, the microstructure test showed no diffusion. Furthermore, the thickness of certain nickel coating will be analyzed to determine the result of the electroplating time. The leakage test used in this test were water pressure tests.

2. METHODS

This study used an experimental research method to test the performance of the metal gaskets that have been coated. The gasket material was SUS304 which has a nominal stress of 398.9 MPa, a tangent modulus of 1900.53 MPa and 210 GPa of young modulus. The nickel coating method used was electroplating with 5 various coating times, namely 6' 16", 24' 17", 32' 20", 4' 22" and 48' 24". Detail research procedure presented in a flowchart as shown in Figure 1.

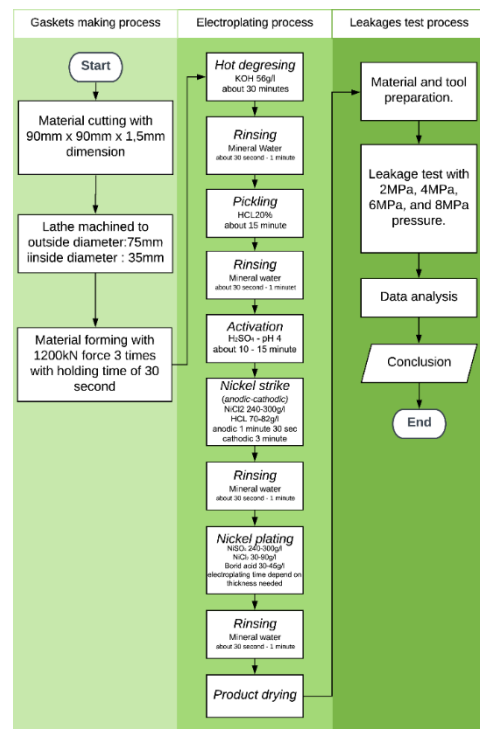


Figure 1. Research flow

Basically, electroplating process that occurs is an electrochemical deposition process. The object to be coated is placed in the middle of electrolyte solution as a cathode and the deposited metal as an anode as shown in Figure 2.

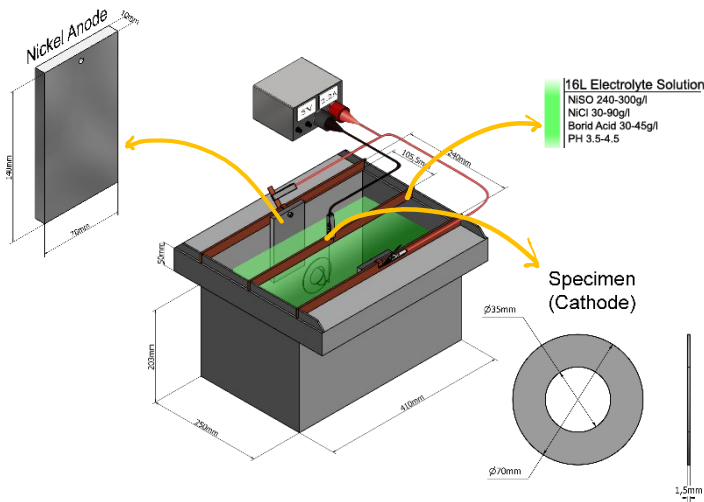


Figure 2. Electroplating bath

After the gaskets were formed into corrugated metal gasket, the next process was electroplating with nickel material the result of the coating can be seen in Figure 3.



Figure 3. Gasket with nickel coating

In this study the testing process that used was liquid leak testing with the water pressure test method or with liquid. The liquid or in this research water (H₂O) was pumped by using kyowa T-100K test pump as shown in Figure 4.



Figure 4. Leakage test equipment

The tested gaskets were inserted into the flange as shown in Figure 5. Then the next step is to tighten the bolt with cross pattern as shown in Figure 6. With tightening force of 40kN, 60kN, 80kN, 100kN, and 120kN. The tightening bolt force was gradually increased according to the applied pressure.



Figure 5. Gaskets inside flange

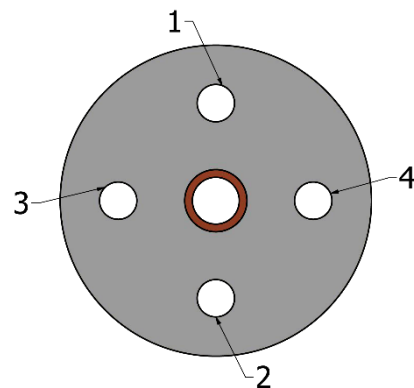


Figure 6. Bolt tightening order

The flange is gripped using a lathe chuck as shown in Figure 7. The use of a lathe chuck is to level flange position in a vertical way so that leaks can be detected easily.

The next process is to apply pressure to the gaskets in stages with a pressure test of 2 MPa, 4 MPa, 6 MPa, and 8 MPa with a holding time of 5 minutes at each test pressure. If a leak occurs then we clean equipment and also increase the tightening force then test again with the same pressure, if leakages not occurs the, increase the pressure test.

3. RESULT AND DISSCUSION

This increasing weight characteristic was intended to find the time needed to reach a certain thickness and the efficiency of the electrolyte solution, the results can be seen in Table 1.

From the data, various kind of information can be taken. By taking the time interval and the average weight at each time interval, a graph can be made as shown in Figure 8.

Table 1. Gaskets weight increase every 5 minutes

Specimen	Initial weight (gram)	Weight Increase											
		5'	10'	15'	20'	25'	30'	35'	40'	45'	50'	55'	60'
1	37,80	38,00	38,22	38,42	38,57	38,80	39,00	39,14	39,37	39,56	39,80	40,05	40,26
	Increase	0,20	0,42	0,62	0,77	1,00	1,20	1,34	1,57	1,76	2,00	2,25	2,46
2	37,60	37,82	38,01	38,24	38,39	38,62	38,79	38,95	39,19	39,41	39,67	39,90	40,27
	Increase	0,22	0,41	0,64	0,79	1,02	1,19	1,35	1,59	1,81	2,07	2,30	2,47
3	37,52	37,70	37,95	38,17	38,31	38,55	38,73	38,92	39,16	39,35	39,56	39,80	39,98
	Increase	0,18	0,43	0,65	0,79	1,03	1,21	1,40	1,64	1,83	2,04	2,28	2,46
Average Weight	37,64	37,84	38,06	38,2767	38,4233	38,6567	38,84	39,0033	39,24	39,44	39,6767	39,9167	40,17
Average increase weight		0,2	0,42	0,64	0,78	1,02	1,2	1,36	1,6	1,8	2,04	2,28	2,46
Thickness		3,05	6,41	9,77	11,91	15,57	18,32	20,76	24,42	27,48	31,14	34,8	37,55

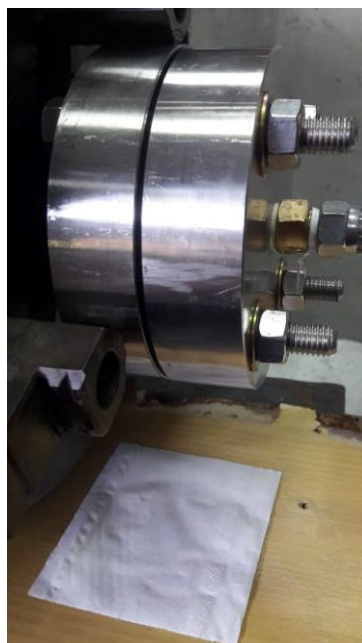


Figure 7. Flange position on chuck

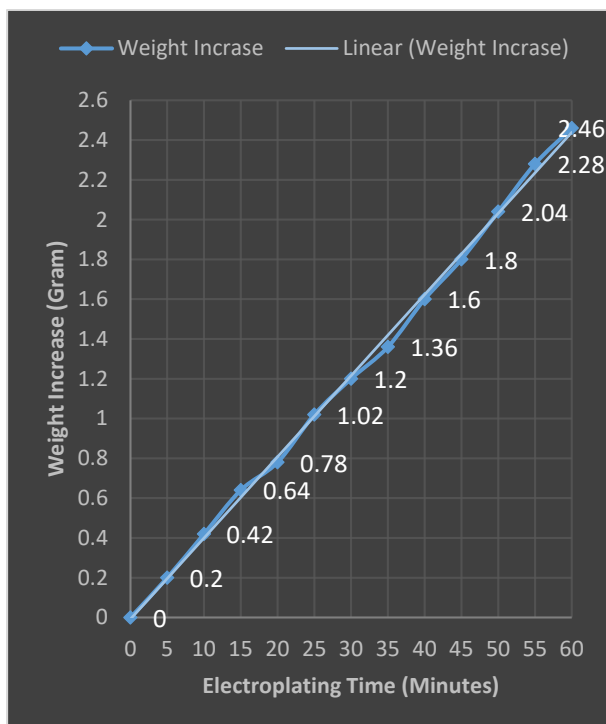


Figure 8. Effect of nickel electroplating time on weight increase

From Figure 8, it can be seen that overtime the weight of the gasket increases, which mean that the thickness of the gasket also increases. Taking the time interval and the average weight gain converted to thickness with time as x and thicness as y as in Figure 9.

From the Figure 9. we get the formula as in equation (1).

$$y = 0.6223x + 0.1174 \quad (1)$$

Where y is the final weight after plating and x is the time taken.

With the formula, we can find p and find the time needed to coat gaskets with a certain thickness, here in this study the theoretical thickness needed is 10, 15, 20, 25, and 30 as can be seen in Table 2.

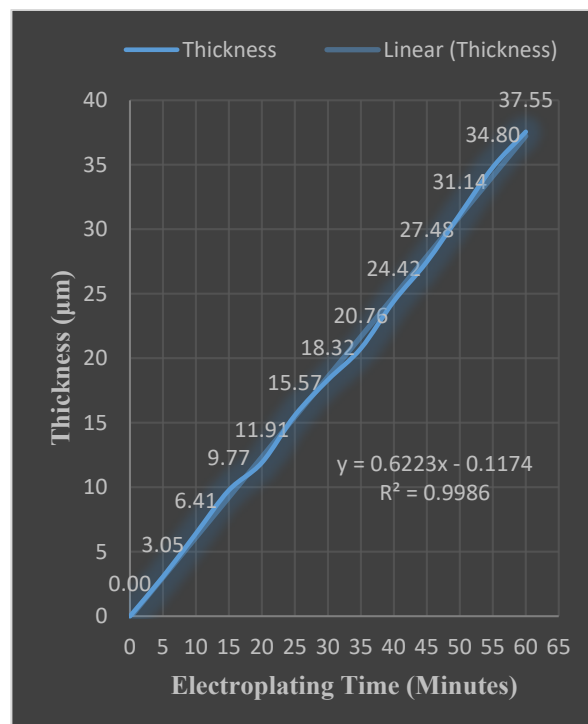


Figure 9. Effect of nickel electroplating time on coating thickness

Table 2. Electroplating time needed

Thic kness (µm)	Weight increase needed (gr)	Theoretical time (minute:sec)	Actual time (min:sec)
10	0,66	14:21	16:16
15	0,98	24:17	24:17
20	1,31	28:43	32:20
25	1,64	35:54	40:22
30	1,97	43:5	48:24

From the formula, the time needed to obtain theoretical thickness obtained. The formula has a difference of 0-10.61% with an avarage 3.46%.

The leakage test was carried out with a water pressure test to determine which gasktes coated with nickel can withstanced the spesific pressure and time. The flange is gripeed by a lathe chick n the pressure is applied with the Kyowa T100K pump test. The test results can be seen in Figure 10.

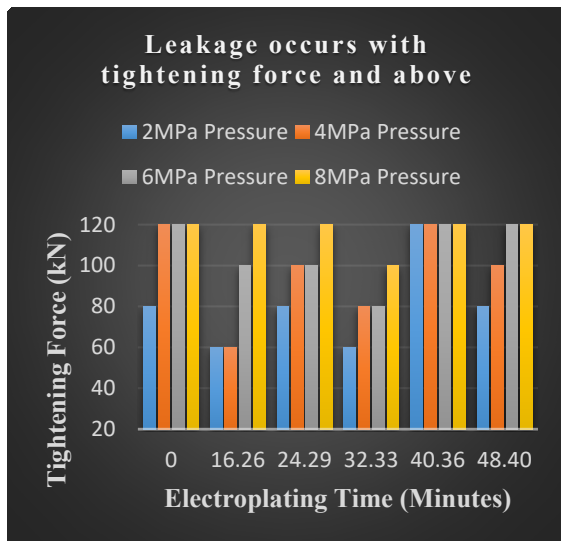


Figure 10. Tightening force needed to withstand leakage on test pressure

From Figure 10, it can be seen that gaskets without coating or with electroplating time of 0 can only withstand leaks with a tightening force above 80kN at 2MPa pressure. Gasket performance with electroplating time 16'26" is much better than gaskets without coating. This gasket is able to withstand a pressure of 2MPa with 80kN tightening force, 4MPa pressure with 80kN tightening force and 6MPa pressure with 120kN tightening force. Gasket performance with electroplating time 32'33" is also much better compared to gasket without coating, because it can withstand 2MPa pressure with 80kN tightening force, 4MPa pressure with 100kN tightening force and 6MPa with 100kN tightening force. Meanwhile, gaskets with electroplating time 24'29" and 48'40" had insignificant increase in performance compared to uncoated gaskets. In the other hand, gasket with 40'36" electroplating time resulting much worse performance than uncoated gaskets because unable to withstand any pressures even with the highest tightening force.

4. CONCLUSION

The time variation effect on the coating thickness is that the longer coating process last (time), the thicker coating layer will be. The optimal performance of the nickel coated gasket is at 32'20" electroplating time. Compared to uncoated gaskets, gasket with 32'20" electroplating time are able to withstand the same or even higher pressures with the same

tightening force. Compared to other electroplated result, a gasket with 32'20" electroplating time able to withstand higher pressures with the same tightening force although at 4MPa pressure, gasket with 16'16" electroplating time are better because it able to withstand pressure with lower tightening force but worse at other pressures. The corrugated metal gaskets performance was better after being treated with electroplating compared to gasket without electroplating treatment, at 2MPa pressure, the average performance of treated gaskets increased 53%, while at 4MPa the average performance increased 118%, and at 6 and 8MPa the uncoated gasket cannot withstand leakage. The treated gaskets can withstand 6MPa on gaskets with 16'16" and 32'20" electroplating time and 8MPa on gasket with 32'20" electroplating time.

At the specimen preparation, it should be gutted on the sharp side so that the coating result will be better at thicker coating. Rectifier may be replaced with a rectifier with a controlling current and voltages so that current during electroplating is more controlled and have more consistent result. If possible, the laboratory should be in a closed place to avoid particles that cause defect in the research process, beside that periodic maintenance is also necessary to avoid this.

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