THE EFFECT OF DEPOSITION TIME OF He-CH_4 TO SURFACE ROUGHNESS ON AISI 410 STEEL SURFACE

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ABSTRACT

Penelitian ini bertujuan untuk mengetahui pengaruh waktu pendeposisian He-CH_4 (helium-metana) pada permukaan baja AISI 410 terhadap angka kekasaran permukaan. Proses pendeposisian He-CH_4 dapat dilakukan dengan plasma *chemical vapor deposition* (plasma CVD). Campuran gas He-CH_4 dideposisikan di permukaan baja AISI 410 menggunakan temperatur 300 °C dan tekanan 2 mbar. Variasi waktu pendeposisian yaitu 1, 2, 3, 4, dan 5 jam. Perbandingan campuran gas He-CH_4 adalah 76% He dan 24% CH_4. Pengujian angka kekasaran permukaan menggunakan instrumen pengukur kekasaran permukaan *Surfcom* 120A. Berdasarkan hasil pengujian angka kekasaran permukaan didapatkan bahwa terjadi peningkatan angka kekasaran permukaan diawal pendeposisian. Angka kekasaran *raw material* sebesar 0,04 μm meningkat menjadi 0,1 μm setelah 2 jam pendeposisian. Penambahan waktu pendeposisian setelah melewati 4 jam menurunkan angka kekasaran menjadi 0,05 μm. Penambahan waktu pendeposisian menyebabkan permukaan lapisan menjadi halus dan rata.

Keywords: Angka kekasaran permukaan, Waktu pendeposisian, He-CH_4, Baja AISI 410

INTRODUCTION

This study aimed to determine the effect of pressure and deposition time of He-CH_4 to the number of surface roughness of AISI 410 steel. The deposition process is carried out by plasma chemical vapor deposition (plasma CVD). Deposition time and pressure of He-CH_4 in AISI 410 steel surfaces affect the rate of surface roughness. An increase in surface roughness will result in increased of wear rate (down wear resistance) [1]. The use of AISI 410 stainless steel as cutting tools and non-cutting [2] is expected to have a good wear resistance.

Deposition by using the plasma CVD process can be done at low temperatures about 200 °C. The use of gas as a coating material to produce a better coating, can be applied to substrates with complex surfaces and produce a uniform layer thickness [3]. By plasma CVD deposition can also be performed by using atmospheric pressure. The resulting layer is a carbon layer with a composition of 43% of sp2 and 57% of sp3 [4].

The main material of deposition may be a hydrocarbon gas. The use of CH_4 as a deposition material due to CH_4 only requires ion energy in each C atom at 500 eV [5]. Number of CH_4 flow effect on the surface of the plasma CVD deposition. The rate of deposition will increase proportional to the reduction in the amount of CH_4 flow. In addition, the lower amount of CH_4 flow would reduce the formation of graphite [6].

RESEARCH METHODOLOGY

Preparation of specimen

The specimen is AISI 410 steel. The chemical composition of AISI 410 steel as shown in Table 1. The shape of the test object is a solid circle with a diameter of 14 mm and a thickness of 4 mm. The specimen is polished before coating and testing. Polishing use a sandpaper with roughness sequence (grid) from 220, 400, 600, 800, 1000, 1500 until 2000. The final step of polishing, the specimen is polished using velvet fabric (velvet) with the metal paste of polish and alcohol 96%. Especially before the specimen is done deposition, it is cleaned again using the ultrasonic cleaner from PSTA-BATAN Yogyakarta with 96% alcohol solution for 15 minutes [7].

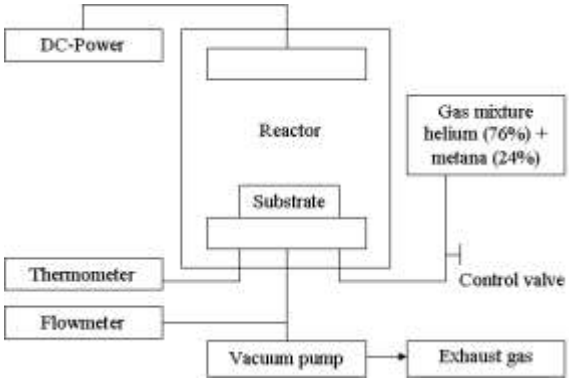
Table 1. Composition of chemical on AISI 410 steel [8]

Element	C	Si	S	P	Mn	Ni	Cr	Fe
wt.%	0.12	0.34	0.03	0.02	0.43	0.21	12.83	85.99

Coating of specimen

Deposition process using the plasma CVD from PSTA-BATAN Yogyakarta. Coating material

using a mixture of helium and methane gas. Comparison of helium gas with methane gas is 76% helium and 24% methane. Deposition temperature is 300 °C, and the deposition pressure is 2 mbar, and the deposition time was 1, 2, 3, 4, and 5 hours. The process begins by flowing nitrogen gas with a pressure of 1 mbar for 5 minutes without performing the electric current. Purpose of flowing the nitrogen gas to push the oxygen out of the reactor. Calculation of deposition time begins after the temperature reaches 300 °C and pressures up to 2 mbar. Scheme of deposition tool as shown in Figure 1 [7].



Gambar 1. Schematic view of the Plasma CVD system [7]

Surface Roughness Testing

Surface roughness testing using the tool Surfcom of 120A from Engineering Materials Laboratory of UGM [7].

SEM observations and EDS Test

SEM observations and EDS test using a JEOL JSM-6510LA from LPPT UGM on a cross section of the test specimen. SEM observation using a voltage of 20 kV [7].

RESULT AND DISCUSSION

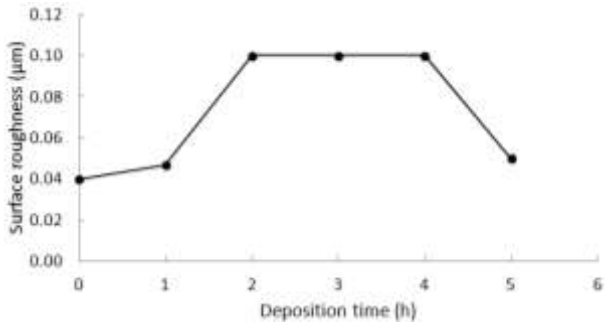


Figure 2. Effect of deposition time to the surface roughness

Figure 2 shows the effect of deposition time to surface roughness of AISI 410 steel. Based on test results of surface roughness obtained an increasing number of surface roughness at the beginning of deposition. The surface roughness of raw materials at 0.04 µm is increasing to 0.1 µm after 2 hours of deposition. The addition of a deposition time after 4 hours decrease the surface roughness becomes 0.05 µm.

Early deposition will lead to increased the surface roughness because the top will be coated faster than the valley. With increasing layer thickness causes the surface roughness being dropped [9]. Reduction in the surface roughness shows a layer formed on the surface of the AISI 410 steel began evenly. Illustration of specimen roughness against He-CH_4 deposition shown in Figure 3.

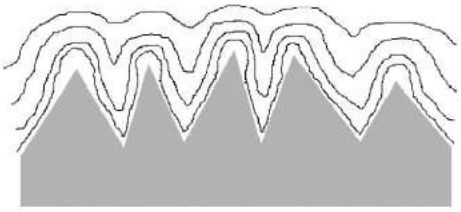


Figure 3. Illustration of substrate roughness to the deposition of He-CH4 [9]

The addition of deposition time also affects the amount of gas that is deposited, diffusion depth, and thickness of coating on the surface of the AISI 410 steel. Relations of deposition time and the amount of gas that can be deposited using equations of 1 and 2 [10].

$$D = D_o \times e^{-\left(\frac{Q_d}{R.T}\right)} \quad (1)$$

$$x = \sqrt{D \times t} \quad (2)$$

with:

D : diffusion coefficient (m^2/s)
D_o : diffusion coefficient on standard situation (m^2/s)
Q_d : activation energy (KJ/mol)
R : gas constants (8.314 J/mol.K)
T : absolute temperature (K)
x : diffusion depth (m)
t : time (s)

In addition, the surface roughness of raw material will also affect the amount of coating gas that must be deposited on the surface. Rough surface of raw material require the amount of coating gas more and longer deposition time. Next, increase in the number of coating gas will lead to increased the thickness of the coating layer.

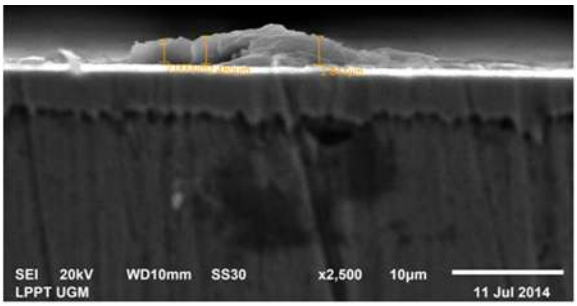


Figure 4. Cross-section SEM images of DLC films deposited at 3 h

Based on SEM observation as in Figure 4, it showed an increase in the thickness of the AISI 410 steel. The thickness of the layer that forms around 2.37 µm for 3 hours of deposition. Based on the testing results of surface roughness (Figure 2) that in 3 hours deposition still produce high surface roughness. Deposition process is carried out over 3 hours, causing a decrease in the surface roughness.

CONCLUSION

Surface roughness of raw materials will affect the results of the surface roughness layer. Earlier deposition will lead to increased surface roughness because the top will be coated faster than the valley. With the addition of deposition time, and followed by an increase in layer thickness caused the surface roughness to be down.

SUGGESTION

Further research needs to be done, with the addition of deposition time on He-CH_4 more than 5 hours.

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