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Analysis the effect of cutting speed on wear and crystal structure on CVD and PVD layer carbide insert materials

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Abstract. It has been done analysis effect of cutting speed on wear and crystal structure on CVD and PVD layer carbide inserts has been performed. The purpose of the study was to determine the effect of cutting speed on wear, crystal size, dislocation density and micro lattice strain on CVD and PVD layer carbide insert materials to cut the AMS5643 stainless steel material. CVD and PVD layer carbide insert cutting process with cutting speed variation 113; 126; 140; 175 m/min with cutting motion of 0.38 mm/round and depth of cut 1.5 mm fixed. Wear test results showed that CVD layer carbide insert wear was 15% higher than PVD layer carbide inserts. The results showed that the size of CVD layer carbide insert crystals was smaller than PVD layer carbide inserts by 42% and the dislocation density of CVD layer carbide inserts made no significant difference to PVD layer carbide inserts, as well as micro lattice strains for CVD layer carbide inserts greater than PVD layer carbide inserts.

1. Introduction

In the manufacture industry is known as cutting tooling machine. Tool cutting machine in its development more developed machine model Computer Numerical Control (CNC). Cutting tooling machine that exists today is generally divided into 2 namely: Milling machine or Machining center and Lathe (Turning Machine).

In addition to the machine is the main tool is also supported by cutting tools as a means of the process of cutting. Cutting tool as the main tool in the cutting process has a great impact on the jump of components produced by the proper setting of cutting parameters.

Previous research by Venkatesh et al. [1] said that under the usual machining conditions when using carbide cutting chisels, the growth of thirst on the surface of *the ribs (flank* face) and the surface of *the rake face* is the main process that results in the damage of the cutting chisel. The chisel life for low cut speeds is 140.33 minutes and at a high cut speed of 14,756 minutes [2].

The cutting parameters and geometry of the work will affect the result of the blinding process. Surface roughness determines the value of a product's quality. The selection of the right cutting parameters and the geometry of good work objects became the deciding factor to get good surface roughness by Hasrin Lubis [3].

The growing Cutting Tool is now known as the carbide powder metallurgy cutting tool or insert. The insert is the result of the powder metallurgy process between tungsten and carbon (w+c) coupled with cobalt as a binder. In its development in developing coating technology / Coating. The first insert coating technology was developed in 1980 with CVD coating technology. Then developed again PVD coating technology. Both technologies each have advantages and disadvantages according to the application of materials processed by the machine.

In addition to the above coating technology that affects the life of the insert, the dominant factor in increasing the life of the insert is the setting of cutting parameters in the machine. Cutting parameters include; Cutting speed (VC), Table motion speed (Feeding), and cutting depth (DOC).

Through the description above the author is interested to know the effect of cutting speed on the wear of carbide insert. The extent of the effect of this cutting speed on the wear and effect of CVD and PVD layer carbide insert carbide. In addition, the authors are also interested to know how the crystal structure of carbide inserts before and after is used on CVD layer carbide inserts and PVD layer insert carbide.

2. Research methods

2.1. Materials

The material to be cut for research is stainless steel type AMS5643. Material with type 17-4PH AMS 5643 stainless steel. With material size 54mm, with Length 77.5 mm. Done turning *external turning or* turning the outside into finished components.

The cutting materials we used in this study are CVD (Chemical Vapor Deposition) and PVD (Physical Vapor Deposition) layer carbide inserts in accordance with ISO DNMG. Carbide insert shape with Rhombic angle 55°, angle of length (N) = 0°, with tolerance class M class, with 15 mm insert IC, insert thickness 06 mm, Insert radius 0.8 mm.

2.2. Tool

The machine used in the machining process is a CNC lathe type MAZAK QUICK TURN NEXUS 200-II M. With specifications; maximum capacity of diameter 380 mm, Maximum length of processable material 541 mm, Maximum spin 5000 rpm, Motor output 19 kw/25. hp, Nexus Matric Mazatrol controller.

X-ray diffractometers to test crystal structure, crystal line, dislocation density and micro lattice strain. With machine spec: Scan axis Gonio, start position (2θ) 20 to 100°, at 25°(C) with copper radiation source (CU) and Wavelength 1.5406 Å. XRD tools can be seen in Figure 1.

Figure 1. XRD tools.

Microscope Dinolite with digital microscope specification (DINOLITE) to measure the width of wear on insert carbide (See Figure 2). Type: AM3113 Series. Dino-Lite AM3113 digital handheld microscope has a resolution of 640 x 480 with the ability to take measurements with Dino Capture software included dino capture software.

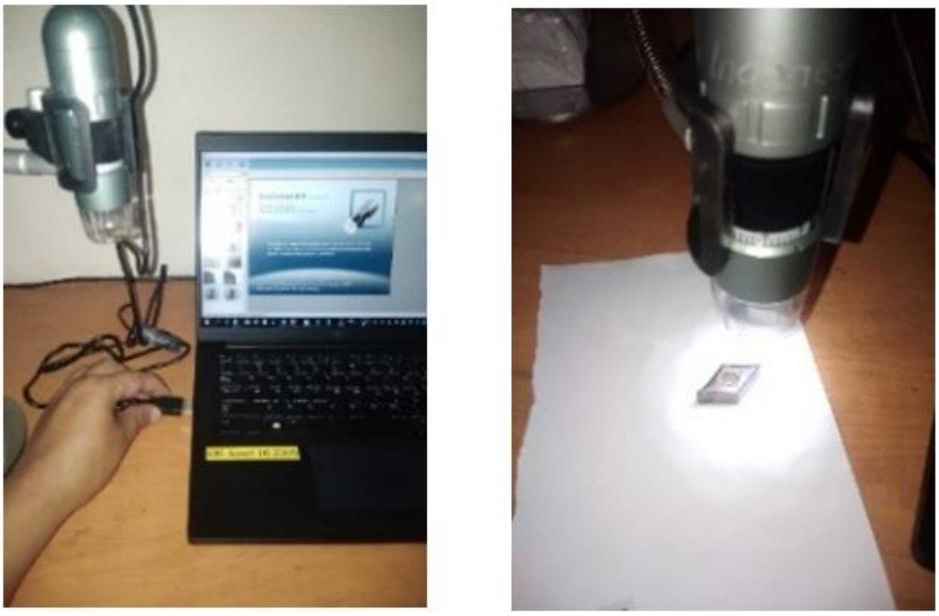


Figure 2. Dinolite.

2.3. Cutting Conditions

Variations in cutting speed are taken based on ISO 3685 (4) recommendations that recommend testing with 4 speed variations. Insert carbide DNMG layer CVD and PVD is done cutting process with cutting speed of 175, 140, 126, 113 m /min, with table motion speed f = 0.35 m /put and cutting depth of 1.5 mm made fixed.

2.4. Chisel wear testing

After the machining process is carried out for further measurement or analysis of insert wear using Microscope Dinolite. The ledge of the wear analysis is as follows;

The following is a step in examining insert wear by using Dinolite.

- Dinolite platform that has been installed on dinolite stand and connect with Laptop
- Place the insert on a flat base, and it is recommended to base it with a light color background
- Dinolite calibration with the tools provided
- Take a corner percorner position to observe and examine each side of the insert
- Take pictures with capture menu available on Dinolite
- Measure each Insert wear length with the menu "Measurement" and will get DL = high in order in mm
- Download the image and then give each side an initial name.

2.5. Crystal structure testing

Testing of the crystal structure of CVD and PVD layer carbide insert materials was carried out using XRD. From this result, the graph is faxed and the angle chart is ed. The x-ray diffractometer testing procedure is as follows:

- Specimens are placed in a place that has been adapted to the firing position.
- Then run with cu radiation source and wavelength $K\alpha_1$= 1.5406Å with range at angle $2.\theta$
- For data processing, samples are examined *using X-Ray Diffraction* (all connected to *the interface* on the computer) and *then analyzed after* the results of the XRD analysis test using *software,* then analyzed qualitatively. Obtained results in the form of a diphcogram pattern.
- From the difaktogram data can be calculated crystal size, dislocation density and micro lattice strain with the formula below:

$$\text{Crystal size (D)} = \frac{\lambda \text{ x k}}{\beta \text{ x } \cos\theta}$$

$$\text{Dislocation Density } (\rho) = \frac{1}{D^2}$$

$$\text{Micro Stretches } (\varepsilon) = \frac{\beta}{4 \text{ Tan}\theta}$$

Where:
K provision scherrer K=0.9 and
λ Wavelength of X-ray diffraction (λ) = 1.5406Å
β Overall width of maximum diffraction peak (FWHM)
θ Bragg angle read by XRD engine

3. Results and discussions

3.1. Wear analysis of CVD and PVD layer carbide insert materials

From the data obtained from changing the parameters of the cutting speed above obtained the result that both PVD inserts and CVD inserts experience a decrease in the jump of components produced by increasing the cutting speed (VC) View Figure 3.

Table 1. Cutting measurement results with CVD and PVD layer carbide inserts.

VC	Quantity Part (Pcs)	
M/Min	PVD Insert	CVD Insert
175	16	10
140	32	21
126	43	29
113	68	45

Quantity components are the result of the resulting part of the cutting process. For example, on the 1st side by using the VC cut speed parameter 175 m/min insert it enlivened 10 pcs of components (see Table 1). For this PVD type insert, the total components produced are 159 pcs. As for CVD insert the total components obtained 105 pcs. From this bandage get results by changing the PVD insert cutting speed to 51% more components than CVD inserts. Comparison results can be viewed in the Figure 3.

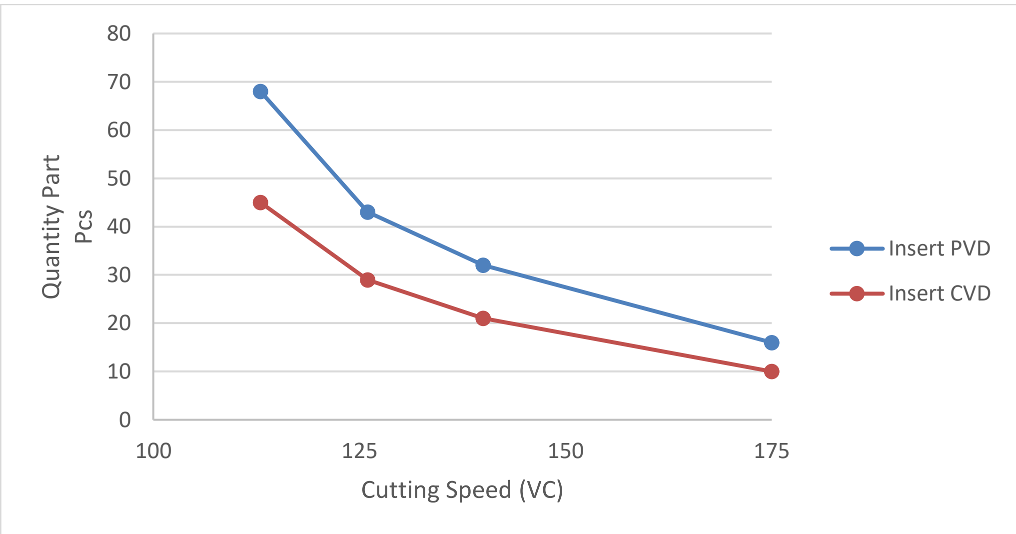


Figure 3. Number of components by CVD & PVD layer carbide insert cutter.

Table 2. Comparison of CVD wear & Insert PVD.

	Corner	**1**	**2**	**3**	**4**
	Cutting Speed (M/min)	**175**	**140**	**126**	**113**
Insert PVD	**Wear in mm**	1.029	0.914	0.801	0.572
Insert CVD		1.291	1.029	0.943	0.657
Percentage	**CVD vs PVD**	20%	11%	15%	13%

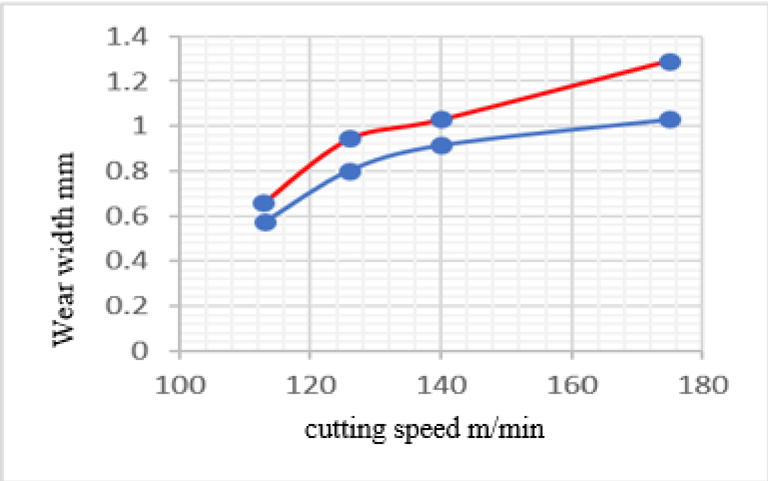


Figure 4. Wear width comparison graph.

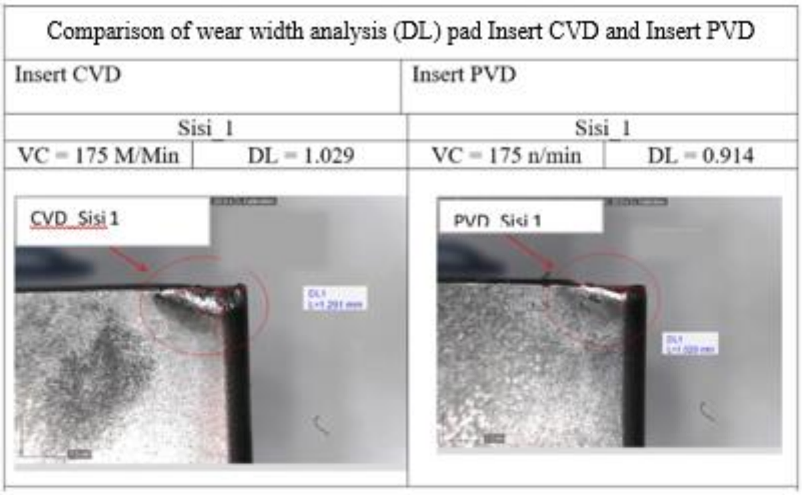
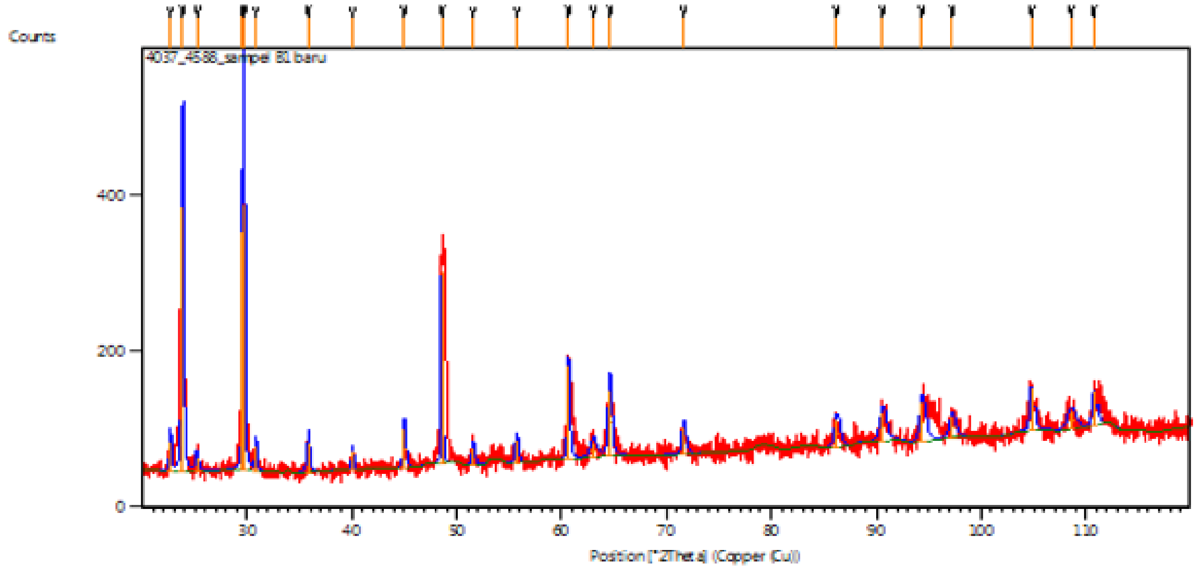


Figure 5. Comparison of CVD and PVD insert wear width.

From the results of the wear analysis with the microscope Dinolite obtained a comparison of wear like Figure 4. Overall CVD inserts have a usacious size 15% wider than PVD inserts. With the largest percentage occurs on VC 175 with a wear procession of 20% (see Table 2 and Figure 5).

3.2. Analysis of crystal size, dislocation density and micro lattice strain of CVD and PVD layer carbide insert materials

Test results with XRD from CVD layer carbide insert material in the form of x-ray diphctogram can be seen in the image (A1) in Figure 6 and insert after use on cutting (A2) in Figure 7.



Difaktogram image from insert A1

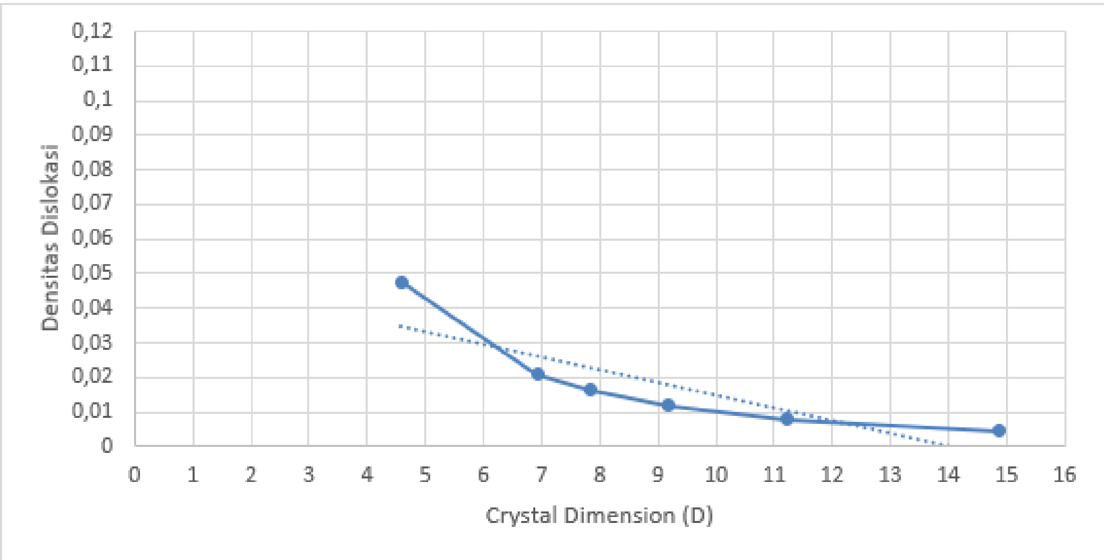
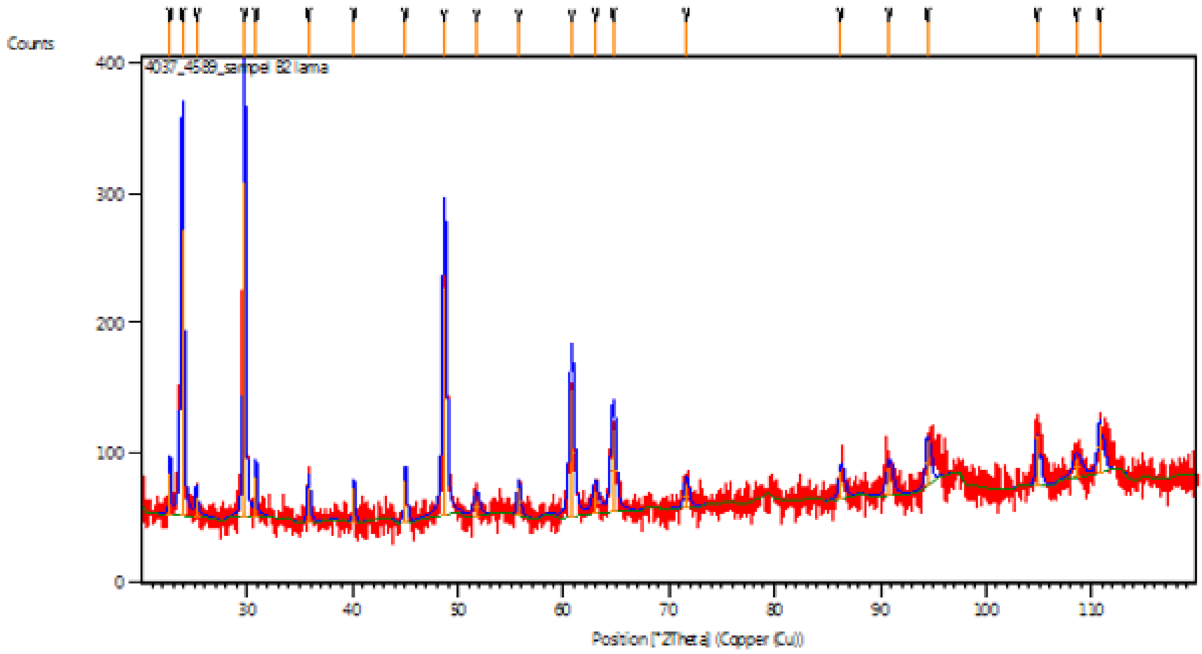


Figure 6. The relationship of crystal size to dislocation density (A1).



X-ray image of insert after use (A2)

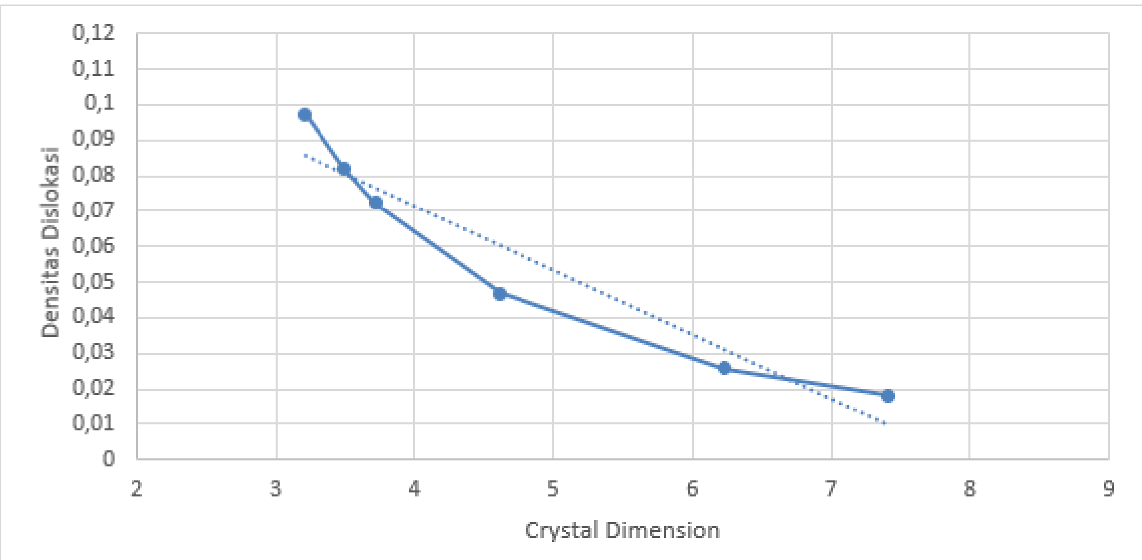
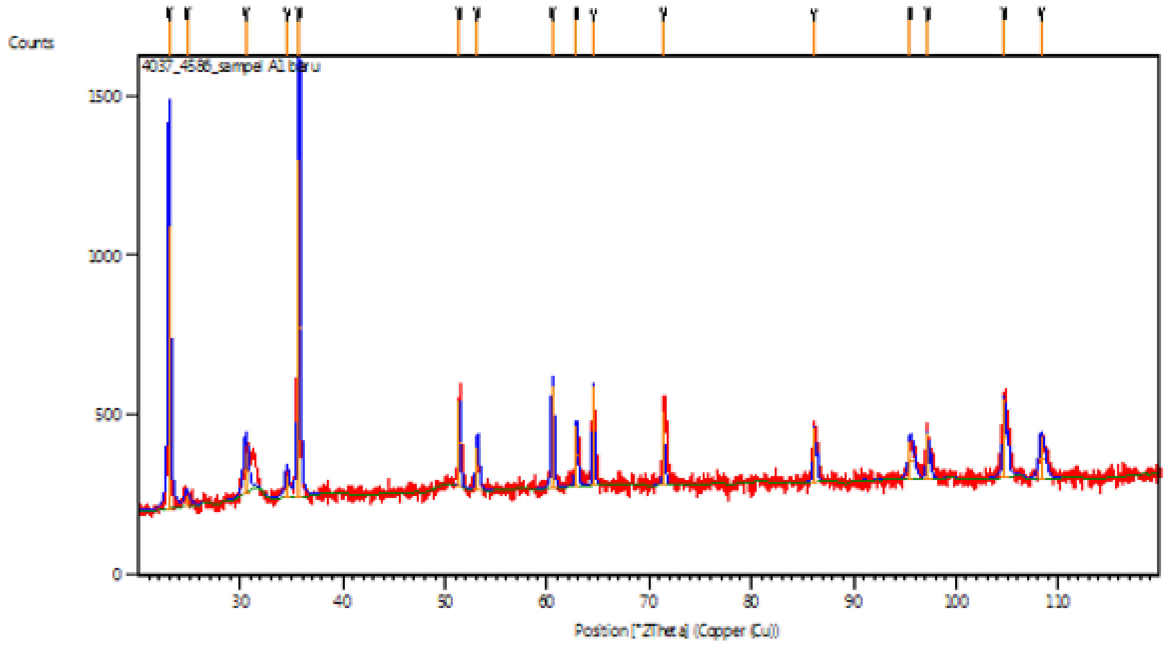


Figure 7. Relationship of crystal size to dislocation density after use (A2).

Test results with XRD from PVD layer carbide insert material in the form of x-ray diphctogram can be seen in the image (B1) in Figure 8 and insert after use on the cutting (B2) in Figure 9.



X-ray Difaktogram image of insert (B1)

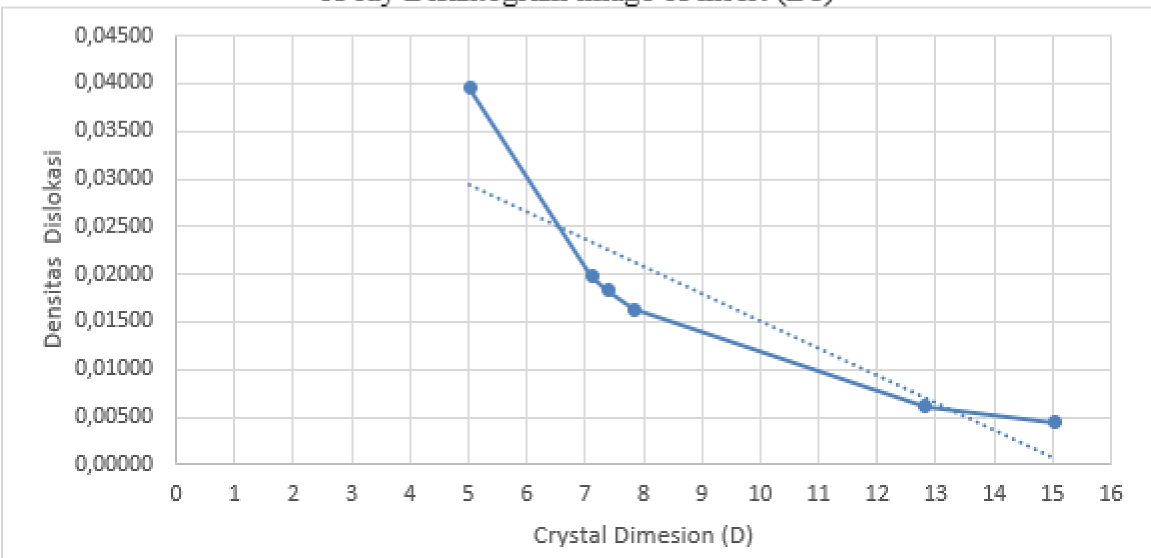
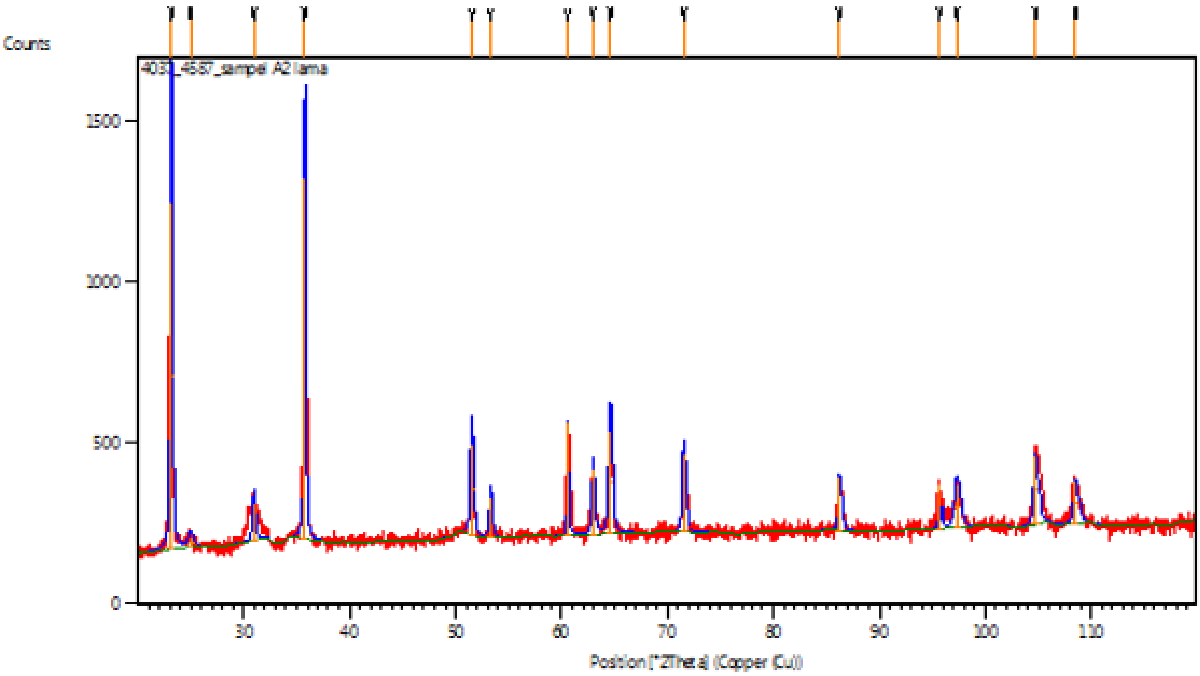


Figure 8. Relationship of crystal size to dislocation density (B1).



X-ray difaktogram image of insert after use (B2)

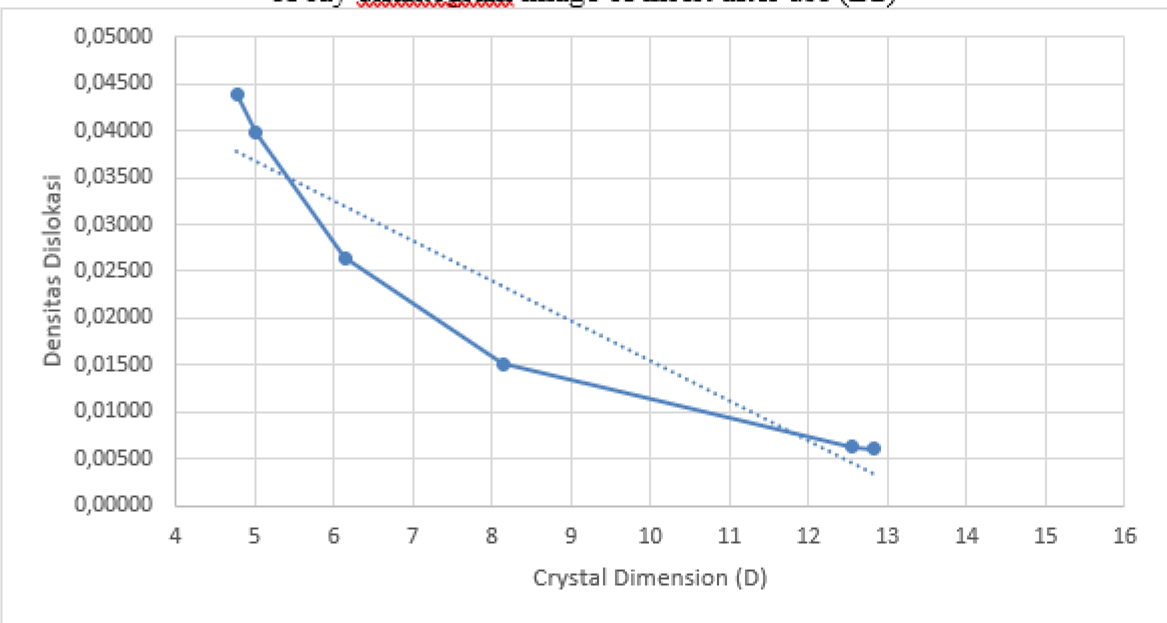


Figure 9. Relationship of crystal size to dislocation density of insert after use (B1).

From Figure 6-9 above shows the peak position, FWHM value and peak intensity of CVD and PVD layer carbide inserts with crystalline fields (100), (002), showing that peak intensity increases and FWHM becomes wide. These results indicate that the average crystal size is reduced and the appearance of crystal defects in the form of lines (dislocation density). Insert CVD and PVD layer carbide after use results in crystal shrinkage, which is characterized by reduced value of micro lattice strain. That may be due to internal pressure and defects in CVD and PVD layer carbide insert materials. Because relaxation of the voltage at the grain limit affects the size of the smaller crystals. Crystal defects that may occur due to mechanical treatment (during cutting) with higher temperatures in room temperature environments may cause voids in the crystal lattice. The increase in crystal defects is indicated by the increasing value of micro strain causing lattice strains to affect the length of the dislocation line per unit of crystal volume.

Analysis of crystal structure between new CVD inserts showed that the size of the crystals decreased by 48% resulting in an increase in the density of dislocation. CVD layer carbide insert material after cutting shows dislocation density increased by 214%, this is due to the heat effect caused in the machining process resulting in crystals splitting into smaller and crystal defects (increased dislocation density). But for PVD layer carbide inserts the results are different than CVD layer. Where the PVD layer carbide insert material after use of the crystal size machining process shrinks by 15%, while the density of dislocation increases by 38%. This indicates that PVD layer carbide insert material has better crystal quality on the surface and is indicated by reduced crystal defects.

4. Conclusion

The results of testing and analysis of CVD and PVD coated carbide insert materials to cut ams5643 stainless steel material are summed up as follows:

- Using high cutting speed will impact the life of the insert short, thus with a low-cut speed resulting in a longer insert life. Cut speed comparison to life span 2: 1
- Result of analyzer of CVD layer insert wear has a usable size of 15% more than PVD layer inserts.
- Result of analyzer of crystal size between new CVD layer inserts and has been used shows that the size of the crystal shrinks by 48% from the new CVD insert. While the density value of CVD insert dislocation has been used increased by 214%, this cause stretches micro lattice also differed 59% banded insert carbide layer CVD.
- The result of crystal size analysis between new PVD (A1) and PVD has been used (A2). Where dimension of crystal insert carbide lapis PVD(A2) is 42% smaller than PVD layer carbide insert (A1). However, densities dislocation and micro strain grid PVD (A2) me increase by 65% compared to PVD layer carbide insert (A1).

References

[1] Venkatesh V C 1980 Tool wear investigations on some cutting tool bahans *J. Lubric. Technol.* **102** 1980 556-559
[2] Henry B and Richard R 2007 Analysis of Carbide Chisel Age and Wear for Alloy Steel Mounting (ASSAB 760) with Variable Speed Machining Test Method Journal of Mechanical Engineering **9** 1 31 – 39
[3] Hasrin L 2013 Effect of Thick Cutting And Cutting Speed On Dry Blinding Using Carbide Chisels Against Roughness Surface Material ST 60 *Journal of Technology* **10** 1