The analysis of carbide particles distribution of HSS performances in relation with the machining process in manufacturing workshops

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Abstract. The aim of research is getting an idea of the carbide compounds spread through the usage of SEM/EDS technology, the type of carbide fraction technology using XRD, and get an idea of the performance/performance of various types of material HSS through a machining test of critical wear criteria. And specified method used was pure experimental. The study consisted of two stages. Phase I testing to determine the lathe machining tool life/performance based on critical wear criteria specified. Phase II characterization to determine the type of carbide that of the lathe chisel HSS and circumstances fractions. Implementation of the Phase I study, first conducted chisel grinding process so that it can be used in the metal cutting process of turning process. Grinding against the two types of chisel studied performed with the same geometry ie chisel Side rake angle (12°-18°). Angle of keenness (60°-68°) and Side relief angle (10° - 12°). Likewise machining parameters were taken with the same machining conditions. Based on test results obtained tool life tool life 27 minutes from Factory-A and from Factory-B 9 minutes to reach the 0.3 mm wear criticism. For both types of materials chisel, distribution of hardness on wear areas generally experienced a decrease of hardness compared with areas away from wear. The existence of this decline due to the influence of heat as a result of the cutting process. Material HSS suffered tempering resulting in decreased hardness. Results obtained from SEM examination that HSS Factory-A origin has the elemental composition of the alloy Ti, Cr, V, Mo and W. The alloy elements forming a complex carbide (the results of the XRD) that is Cr7 Mo24 C19 Fe6 W6 C and V2 C. While the HSS from Factory-B are Ti, V, Cr, and Mo. Alloying elements that will form carbides Cr23 Fe21 (W, Mo) 2 C19 and V4 C3 while the impurities that exist, namely Al2 O3.

1. Introduction

A good chisel must have certain traits, so that later can produce a good quality product (right size) and economic (time required short). Hardness and strength of the chisel should remain despite the high temperatures, these properties are called hot hardness. Toughness of the chisel is needed, so that the cutting tool will not break or crack especially when cutting with shock loads. Wear resistance is needed which endurance chisel to cut without inducing rapid wear. The determination is based on the type of cutting tool material, workpiece material and cutting conditions (coarsening, the shock loads, smoothing).

Five advantages that exist in the material used as the cutter is 1) have good hardness, 2) tenacity that can withstand shock loads, 3) retention on load thermal shock, 4) The adhesion properties are low and
5) had the solubility of elements/components material chisel Low [1]. One of the most important properties which the material will be used as cutting/carving is priced higher than the hardness of the material being cut. The following characteristics of the material chisel. In general, the hardness value will go down when the temperature reached ride.

![Figure 1. a) the value of the material hardness chisel with temperatures reached, b) the value of hardness at high temperatures (hot hardness) and wear resistance.](image)

There are many types of materials used in the cutting chisel metal forming processes such as ceramic material, cemented ceramic, CBN, HSS, Cast cobalt and carbon tool steel. The material is widely used because these materials also meet the criteria described above are material High Speed Steel (HSS). Chisel material is easily available in the market at a price which is quite affordable and easily sharpened when undergoing a process of wear and tear. There are many manufacturers of this type of cutting tool material, so as to have different characteristics, for example in terms of the sales price. There was also a difference in terms of performance if the chisel material used in the machining process. This performance difference is visible from different tool life between one another manufacturer.

HSS is used in the machining process at high speed. There is also interpreted this steel is steel cut quickly, because at the time of use, the workpiece is cut has a cutting speed (Cs) is high. Type of tool steel was discovered in 1898 with the type of high alloy steel with alloying elements Chromium (Cr) and Tungsten (W). Through the process of casting, followed by a rolling process, HSS is formed into bars or cylinders. In the process of soft conditions (results spheroidizing), the material can be processed by machining to form a variety of cutting chisel. After the heat treatment process hardness will be high enough so that it can be used on cutting high speed (up to 3 times the cutting speed to chisel CTS known at the time of about 10 m/min) so-called High Speed Steel [2]. High speeds can be achieved thanks to the relatively high hardness despite its fairly high temperature.

HSS microstructure in the annealed condition is disperse carbide particles in the matrix of ferrit. That complex carbides serve to increase the hardness and wear resistance at high temperatures. Carbides which exist at high speed steel annealing conditions can be seen in the following table.

| Carbide Type | Properties |
|--------------|------------|
| Carbides     | High hardness and wear resistance at high temperatures |
| Carbon steel |             |
| High Speed Steel (HSS) |             |
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| TYPE       | Prototype                | Lattice | SIZE Lattice (Å) |
|------------|--------------------------|---------|-----------------|
| M₆C        | Fe₄W₂C or Fe₄Mo₂C        | FCC     | 11.07           |
| M₂₃C₆      | Cr₂₃C₆                   | FCC     | 10.64           |
| MC         | VC or V₄C₃               | FCC     | 4.15 or 4.30    |

Tungsten and molybdenum more complex form carbides M₆C, carbides such as VC is a kind of MC carbides are stable at high temperatures so that the hardness and wear resistance at high temperatures increases. Cr₂₃C₆ carbide will dissolve in austenite at temperatures of 1090 °C [5], resulting in the condition after a heat treatment (quench and temper), the type of carbide is not observed.

2. Research method
The method used in this study was purely experimental. The first stage, the HSS from both groups were selected, test performance in the process of turning the machining parameters and wear the same criteria. Hardness test is then performed well in the area around the wear and far from wear. The next stage is the analysis of SEM/EDS to determine the morphology and chemical composition of both types of material HSS. To determine the type of carbide that appears, then the analysis of X-Ray Diffraction (XRD). For more details, made lines of inquiry as follows.

Figure 2. Research method lines.
3. Discussion

3.1. Testing machining
Machining process to determine the tool life is done by way of stoppage, that for a certain length measured cutting edge wear large (VB). Measurements were made using a comparison tool measuring in microscope.

![Figure 3. Wear a) HSS Factory-B, b) HSS Factory-A.](image)

Data from the machining process can be seen in the following table.

| No. | Length (mm) | Time (min) based stopwatch | Wear and tear (mm) that occur at any time of slaughter |
|-----|-------------|----------------------------|------------------------------------------------------|
| 1   | 450         | 4.5                        | 0.05                                                 |
| 2   | 450         | 4.5                        | 0.1                                                  |
| 3   | 450         | 4.5                        | 0.13                                                 |
| 4   | 450         | 4.5                        | 0.17                                                 |
| 5   | 450         | 4.5                        | 0.25                                                 |
| 6   | 450         | 4.5                        | 0.3                                                  |
| Total | 2700       | 27                         | 0.3                                                  |

| No. | Length (mm) | Time (min) | Wear and tear (mm) |
|-----|-------------|------------|--------------------|
| 1   | 450         | 4.5        | 0.16               |
| 2   | 450         | 4.5        | 0.3                |
| Total | 900       | 9          | 0.3                |

From the comparison tool life with critical wear VB = 0.3 mm, the tool life HSS from Factory-A longer (T_c = 27 minutes) compared with the HSS from Factory-B (t_c = 9 minutes). The causes of this difference will be explained by looking at the metallurgical characteristics of the two types of the cutting tool material technology using SEM / EDS.

3.2. Hardness test
Hardness test was conducted to determine the decrease in hardness after the chisel was used. The second material hardness distribution of the chisel can be seen in the picture below.
Figure 4. Factory-A HSS Hardness distribution.

Based on the test results of the HSS material hardness against Factory-A, (point 1, 1.5 and 2) is the area of wear and hardness when compared with much of the wear and tear (point 8) a decline in hardness. A decrease in hardness since the material in the cutting area experienced a tempering process that causes the hardness to be down.

Figure 5. Factory-B HSS Hardness distribution.

Together with the material conditions of HSS Factory-A, the HSS material Factory-B was also a decline in the hardness wear areas than in areas far from tool wear. The existence of a considerable difference of these two types of hardness decline chisel it, causing also the difference in the life of both types of chisel.

3.3. With SEM examination
Examination by SEM aims to determine the microstructure and distribution of carbide particles that arise from the HSS material.
Based on the comparison image above can be qualitatively explained that the spread of grain carbide in HSS German prevalent than Factory-B and large grain carbide in HSS Factory-A / Factory-A more subtle. The existence of these differences lead to differences in tool life. Carbide is a very hard compound and, if spread evenly, the hardness also be evenly distributed so that the tool life could be longer. Meanwhile, if the size of the fine carbide, then in accordance with the theory of Hall-Pecht will increase the strength of the material, so that in this case the HSS from Factory-A has a longer tool life.

3.4. Chemical composition analysis with EDS
The purpose of this analysis was to determine the chemical composition exist in both the types of HSS. The technique used to determine the chemical composition is Energy Dispersive Spectroscopy (EDS).

Material HSS from Factory-B contained an element of aluminum (Al). This allows the elements Al oxide Al₂O₃ which is an impurity that is detrimental to (be able to decrease the strength of the material). The emergence of Al element can be presumed from the melting furnace walls (refractory) during the making of the HSS material. The element Molybdenum (Mo) can form carbides compound which can increase the strength of the material.

At HSS from Factory-A in addition to the element Chromium (Cr) and molybdenum (Mo) also contain other elements such as vanadium (V), titanium (Ti) and tungsten (W). Elements will form carbides.
3.5. XRD analysis
This test was conducted to determine the various types of carbide is formed by two types of alloy elements of the HSS material. Analysis of the determination of the type of carbide is done by using the possibility of emergence patterns at various angles θ. Carbides formed in HSS origin Factory-A is Cr7Mo24C19Fe5W6C and V2C while carbide contained by HSS from Factory-B is Cr23Fe21(W,Mo)2C19 and V4C3.

4. Conclusion
Based on the results of the performance testing of machining tool life can be summed up as follows:

- The HSS’s ages produced by Factory-A longer than the HSS produced by Factory-B for the machining parameters and critical wear the same criteria. The big difference in the ages, due to the differences in chemical composition.
- Both types of material HSS containing carbide compounds but different in its composition.

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