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Wear behavior of new generation powder metallurgical cold work tool steels

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Cold work tool steels are alloy steels having chromium, vanadium, tungsten which are known as strong carbide former elements. Their mechanical properties are directly affected by manufacturing technique, alloying content, heat treatment and final microstructure. The steels produced by powder metallurgical (PM) methods have more superior mechanical properties due to their fine and homogenous matrices than the ones produced by conventional casting and then deformed. Today, PM cold work tool steels are used in several industrial applications and the investigation of their wear behavior under service conditions is one of the popular subjects [1-15].

In this study, the wear behavior of Vanadis 4 (1.50 C, 0.40 Mn, 1.00 Si, 8.00 Cr, 1.50 Mo, 4.00 V, wt-%) and Vanadis 10 (2.90 C, 0.50 Mn, 0.50 Si, 8.00 Cr, 1.50 Mo, 9.80 V, wt-%), known as new generation PM cold work tool steels, was investigated under dry sliding conditions. Vanadis 4 and Vanadis 10 grade steels were solution annealed at 1050 °C and 1100°C for 20 minutes, respectively. After cooling in air, the steels were tempered at 525 °C for 250 minutes. The specimens taken from heat treated steels were ground using grinding papers of 120, 320, 600 and 1000 mesh in turn, and polished with diamond paste of 3 µm in size. The polished surfaces were then etched chemically with 3% Nital (3 ml HNO_3 + 97 ml ethanol) solution to obtain phase contrast in the structure. In order to determine the tribological characteristics, the steels were tested using "ball-on-disc" type tribometer. In the wear test, load, total distance and rotating speed were selected as 25 N, 250 m and 100 rpm, respectively. The results were evaluated using the friction coefficient-distance diagram and loss in weight. All worn surfaces were examined by light microscope (LM) and scanning electron microscope (SEM). The wear characteristics of PM steels were discussed as a function of the microstructural features.

It was concluded that (i) the steels had tempered martensitic matrices (Figure 1a and b), (ii) their matrices included precipitates as carbides (Figure 2 and b), Vanadis 10 grade had higher hardness (67 HRC) due to higher carbon and vanadium content than that of Vanadis 4 grade (63 HRC), (iii) Vanadis 10 grade had a lower friction coefficient (Figure 3), (iv) both grades exhibited abrasive-adhesive tracks on their worn surfaces (Figure 4)

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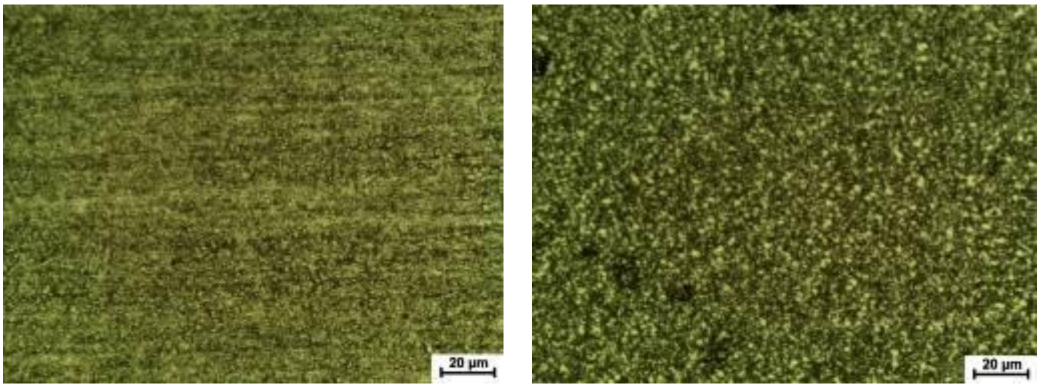
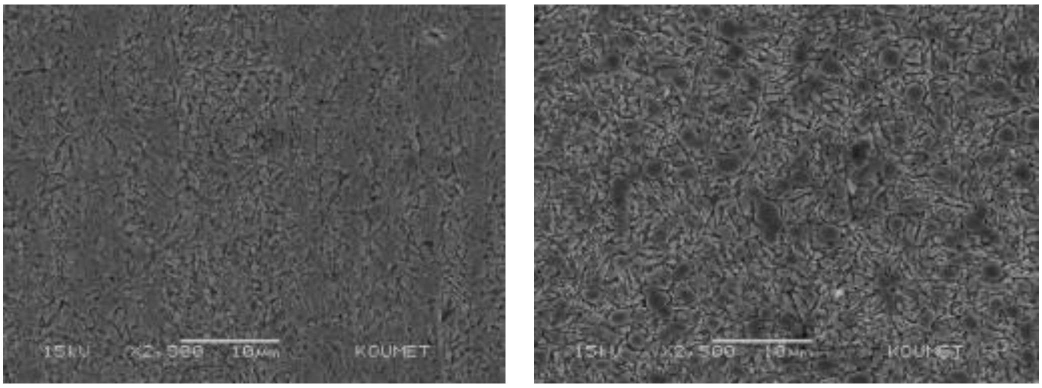


(a) (b)

Figure 1. LM micrographs showing the microstructures of heat treated MP cold work tool steels having tempered martensitic matrix; (a) Vanadis 4 and (b) Vanadis 10 grade.



(a) (b)

Figure 2. SEM micrographs showing the microstructures of Vanadis 4 (a), Vanadis 10 grade (b).

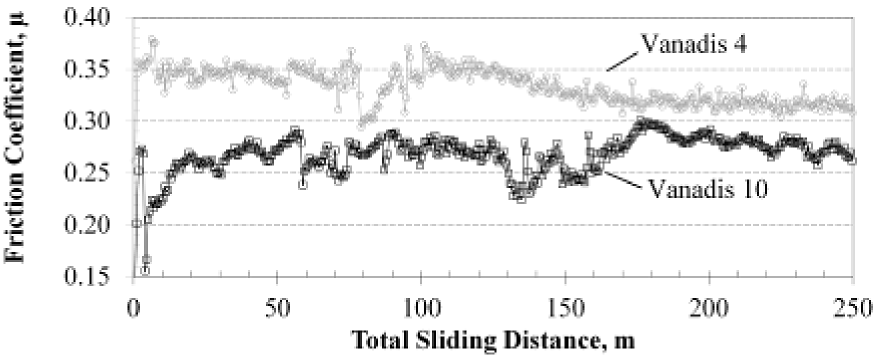
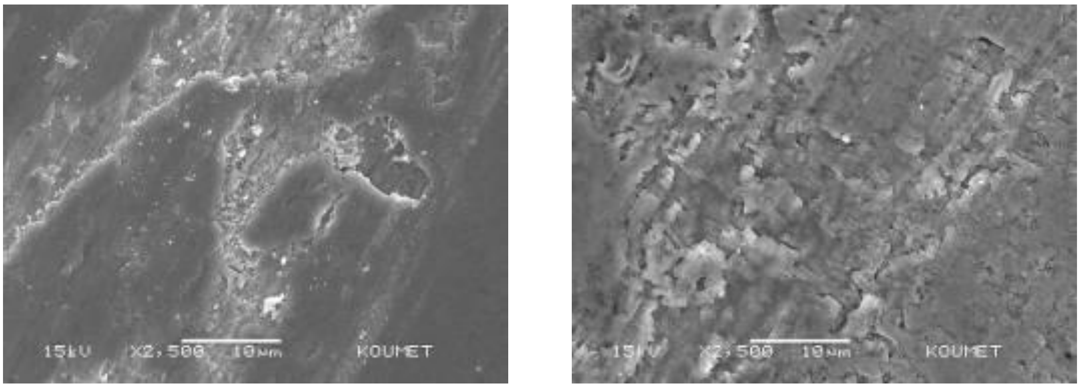


Figure 3. The relationship between friction coefficient and distance for Vanadis 4 and Vanadis 10 grade steels.



(a) (b)

Figure 4. SEM micrographs showing the abrasive-adhesive tracks on the worn surfaces of Vanadis 4 (a), Vanadis 10 grade (b)