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Comparison of the microstructures in continuous-cooled and quench-tempered pre-hardened mould steels

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ABSTRACT

The increased demand for plastic mould steels in pre-hardened condition has drawn the attention to this specific type of steel. As a result, more investigations are performed to understand microstructure and properties. In this work, the microstructures of two pre-hardened plastic mould steels, one quench-tempered (Uddeholm Impax HH) and the other continuously cooled (Uddeholm Nimax), are studied in delivery condition by means of different microscopy techniques and are linked to their production procedure. The results show that the quench-tempered material contains large amounts of M_3C carbides formed within the martensite plates as well as at the lath- and prior austenite grain boundaries. A few coarser Cr-rich M_7C_3 carbides have also been found. In comparison, the microstructure of the continuously cooled material consists of mainly bainite with much lower density and finer cementite particles. The hardness is with ~40 HRC more or less constant over the cross section of both materials.

1. Introduction

Increased usage of plastic products has increased the importance and consequently the market share of plastic mould steels. Compared with moulds made of copper and aluminum, steel moulds possess higher strength and can therefore be used for mass production. Depending on the size and type of the mould needed, different plastic mould steels can be used:

- Pre-hardened mould steels (29–40 HRC) are utilized in almost all applications.
- Post-roughing hardened mould steels (40–62 HRC) and ledeburitic steels (~60 HRC) are used when high wear resistance is required.
- Case hardening steels (up to 60 HRC) are applied when very high wear resistance and surface finish is required.
- Corrosion resistant mould steels have to be used for application in very corrosive environments.
- Precipitation hardening mould steels (max. 55 HRC) are used when high wear resistance is required. The required hardness is achieved by precipitation of fine intermetallic particles.

The choice of steel type influences the mould making process. Pre-hardened mould steels provide the easiest mould making process. Hence, today around 80% of the plastic mould steels are delivered in pre-hardened condition of ~40 HRC. Mechanical strength, wear resistance and polishability are sufficiently high for many mould applications [1]. Uddeholm Impax HH and Nimax are both plastic mould steels and are delivered in the pre-hardened condition of ~40 HRC. Impax HH resembles the P20 modified grade and is used where high surface finish and wear resistance is required. Because of the high hardenability of Impax HH (higher than the conventional P20), it is possible to use the material even when large cross sections are needed since larger differences in hardness between core and surface can be avoided. Larger cross sections are more and more in demand especially in automotive industry in which around 80% of all plastic mould steels are used.

Nimax has a lower carbon content and possesses a microstructure that provides a high toughness and shock resistance. It is replacing the P20 steel grades and can be referred to as new generation of pre-hardened plastic mould steels. The advantage of Nimax is that the required hardness can be achieved by air-cooling from the forging temperature. This means, that there is no need for additional treatments such as quenching and tempering which increase time and cost of production. The other important advantage of lower carbon content is the higher weldability and lower hardness difference between HAZ and matrix that results in better photoetchability of the weld joint [2].

The superior properties of Uddeholm Nimax over some AISI P20 grades have been reported before [2]. However, detailed knowledge about the microstructure of these materials is required to understand the reasons for the observed properties. Hence, in this

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