# Evolution of Carbides in High Speed Steel during Heat Treatment

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## Introduction

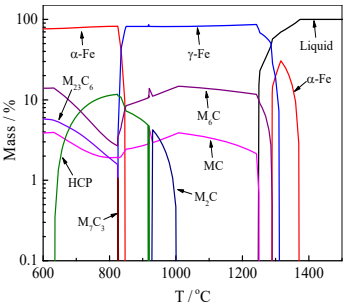
High speed steels are widely used in making high speed cutting tools, which always requires high hardness, good wear resistance and good thermal fatigue resistance at elevated temperatures. It is well known that the type, morphology, size and distribution of carbides have great influence on the mechanical properties of high speed steel. The evolution of microstructure and carbides in high speed steel are strongly influenced by the obtainment process. Ideally, depending on the application, some best mechanical properties are expected when the microstructure showed a homogeny distribution of the carbides in the matrix, but the achievement of this microstructure is very difficult because the carbide formation occurs in several stages of the obtainment process.

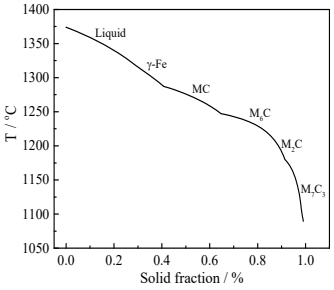
## Materials and Methods

The composition of sample is (weight%) 1.2C-3.5W-8.Mo-3.9Cr-2.8V-0.62Si-0.3Mn-0.03Y.

**Process:** 1130°C×10h and 1150°C×10h

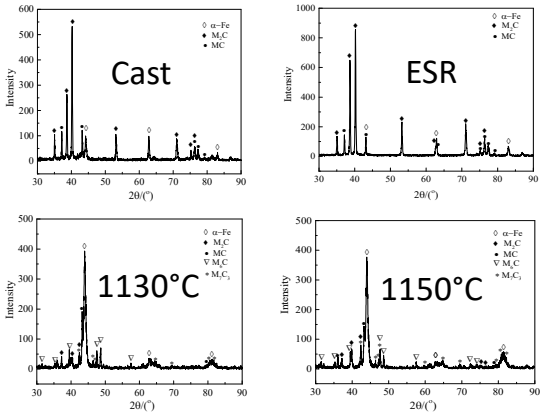

The equilibrium and non-equilibrium phase diagram of high speed steel were calculated by Thermo-Calc software.

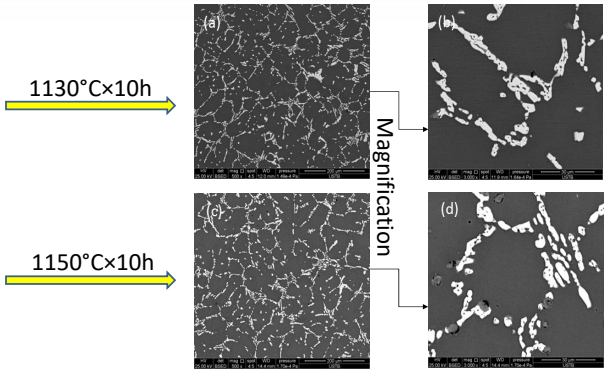



## Results and Discussions

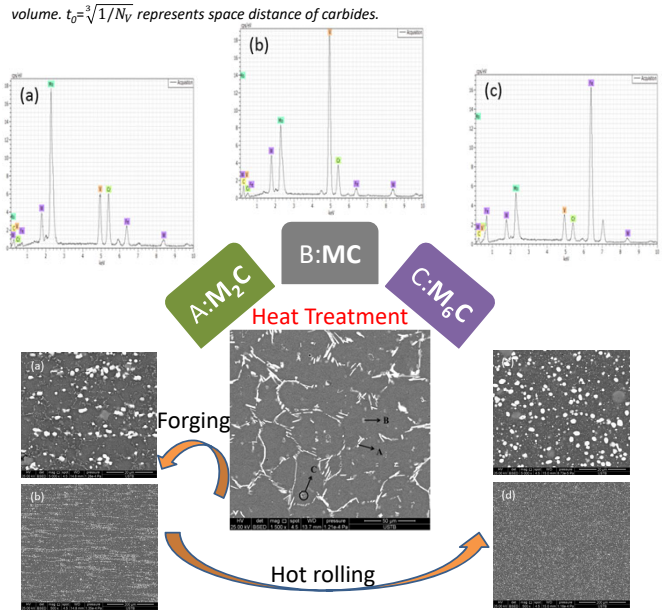
**Carbides type X-ray diffraction analysis:**




| Status | Basic parameters | | | | | Characteristic parameters | | |
|---|---|---|---|---|---|---|---|---|
| | $N$ | $A$/μm² | $D$/μm | $L$/μm | $W$/μm | $V_V$/% | $N_V$ | $t_0$/μm |
| As-cast | 1671 | 5491 | 3.84 | 300.58 | 258.82 | 7.06 | $5.60e^{-3}$ | 13.37 |
| Heat treatment | 522 | 7706 | 5.03 | 300.59 | 259.00 | 9.90 | $1.33e^{-3}$ | 27.39 |
| Hot-rolling | 2334 | 1817 | 1.28 | 148.55 | 128.20 | 9.54 | $9.57e^{-2}$ | 3.23 |

*$V_V=A_A$ represents volume fraction of carbides. $N_V=N_A/D$ represents number of carbides in per unit volume. $t_0=\sqrt[3]{1/N_V}$ represents space distance of carbides.*




## Conclusions

- $M_2C$ and MC are common carbides in as-cast high speed steel. Through high temperature treatment, $M_2C$ completely decomposed into MC and $M_6C$. Through solution treatment, $M_6C$ transformed to short rod and MC existed in $M_6C$ and the base body. Through forging and hot rolling, $M_6C$ was broken into spherical and uniformly distributed in the matrix while MC was completely dispersed into the matrix.
- It is found that the number of carbides per unit volume decreased after the heat treatment, but the volume fraction increased. Significant increment in the number of carbides was observed after hot rolling, and the average diameter reduced to 1.28μm. At the same time, the unit volume number increased by a large extent and the spatial distance decreased to 3.23μm.

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