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Effect of Sintering Temperature, Heat Treatment and Tempering on Hardness of SH737-2Cu-0.9C Sintered Samples

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Abstract

The study examines hardness pattern of SH737-2Cu-.9C samples transient liquid phase sintered at different temperatures viz. 1120°C, 1180°C and 1250°C, heat treated by various methods and then tempered at different temperatures. Sintered samples were characterized for density and densification parameter, and austenitized at 900°C, subsequently cooled by four different methods viz. annealing, normalizing, oil and brine quenching. Hardness pattern was found minimum for air cooled and maximum for brine quenched, and samples sintered at 1250°C had relatively higher hardness. The O.Q and B.Q samples were then tempered at 200°C, 400°C, 600°C and700°C. Hardness pattern typically showed secondary hardness taking place, with maximum around 600°C.

Keywords: SH737-Cu-C; quenching; tempering; secondary hardness

1. Introduction

This study focuses the investigation of hardness pattern of alloy SH-737(designated) which has nominal composition of Fe-1.25 Mo-1.4 Ni-0.42 Mn (wt%).Sinter hardened grade steels have advantages over carbon steel as they get hardened, during the process of sintering itself as the alloying elements (like Mn, Mo, Co & Ni) enhance the hardenability by shifting the continuous cooling transformation curve to the right. These alloying elements give secondary hardening even at slower coling. These alloying elements give secondary hardening to austentized & heat treated samples and as temperature increases hardness reaches a maximum around 600°C.

2. Experimental and Results

For present investigation, partially prealloyed powder mixture of Fe, 1.4 w/o Ni, 1.25 w/o Mo, 0.42 w/o Mn, 2%Cu and 0.9% graphite, a proprietary process developed by Hoeganaes Corp [1, 2], were used as starting material. Powders were pressed at 600 MPa to obtain cylindrical pellets (16 mm diameter and 6 mm height). The green compacts were dewaxed in N_2-20H_2 atmosphere at 850°C for 30 min. Then the compacts were sintered at 1120°C, 1180°C and 1250°C respectively for 30 min in a tube furnace, in N_2-20H_2 atmosphere. The densification was observed and densification parameter was calculated. Bulk hardness of the samples was measured by Vickers hardness tester at 10kgf load.The samples sintered at different temperatures were then heat treated at 900°C for one hour and subsequently were cooled by four different methods viz. Annealing, Normalizing, Oil and Brine quenching.The samples were again tested for their hardness and pattern was observed.The O.Q and B.Q samples were then tempered at four different temperature viz.. 200, 400, 600 & 700°C. Their hardness pattern was also observed and plotted.

The sintered density improves (~0.5%) with every 60°C increase in sintering temperature from 1120°C to 1250°C, and the porosity turned out to be around 11~12%.

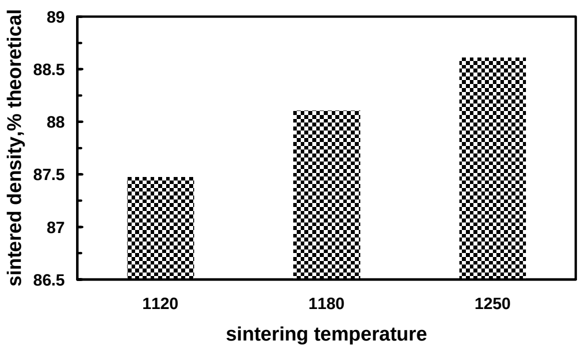

Fig. 1: Effect of sintering temperature on the sintered density, %theoretical SH737-2Cu-0.9C.

Densification parameter increases with increase with temperature is positive for 1250°C. From figure 5, it is quite evident that furnace cooled is having the least hardness regardless of sintering temperature. The trend of hardness is as per follows: **Annealed < Normalized<Oil Quenched < Brine Quenched < As Sintered.**

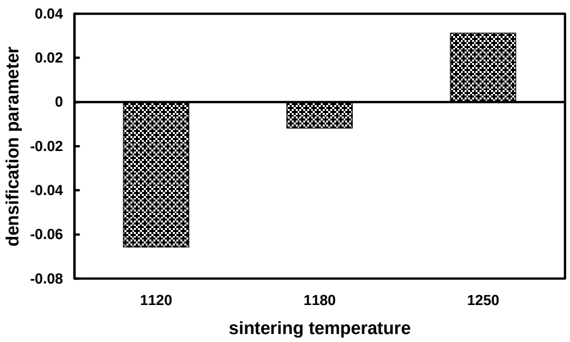

Fig. 2: Effect of sintering temperature on the densification parameter of SH737-2Cu-0.9C.

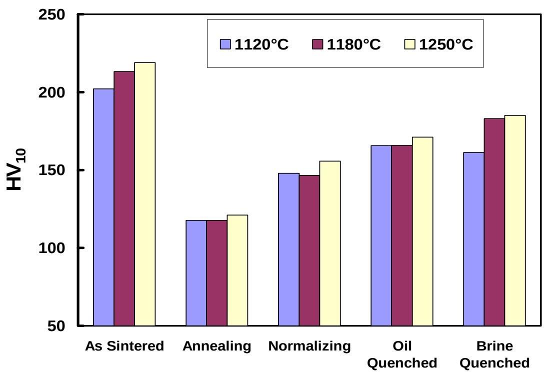

Fig. 3: Bulk Hardness of SH737-2Cu-0.9C samples sintered at different temperatures and cooled by different methods.

The as sintered samples have highest hardness, because the austentisation temperature, 900°C. As the sample was heated to this temperature, the alloyed carbide which precipitated during post-sinter cooling gets dissolved. Being just above A3 line, the samples does not get enough time to form alloy carbides, hence formation of cementite is favoured.Thus we get lower hardness in case of heat treated samples regardless of the way through which it is cooled.

Now on tempering the samples, the hardness starts to increase reaches a maximum around 600°C and decreases. This is due to secondary hardening taking place in the quenched samples. Secondary hardening is taking place in the samples due to presence of sufficient amount of carbide formers like Mn, Mo. Above 500°C, these elements have high diffusivity to nucleate and grow to form fine dispersion of alloy carbides to cause secondary hardening.

But after 600°C the carbides precipitate starts coarsening thus decreasing the hardness.

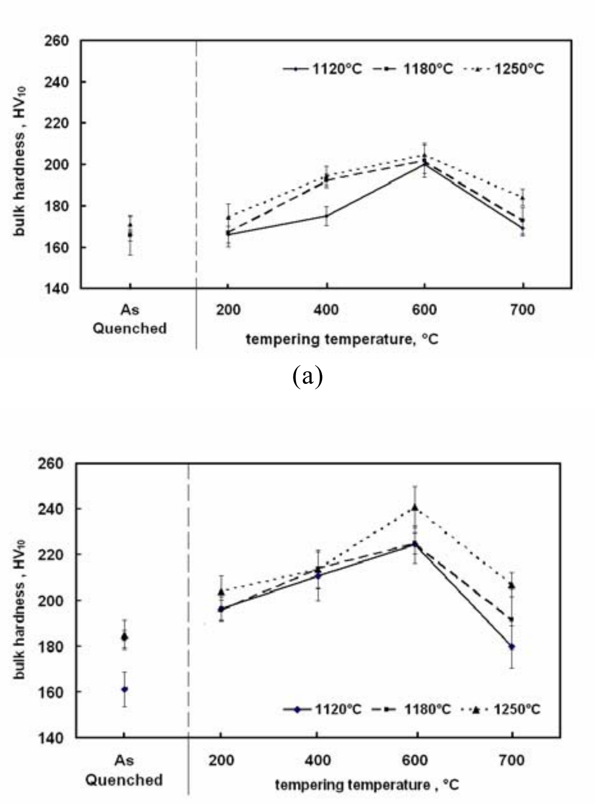

Fig. 4: Effect of tempering temperatures on hardness of (a) Oil quenched and (b) Brine Quenche SH737-2Cu-.9C samples sintered at different temperatures.

3. Summary

Sinter hardned grades have sure advantages over simple carbon steels, as they do not require secondary processing which is quite evident from the above data that hardness of sintered SH737 samples is same as that obtained from heat treatment and tempering. Thus, sinter hardened steel have enormous processing time advantage over simple carbon steel.

4. References

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