Available online at www.sciencedirect.com
ScienceDirect
JOURNAL OF IRON AND STEEL RESEARCH, INTERNATIONAL. 2011, 18(5): 59-63

Influence of Hot Press Forming Techniques on Properties of Vehicle High Strength Steels

CHANG Ying, MENG Zhao-huan, YING Liang, LI Xiao-dong, MA Ning, HU Ping
(School of Automotive Engineering, State Key Laboratory of Structural Analysis for Industrial Equipment, Dalian University of Technology, Dalian 116024, Liaoning, China)

Abstract: Based on the combination of materials science and mechanical engineering, hot press forming process of the vehicle high strength steels was analyzed. The hot forming process included: heating alloys rapidly to austenite microstructures, stamping and cooling timely, maintaining pressure and quenching. The results showed that most of austenite microstructure was changed into uniform martensite by the hot press forming while the samples were heated at 900 ℃ and quenched. The optimal tensile strength and yield strength were up to 1 530 MPa and 1 000 MPa, respectively, and the shape deformation reached about 23%. And springback defect did not happen in the samples.
Key words: high strength steel; lightweight; hot forming; martensite

As an effective economical energy measure, the lightweight development direction of automobile has become one of the most important research subjects in the automotive industry. There are three major ways to achieve automobile lightweight: optimizing vehicle frames and structures; making vehicle body or frame of new and alternative materials to reduce the vehicle mass (The high and ultra high strength steel can be used as alternative materials because of its thinner thickness); adopting advanced manufacturing techniques for the sake of automobile lightweight, such as thickness-gradient high strength steel (HSS) or metal based compound plates by continuous pressing or hot press forming[1]. Although HSS has been applied in some domestic top-grade vehicles, the key producing technologies have always been dominated by foreign companies, such as Acelor Company, so as to raise the product cost obviously. By domestic self-designed hot press forming techniques and water-cooling mould, the automobile HSS can be produced to substitute foreign vehicle parts.

In general, with the enhancement of steel blank's mechanical strength, its formability is worsened dramatically. It is difficult to apply the traditional cold stamping technology into the field of pressing HSS. Thus, the hot stamping technology of martensitic steel blank is applied as a new technology, which combines metal thermoplastic forming method and water-cooling mould quenching principle. In this paper, boron steel blank was formed and water-cooling mould was quenched simultaneously during the process of hot stamping. Compared with original automobile pearlite steel[2], the automobile HSS obtained by advanced hot press forming technique can reduce about 30% of the total vehicle mass and achieve complex geometries, high security and mechanical strength. The reason is that austenite microstructure with optimal plasticity and ductility can be obtained by hot press forming at high temperature[3-5], and the HSS with both excellent mechanical properties and lightweight will be obtained after being formed and quenched[6-8]. The application of hot-formed thinner HSS plates will become an important measure to realize vehicle lightweight.

1 Experimental Setup

In order to form HSS at high temperature, and

Foundation Item: Item Sponsored by National Natural Science Foundation of China (50901011); National Science Fund for Distinguished Young Scholars of China (10125208); Liaoning Province Doctor Startup Fund of China (20071090)
Biography: CHANG Ying(1978—), Female, Doctor; **E-mail**: yingc@dlut.edu.cn; **Received Date**: June 28, 2010

to avoid cracks and springback, the samples need rapid heating and transform completely into stable austenite microstructure. And then, samples are pressed and cooled in self-made water-cooling mould. For the obtained HSS sample, its shape-freezing character or no springback defect is an obvious advantage, and most of microstructure in the sample is martensite. The thickness of sample is 1.6 mm, and the main elements of HSS in this experiment are shown in Table 1.

Table 1　Main elements of material in the experiment

22MnB5	C	Mn	Cr	Si	B	P	S	Al
Minimum	0.220	1.200	0.110	0.200	0.002	—	—	0.020
Maximum	0.250	1.400	0.200	0.300	0.005	0.020	0.005	0.050

Actual experimental procedure included: 1) set different heat treatment temperatures in the range of 750 to 1000 ℃; 2) put the sample into the heat treated furnace to be heated for 4 min at a certain temperature; 3) remove it by mechanical hand and put it into the hot forming moulds to be pressed quickly; 4) simultaneously, it was water-cooled at about 30 ℃/s in the mound. The mechanical properties of sample were analyzed by tensile test system and the microstructure appearance was analyzed by metallographic analysis device.

The shape and size of test sample are shown in Fig. 1.

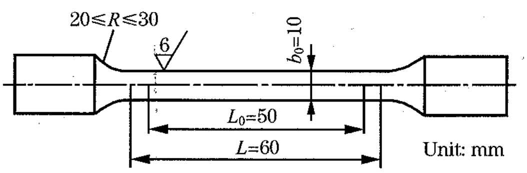

Fig. 1　The shape and size of specimen

2　Results and Discussion

Mechanical properties of HSS (boron steels) with different thicknesses (1.0 mm, 1.6 mm, 2.0 mm, 2.5 mm, 3.0 mm and 4.0 mm, respectively) were checked (GBT 16865-1997 was consulted, and samples were selected along 0°, 45° and 90° rolling direction respectively). The unidirectional tensile tests (based on the metal tensile testing standard of GBT 228-2002) were finished. Compared with USIBOR1500, the values of basic mechanical properties for HSS with different thicknesses in the experiment are shown in Fig. 2.

Fig. 2 shows that after water-cooling quenching, the tensile strength and yield strength of samples (except the one with thickness of 4.0 mm) reached 1500 MPa and 1000 MPa, respectively. The values of the strength were twice better than those of samples before quenching, and nearly the same to those of the plates of thickness 1.75 mm from Acelor

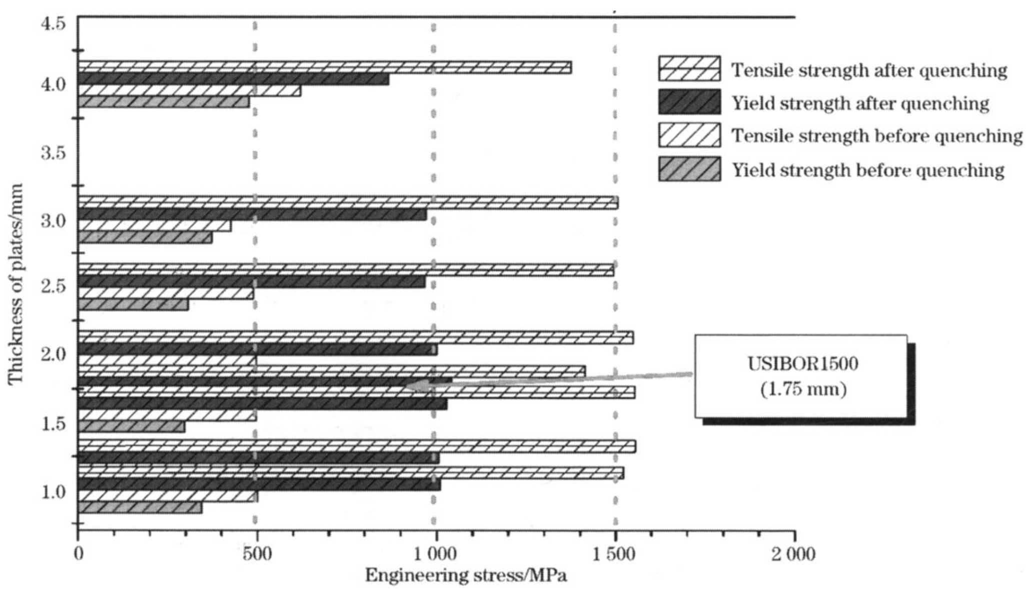

Fig. 2　Tensile and yield strength of high strength steels with different thicknesses before and after quenching