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Recent Activities in Research of Shapes, Bars, and Wire Rods

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Synopsis :

Main research themes of H-shapes and bars and wire steels based on market demands are a new TMCP for H-shapes, an advanced TMCP and micro alloying for bars, a fatigue control for bearing steels, a metallurgy of carbon steel, and strengthening of bars. These studies have enabled the development of many useful H-shapes and bars and wire steels, including the 80 mm thick heavy gauge H-shapes, the new non-heat-treated high strength bars produced by the newly developed thermo mechanical precipitation control process (TPCP), a new economical bearing steel, graphitized steel, which has an excellent machinability, and cold forgeability.

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1 Introduction

Main research themes of H-shapes and bars and wire steels based on market demands in the past decade and steels developed through these research activities are shown in **Fig. 1**. One of the main research subjects for H-shapes is a new TMCP for heavy gauge H-shapes for columns of ultra high-rise buildings. For bars and wire steels, the main research subjects are (1) TPCP (thermo mechanical precipitation control process) technology for non-heat-treated bar steels, (2) contact fatigue control of bearing steels, (3) metallurgy of carbon steels, and (4) strengthening of bar steels.

These studies made it possible to develop useful steel products in each field. Some typical steel products are described below.

2 Research on H-shapes

Research on H-shapes has mainly focused on shape functions. The H-shape named "Super HISLEND-H", which has a constant outer dimension regardless of flange thickness is a typical one.[1] Recently, greater seismic resistance has been required of H-shapes after the North Ridge and Hanshin-Awaji Earthquakes. Such heavy gauge H-shapes as the extra tough 80 mm thick are increasingly being used in the columns of high-rise buildings.

Optimum rolling conditions for mechanical properties can not always be set for H-shapes because of their complicated shapes. Therefore, research on the advanced property control of H-shapes was carried out to overcome these difficulties. Based on this study, VN steels (River Tough (RT) 325 and 355) for JIS grade SN490, which applies FIM (fine inclusion metallurgy) technology, and the extremely low carbon type RT440 steel for JIS grade SA440 were successfully developed. The new TMCP technology, which makes use of vanadium nitride as a nucleation site of ferrite during γ to α transformation,[2] is schematically depicted in **Fig. 2**. This technology also enables the R position of H-shapes to be toughened.[3]

3 Research on Bars and Wire Steels

3.1 Evolution of Bearing Steels

Bearings, which are mainly manufactured from high carbon-chromium steel such as JIS grade SUJ2, are widely used in many kinds of components. Research on steel for bearings has usually focused on lowering non-metallic oxide inclusions because they lower the rolling contact fatigue life. Microstructural fatigue damage during cyclic loading has been newly proved to be a major controlling factor of the rolling contact fatigue life.[4] Based on the alloy design for suppressing microstructural fatigue damage, a new bearing steel named KUJ7,[5]

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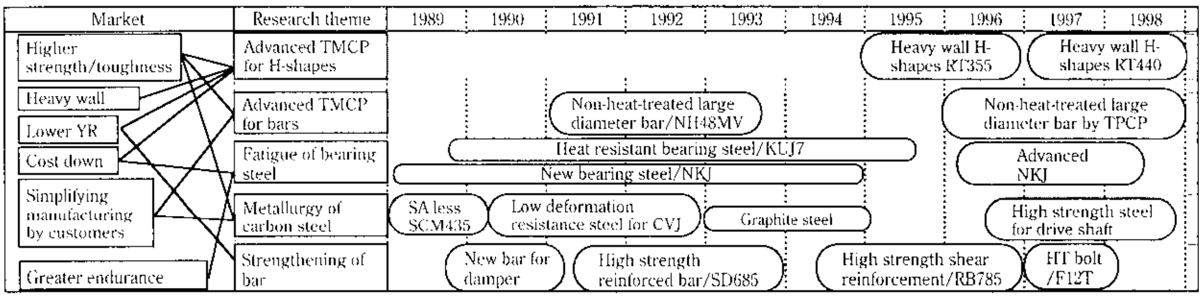

Fig. 1 Market demands, research themes and developed H-shapes, bar and wire rod products for the last ten years

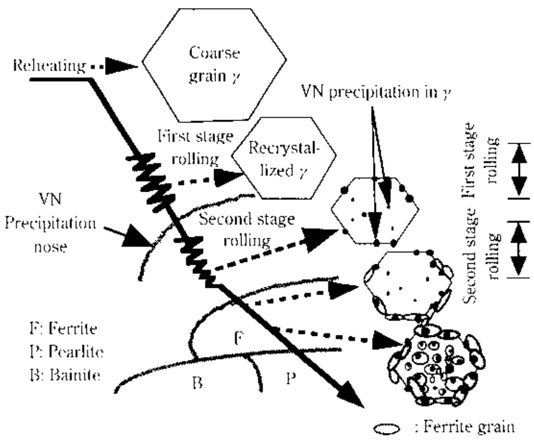

Fig. 2 Schematic illustration of newly developed TMCP for H-shapes

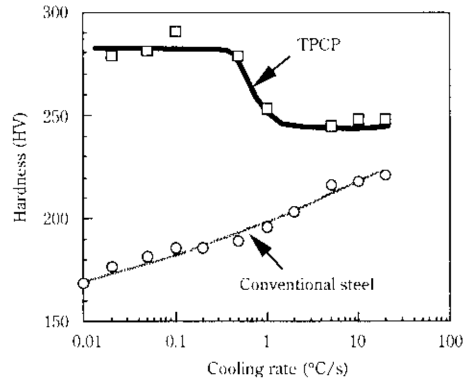

Fig. 3 Relation between cooling rate and hardness of conventionnal and newly developed extremely low carbon bainitic steels

which can be used at high temperatures up to 350°C, was successfully developed. These studies also enabled us to develop a new economical type of bearing steel named NKJ whose properties are equivalent to JIS grade SUJ2.

3.2 Non-heat-treated High Strength Steel Bar Produced Using TPCP Technology

Non-heat-treated, high strength steels for machine structural use have been widely used in automotive parts in this decade to increase economy. As a result, many automotive components which required a strength of 700~900 MPa now contain non-heat-treated steels rather than quench-tempered ones. However, vanadium precipitated ferrite-pearlite non-heat-treated steels containing 0.2~0.5 mass%C are rarely used when a higher toughness is required, and non-heat-treated bainitic steels have not been put into practical use because of their lower yield ratio and larger mass effect.

The microstructure control technique named TPCP, was recently developed, based on our study of extremely low carbon steels,[6] to overcome the limited usages of conventional non-heat treated steels. The TPCP technique consists of an alloy design which produces a uniform microstructure nearly independent of the cooling rate, and strength control by precipitation hardening. The extremely low carbon steel is the most suitable for a uniform microstructure. The precipitation control of this steel can be achieved by adjusting its content of precipitation hardener and optimizing the hot rolling conditions according to required strength and toughness levels. This technique was applied to machining and hot forging uses; an example for machining use is described below.

Low alloy heat-treated steels such as JIS grade SCM435 are usually used for thick shafts or thick pins over 90 mmϕ in diameter. It had been generally believed that it is very difficult to adopt non-heat-treated steels for these uses. However, the TPCP technique made it possible to obtain equivalent properties to low alloy heat treated steels.

The relation between cooling rate and hardness of TPCP steel is shown in **Fig. 3**. The hardness of the steel is maintained constant and is equivalent to that of quench-tempered JIS grade SCM435 in a wide range of cooling rates from 0.01°C/s to 0.1°C/s. TPCP steel also shows excellent machinability in turning.

3.3 Graphitized Steel

Many kinds of important machine components have been manufactured by using carbon and low alloy steels

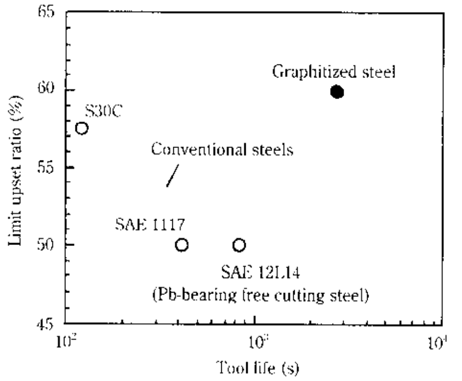

Fig. 4 Relation between tool life in turning test and limit upset ratio in cold forging test

through various processes such as forging, machining, and so on. Though a process combining hot forging and machining has been widely used, cold forging followed by machining is recently becoming the main process for manufacturing the components due to its greater economy. Steel having both excellent cold forgeability and machinability has come into increasingly demand.

It is possible to improve both properties by changing the carbon in the steel from a hard cementite to a soft graphite.[7)] The graphitizing treatment has usually taken so long that graphitized steel in rarely used commercially. Therefore, research for improving graphtization was carried out to overcome this difficulty. This research showed that the formation of BN in steel promotes graphitization.[8)] The relation between tool life in turning tests and the cold forgeability of graphitized steel compared to a conventional steel is shown in **Fig. 4**. The graphitized steel exhibits excellent machinability and cold forgeability. One potential use as a substitute for Pb added free cutting steel is especially promising because of its excellent machinability.

4 Conclusion

As market demands for H-shapes, bars, and wire steels become more diverse, steel which can minimize total manufacturing costs from steel makers to users, must be developed.

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