KAWASAKI STEEL TECHNICAL REPORT
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Properties of Hot Rolled High Strength Steel Sheets for Automotive Use

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Synopsis :

There are three methods of increasing the stre ngth of steel: solid solution hardening, precipitation hardening and dual phase (ferri te and martensite) structure hardening. The characteristics of high strength hot ro lled steel sheet manufactured by these three methods are examined. Also, the mechanical properties, formability, weldability and fatigue properties of spot welded joins of 60 kgf/mm2 class tensile strength hot rolled steel sheet are studied. The dual phase steel sheets have a lower yield ratio, high work hardening rate particularly in the low st rain region and excellent properties of elongation and stretch frangeability, compar ed with conventional high strength steel

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precipitation hardening and dual phase (ferrite and martensite) structure hardening. The characteristics of high strength hot rolled steel sheet manufactured by these three methods are examined. Also, the mechanical properties, formability, weldability and fatigue

Table 1 Comparison of the effects of additives

	Nb	V	Ti
Grain refinement	VS	W	S
Precipitation hardening	VS	S	VS
Inclusion shape control	N	N	S

VS: Very strong, S: Strong, W: Weak, N: No effect

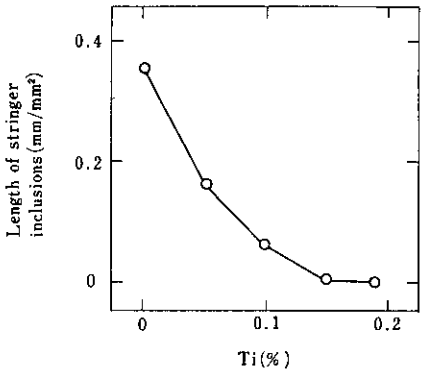


Fig. 1 Effect of the quantities of Ti additions upon stringer inclusion

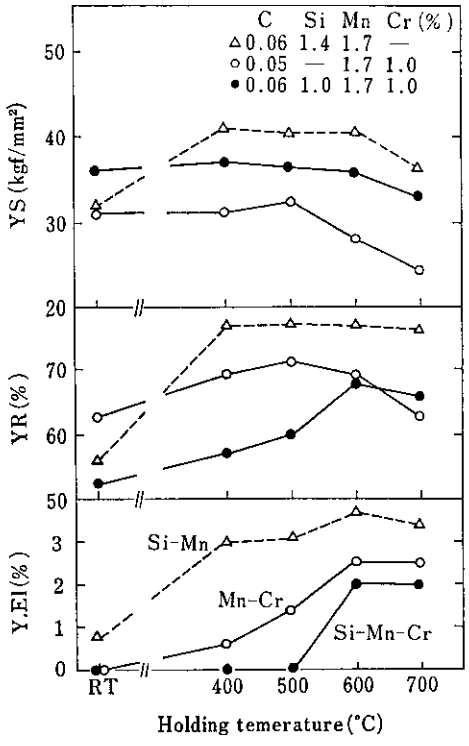


Fig. 2 Effect of the holding temperature after hot rolling upon the mechanical properties of Si-Mn steel, Mn-Cr steel, and Si-Mn-Cr steel (holding time 1 hour each)

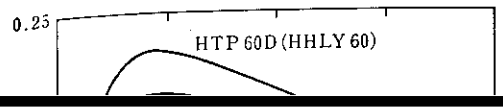
Characteristics of Nb, V and Ti used for precipitation hardening are shown in **Table 1**. Although Nb has precipitation hardening and grain refining effects, it has no inclusion shape control effect. V has less respective effects than Nb. As shown in **Fig. 1**, Ti, other than the same effects as of Nb, has a remarkable inclusion shape control effect; it improves mechanical properties in the direction perpendicular to rolling and diminishes anisotropy of the steel sheet[6]. While additions of Nb in large quantities result in saturating an increase in strength, Ti can increase strength to a higher level. In order that high strength hot rolled steel of precipitation hardening type makes full use of

to coiling at 500° to 600°C followed by slow cooling. In obtaining the dual phase by this process, however, additions of Mn, Cr, Mo, etc. in large quantities are required to transform austenite into martensite during slow cooling, since the cooling rate after coiling is smaller than that after continuous annealing.

In order to investigate the effect of these alloying elements, changes in mechanical properties by heat treatment of hot rolled steel to which Si, Mn and/or Cr were added have been examined. **Fig. 2** shows

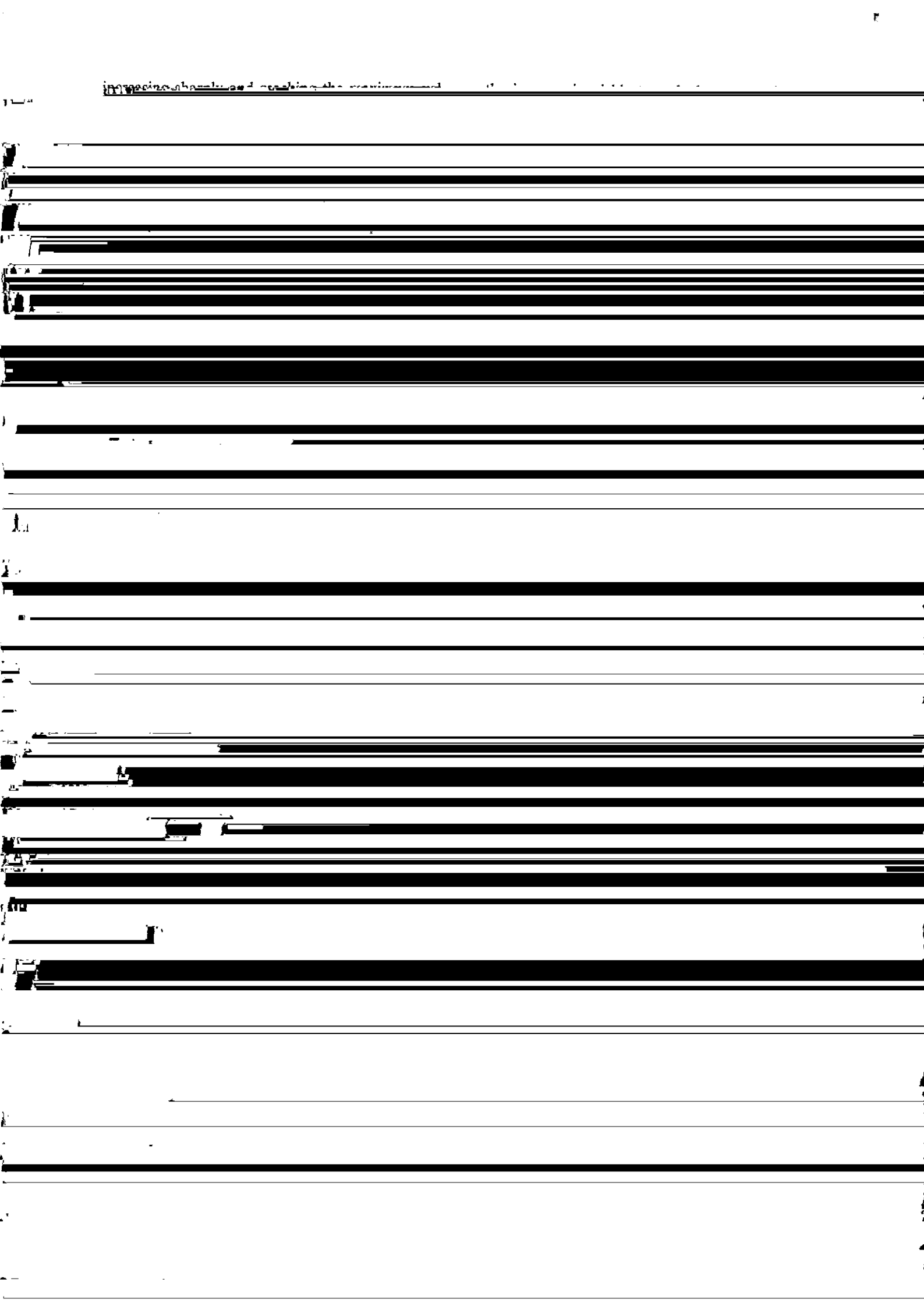
Table 2 Typical mechanical properties of high tensile strength hot rolled sheets, 2.3 mm thick

Type	Class	Tensile properties					n_{5-15}	$\bar{r}$	Notched tensile Elongation(%)	Hv	Minimum bend radius
		YS (kgf/mm²)	TS (kgf/mm²)	El (%)	Y.El (%)	YR (%)					



martensite. The grain size of HTP 60F is very fine due to controlled rolling and the grain refining effect of Ti.

In order to investigate the properties of ageing and bake hardenability, changes in yield strength and tensile strength were measured in two different conditions:



3.2 Spot Weldability

and spot welding in order to examine the spot weldability of high strength steel sheet. With welding time of 26 cycles and holding time of 15 cycles set constant, the welding current and electrode force were varied to determine the critical curves for expulsion. The result [illegible] In the case of high strength steel

ing elements, the expulsion limit of HTP 60D is at lower current than that of HTD 60F. Spot welding was

expulsion limit and the results such as the static tensile shear strength and the cross tensile strength are described in **Table 5**. Changing the welding condition will not appreciably alter the strength of welded joints. The tensile shear strength increases in proportion to

ing time of 26 cycles and the current just below critical curve for expulsion. The fatigue test was of the tensile shear fatigue, load control type: 0-tensile load was

continue; and because higher strength hot rolled steel sheet contributes greatly to reducing weight, it will draw more attention.