Abridged version

KAWASAKI STEEL TECHNICAL REPORT
No.13 (September 1985)

Properties of YP 36-kgf/mm2 Class Hull Structural Steel Plates Produced by Accelerated Control Cooling Process

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Synopsis :
Online thermomechanical controlled cooling system named MACS (Multipurpose Accelerated Cooling System) was set into operation in April 1983 at No. 2 Plate Mill at Mizushima Works, Kawasaki Steel Corporation. The mechanical properties of YP 36 kgf/mm2 (350 MPa) class hull structural steel plates of A, D, and E grades manufactured by the MACS process, have been investigated. The plates, manufactured by the MACS process, having 0.05 to 0.09% lower carbon equivalent than usual, are superior to conventional steel plates in the welding crack and toughness at the heat affected zone of a large heat input welded joint. The values of tensile and fatigue tests both in base metal and in the large heat input welded joint, are satisfactory. The application of the MACS device to producing higher strength steel with lower Ceq will introduce the increase in the amount of higher strength hull structural steel plates based on the superior characteristics of their mechanical properties.

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The body can be viewed from the next page.

Steel Plates Produced by Accelarated Control Cooling Process*

Synopsis:

Online thermomechanical controlled cooling system

Table 1 Chemical composition of YP 36 kgf/mm^2 steels used

Steel	Grade	Thickness (mm)	Chemical composition (wt %)									Remarks
			C	Si	Mn	P	S	Al	N (ppm)	C_{eq}*	P_{cm}**	
A 1	AH36	25	0.15	0.24	1.02	0.016	0.004	0.029	29	0.32	0.21	

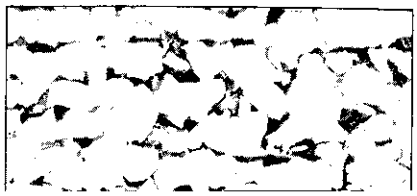
3 Base Metal Properties

toughness in the through-thickness direction of the sample steel at the 1-mm under-surface and the 1/2-t

Table 2 shows the base metal tensile test results and 2-mm V-notch Charpy impact test results of sample steels. Base metal strength fully satisfies the require-

surface, but the difference in 50% FATT is only within 20°C.

Figure 2 shows the measured values of sample steel B3



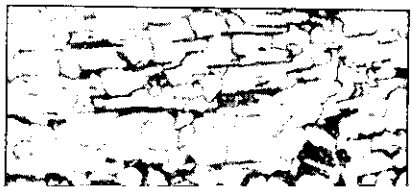


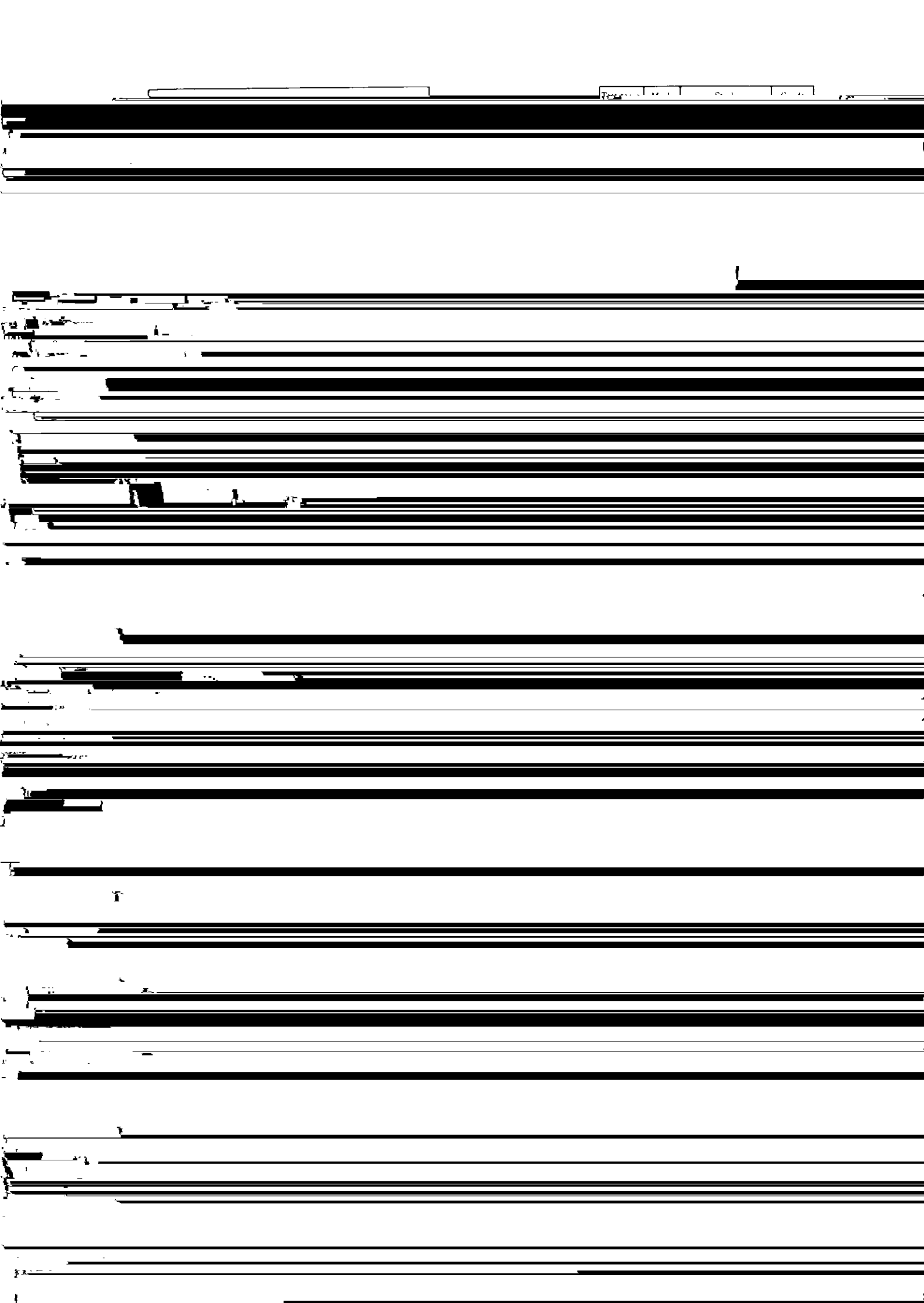
Table 3 Fracture toughness of base metal

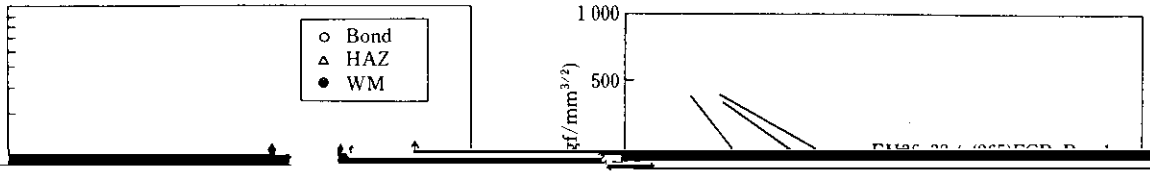
Grade	Steel	Thick. (mm)	Longitudinal				Through thickness		
			COD		Deepnotch $K_C=200$ (°C)	ESSO $K_{ca}=600$ (°C)	COD		Deepnotch $K_C=200$ (°C)
			$\delta_C=0.1$ (°C)	$\delta_C=0.2$ (°C)			$\delta_C=0.1$ (°C)	$\delta_C=0.2$ (°C)	
AH36	A 1	25	<-100	-100	—	—	-87	-72	—
	A 2	35	-55	-40	—	—	-81	-54	—
DH36	B 2	25	-71	-73	-158	-1	-64	-47	—
	B 3	35	-84	-62	-150	—	—	—	—
EH36	C 3	38	-107	-99	-145	-48	-75	-51	-112

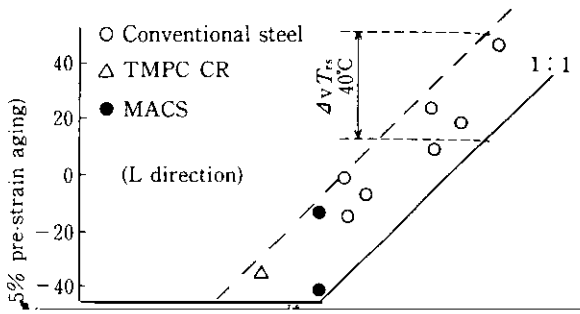
3.3.2 Crack arrest toughness

Figure 8 shows the dependence of the K_{ca} value on temperatures obtained by the ESSO test for sample steel C3. The temperature at which $K_{ca} = 600$ kgf/mm$^{3/2}$ is obtained is −48°C, which is fully on the safe side in terms of crack arrest toughness.

joint. MACS steel is promising in improving the toughness of the high heat input welded joint and in enhancing welding efficiency due to its C_{eq} decrease effect, but softening of the welded joint and droping of its fatigue strength cause apprehension.[2,5] To confirm these points, various types of large heat input welded joints were made using MACS steel and their properties have been investigated.




Bond
HAZ
WM
1 000
500
kgf/mm$^{3/2}$



equal to each other.

Figure 16 shows the relation between Charpy absorbed energy after flame heating and the carbon equivalent. For the heating and cooling conditions, two methods stipulated by JSQS (Japan Shipbuilding Quality Standards) were selected, one being the method of air-cooling down to 500°C after heating up to 900°C and then water-cooling and the other being the method of water-cooling immediately after heating up to 900°C.

excellent in low-temperature welding crack sensitivity[7] and large heat input welded joint performance, with expectations for higher efficiency at actual construction

Structures, Soc. Naval Architects Japan, (1983), pp. 117–147
3) T. Shiga, T. Hatomura, K. Amano and T. Enami: *Tetsu-to-Hagané*, **68**(1982)12, A227