KAWASAKI STEEL TECHNICAL REPORT
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Manufacture of Forged Shell Rings for PWR Nuclear Reactor Vessels

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Synopsis :
A 250 ton hollow ingot was made for an experimental purposes of which internal properties can be simulated to those of large-sized hollow ingots. The investigation results indicated that this ingot had less C segregation and good cleanliness. Forged shell ring, a component of the 1300 MWe PWR type nuclear reactor vessel, was manufactured from large hollow ingot by using 6000 and 4400 t forging presses, large heat treating furnace and large turn miller. Mechanical properties obtained after heat treatment showed good results. Forged shell ring turned out free of defects as the results of UT and MT which were performed by automatic UT and MT equipments. Furthermore, by using solidification simulation techniques, Kawasaki Steel is manufacturing large hollow ingots up to 320 t for forged shell rings.

The body can be viewed from the next page.

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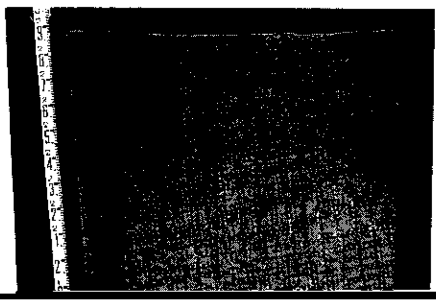
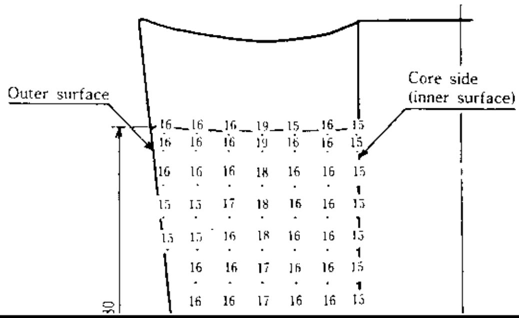
Table 1 Chemical composition

(wt %)

	C	Si	Mn	P	S	Ni	Cr	Mo	V	Co	Nb	B	As	Sn	Sb	Cu
Ladle analysis	0.16	0.24	1.44	0.004	0.002	0.74	0.19	0.52	0.002	0.003	0.001	0.0001	0.002	0.001	0.0005	0.01





3 Manufacture of Forged Shell Ring for PWR

Mn-Ni-Mo steels are used as the material for reactor

· 275 t RH vacuum degasser


perform three-dimensional machining of curved surfaces and has wide application, ranging from super-heavy machining to finish machining. The basic specifi-

Table 2 – Mechanical properties

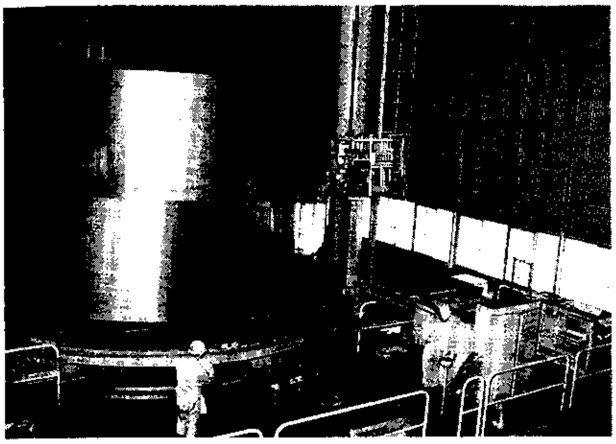


Photo 7 Automatic ultrasonic equipment for large forged shell ring

Maximum weight of work: 200t
Maximum outside diameter: 7.5 m

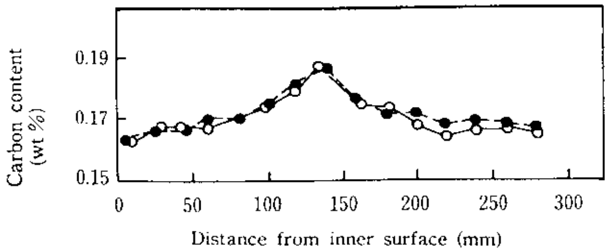
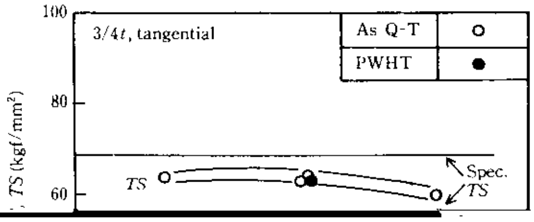


Fig. 7 Carbon distribution of forged shell ring made from 220 t hollow ingot (top sample-corresponding to top of the ingot)

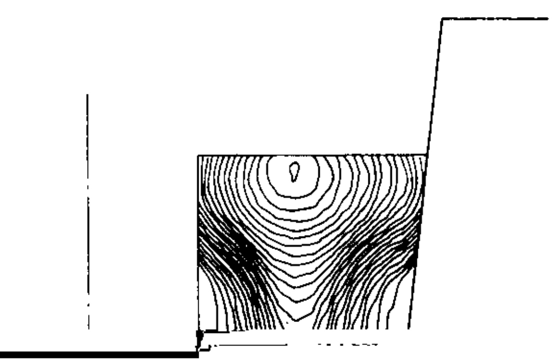


100

Mark	Orientation
O	A

(radiation heat transfer), each through a coating [redacted]

top of the ingot, surface in contact with the core (inside diameter side), and surface in contact with the mold (outside diameter side), respectively.



[redacted]

Results of the simulation of the solidification profile of [redacted]

results are in good agreement with those shown in Photo 1. It was thus found that solidification proceeds gradually toward the center of the thickness due to cooling from both the core side and the mold side.

A comparison between prediction and results of the final solidification point in the inverted-V segregation region is shown in **Fig. 12**. Good agreement is observed between the two, showing it is possible to predict qualities of large ingots by simulation.

5 Conclusions

Kawasaki Steel manufactured a forged shell ring for a 1 300 MWe class nuclear reactor pressure vessel using a 220-t hollow ingot made by the basic oxygen furnace- [redacted]