

대형엔진의 용접실린더프레임 적용

김용재⁺ · 정근수⁺⁺ · 권오신⁺⁺⁺

Introduction of Welded Cylinder Frame for large bore engine

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Contribution by
Hyundai Heavy Industries Co. Ltd.

주요특징
 * 용접실린더프레임의 도입으로 1,000톤급의 대형엔진에 적용 가능
 * 용접실린더프레임의 도입으로 1,000톤급의 대형엔진에 적용 가능
 * 용접실린더프레임의 도입으로 1,000톤급의 대형엔진에 적용 가능

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1. Introduction

HHI, the world's first 50million BHP production achievement, have introduced the welded cylinder frame to the large bore, K98MC-C engine.

Existing design (Cast)	Alternative design (Welded)
<ul style="list-style-type: none"> Characterized by being cast in 2 cylinder block unit. Comprised many units and connections. 	<ul style="list-style-type: none"> Being fabricated in 2 block, fore and after unit. Comprised 2 units and a few connections.

- Due to the limitation of machining capacity, welded cylinder frame with separated scavenging air receiver introduced.
- Overload of HHI's foundry shop relieved and resulted in production of cast components available just in time.
- Engine weight can be reduced by 75 tons. Eventually ship's dead weight can be increased.

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2. Comparison of cast and welded cylinder frame

Description	Welded cyl. frame	Cast cyl. frame
Material	Steel plate + Cast Steel (Top plate)	Cast Iron(C3Cu)
Block units	2 Fore part with chain wheel frame + AH part	7 6 block frames + 1 chain wheel frame
Weight (tons)	194	270
Cylinder liner	Not exchangeable with casting one	
Production lead time	Fabrication: 3months Machining: 2months	Casting: 3months Machining: 2months
Sub-assembly	Handling easier	
Top plate thickness	310mm	465mm

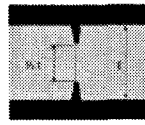
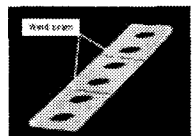
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3. Consideration of Design

Cast steel top plate

- Low carbon equivalent $C_{eq} < 0.38\%$ to omit pre-heating.
- Manganese : sulphur ratio > 40 to avoid "hot cracks".
- Assembly of top plate: 2 cylinder/block; by welding.
- Partial penetrated butt welds, EN 601 M Q2.


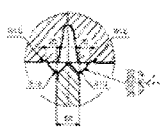
Joint and block of top plate

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Welding quality

- Post Weld Heat Treatment not required.
- Full penetrated K-butt welds, EN 601 M Q3 between top plate and vertical walls.
- Grinding of weld toes between top plate and vertical walls.

Improvement of fatigue strength by the Grinding

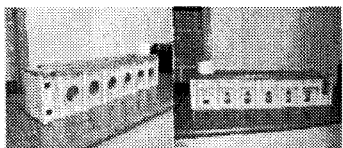
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4. Planning and Production

HHI have put in a lot of efforts in planning the manufacture of the welded cylinder frame.

Made a cardboard model with 1 to 20 scale



Confirmed the process of welding, machining and handling

Cardboard model

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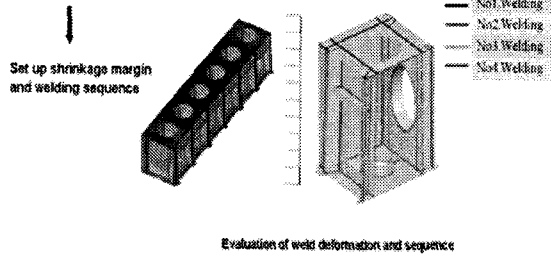
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Evaluated the welding deformation and shrinkage by HIRI's Weld Deformation Expectation and Control program



*HIRI: Hyundai Industrial Research Institute



Top plate production

- Material: S17F
- Carbon equivalent $C_{eq} < 0.32\%$
 - Cast with the welding side down to get the best quality



- Evaluated No's of turn over during top plate welding.

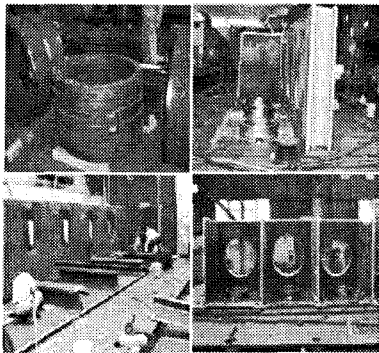
Cast steel top plate and evaluate No's of turn over



Fabrication

Fit-up and welding sequence in production

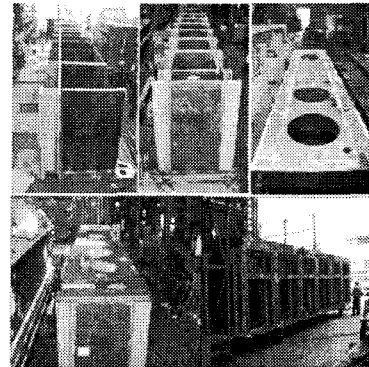
- Parts to be ready
- Bottom plate
- Exhaust side plate



- Middle web plate
- Fuel pump side plate
- Top plate
- Accessories etc.

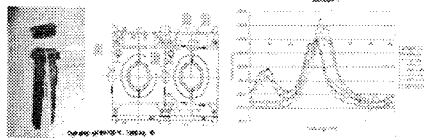
During the production

- Target of overall deformation: 5-7mm
- Actual deformation: Max. 6.2mm.



5. Measurement

- Strain gauges: fitted in the first welded cylinder frame.



- Measurement: carried out at 100% load.

Measurement Point	Strain (%)
1	0.0000
2	0.0000
3	0.0000
4	0.0000
5	0.0000
6	0.0000
7	0.0000
8	0.0000
9	0.0000
10	0.0000
11	0.0000
12	0.0000
13	0.0000
14	0.0000
15	0.0000
16	0.0000
17	0.0000
18	0.0000
19	0.0000
20	0.0000
21	0.0000
22	0.0000
23	0.0000
24	0.0000
25	0.0000
26	0.0000
27	0.0000
28	0.0000
29	0.0000
30	0.0000
31	0.0000
32	0.0000
33	0.0000
34	0.0000
35	0.0000
36	0.0000
37	0.0000
38	0.0000
39	0.0000
40	0.0000
41	0.0000
42	0.0000
43	0.0000
44	0.0000
45	0.0000
46	0.0000
47	0.0000
48	0.0000
49	0.0000
50	0.0000

- Safety factor: 1.9 at ground area.



6. Conclusion

HHI have introduced welded cylinder frame to the large bore engines first in the world

- Thanks to MAN B&W's simple & robust design criteria, the components were manufactured and in-service successfully without any problem.
- Possible solution to manufacture cylinder frame.
- Cylinder liner has no inter-changeability.
- To get competitiveness, hot rolled thick top plate and integrated cylinder frame with air receiver is to be considered.