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A Study for Mitigating Residual Stress in CRDM Penetration Nozzle Weld

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Key Words: CRDM Penetration Nozzle(), J-Groove Weld(J-), PWSCC(), Residual Stress(), Residual Stress Mitigation()

Abstract

In this study, we proposed new method to mitigate tensile welding residual stress for preventing PWSCC in CRDM nozzle. Residual stress analysis using finite element method is performed to confirm benefit of the new method. In case of applying existing method, tensile axial residual stress decrease by about 28% and tensile hoop residual stress decrease by about 33%. In case of applying the new method, tensile axial residual stress decrease by about 32% and tensile hoop residual stress decrease by about 43%. Therefore, we conclude the new proposed method is more effective to prevent PWSCC than existing method.

1.

182

Ocone 2 3
(CRDM) (penetration nozzle)
가

600
600 가
가
(2).

(1)가 . Ocone 1

Arkansas

J- 가

182

ASME Sec. IX

(PWSCC)

가

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(3,4)

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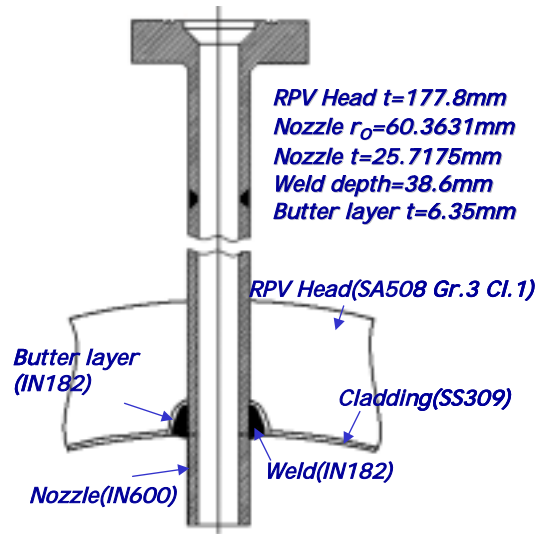


Fig. 1 Configuration for CRDM nozzle weld

2.

2.1

Fig. 1

SA508 Gr.3

Cl.1,

600,
182가

Fig. 2

2,368

2,536

model)⁽⁵⁾

7

(lumped

가

(element add and remove)⁽⁶⁾

ABAQUS⁽⁶⁾

가

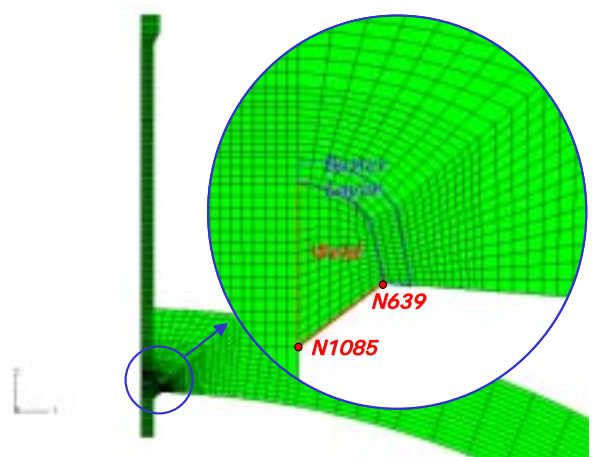


Fig. 2 FEM model for CRDM nozzle weld

2.2

Fig. 3 Fig. 2

639 1085

가

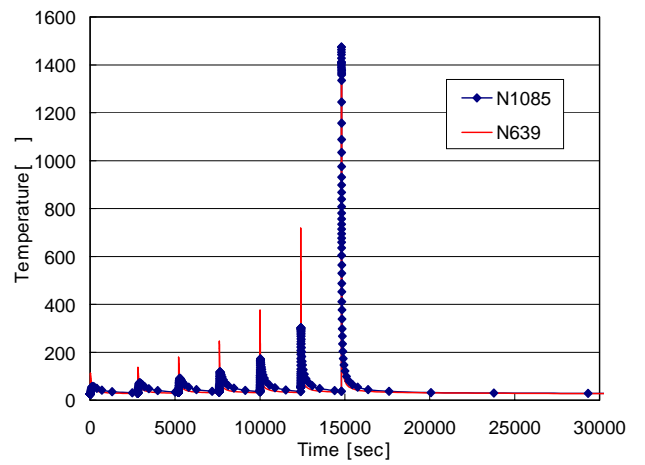
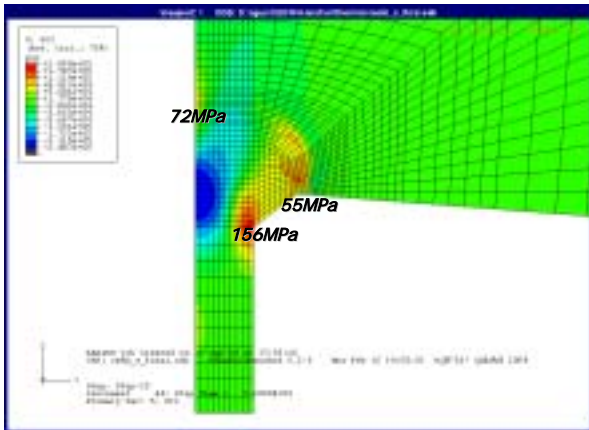
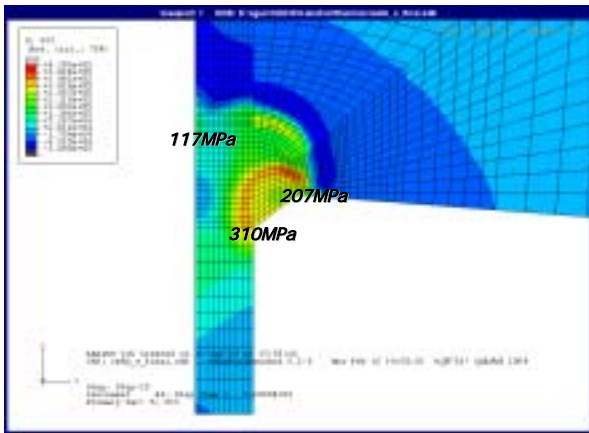


Fig. 3 Temperature history at nodes 639 and 1085

Fig. 4



(a) Axial stress



(b) Hoop stress

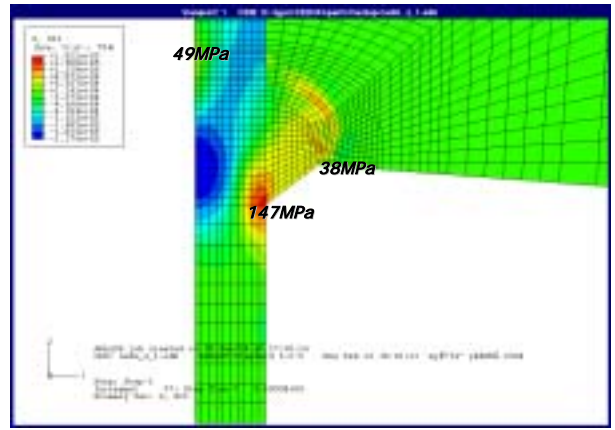
Fig. 4 Residual stress distribution after welding

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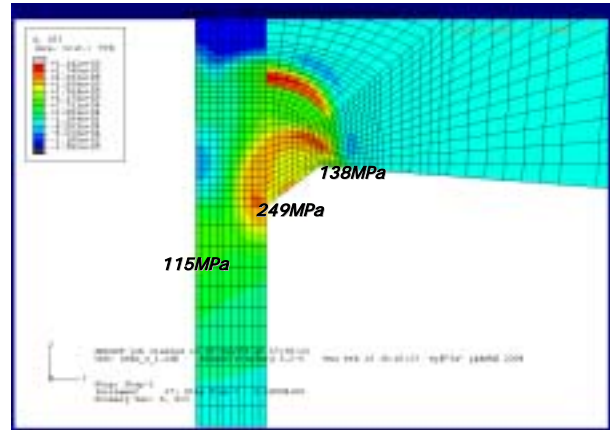
가 (: 156MPa, : 310MPa), (: 72MPa, : 117MPa).
 (7) 325
 600 210-240MPa 가

Fig. 5 . 310MPa
 249MPa

가 .



(a) Axial stress



(b) Hoop stress

Fig. 5 Residual stress redistribution considering heatup condition in normal operation

3.

3.1

◦ AEAT MSIP(Mechanical Stress Improvement Process):

가

◦ WJP(Water Jet Peening):

가

2가

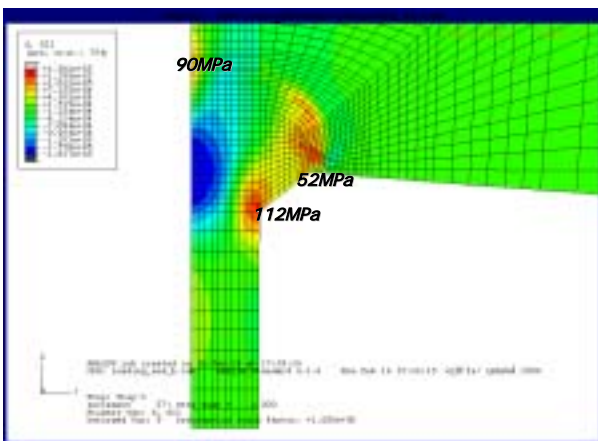
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AEAT MSIP
(NRC) NUREG-0313

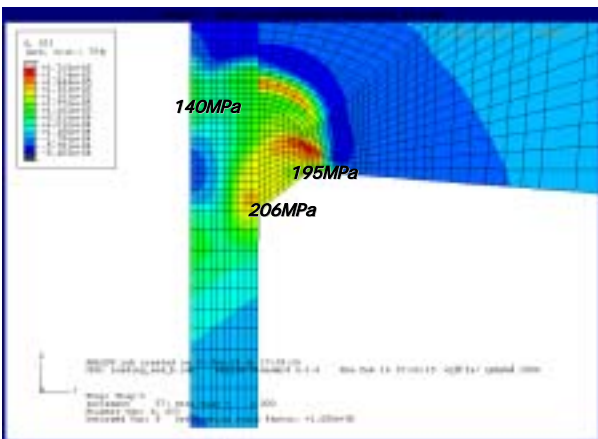
Fig. 6 AEAT MSIP

150MPa 가
156MPa 112MPa
28% 310MPa
206MPa 33%
AEAT MSIP

3.2
AEAT MSIP



(a) Axial stress



(b) Hoop stress

Fig. 6 Residual stress redistribution after AEAT MSIP

가
가

가

WJP

가

가

Fig. 7
(a)
가

, (b)

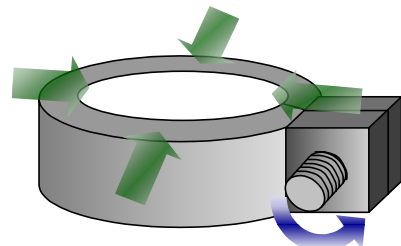
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Fig. 8

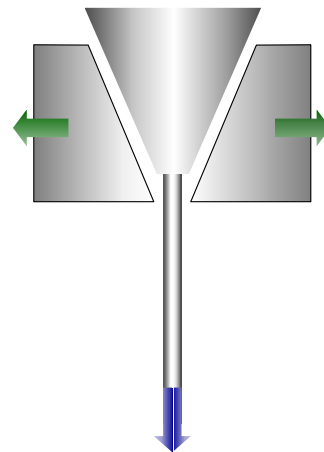
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가 가



(a) Compressive load on outside surface



(b) Compressive load on inside surface

Fig. 7 Mitigation devices

가 가

Fig. 7 (a)

150MPa

가

(b)
150MPa

가

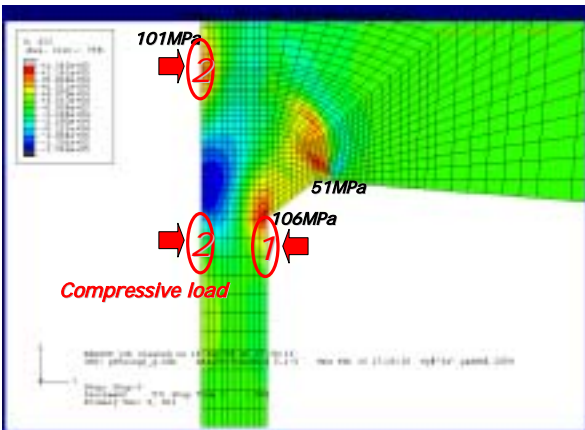
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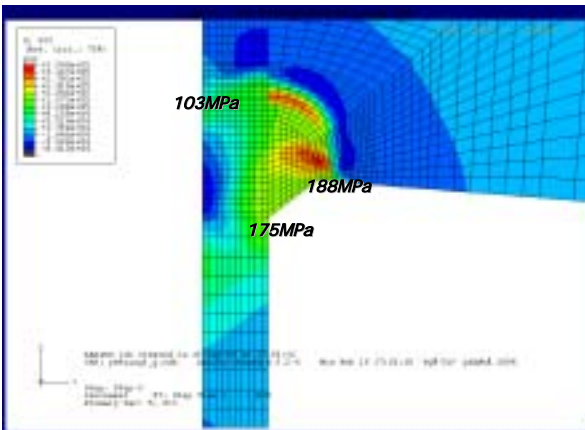
32% 156MPa
310MPa 106MPa
175MPa 43%

5.

(1)



(a) Axial stress



(b) Hoop stress

Fig. 8 Residual stress redistribution after newly developing mitigation process

249MPa
210-240MPa

(2)

AEAT

MSIP 150MPa

28%

33%

(3) AEAT MSIP WJP

150MPa

가

32%

43%

(4)

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