NASA TECH BRIEF

Improved Welding of Rene-41

The strength of Rene-41 weldments conventionally welded by gas-tungsten arc (GTA), with Hastelloy-W used as the filler, is limited by the poorer mechanical properties of the filler. Much stronger joints are now possible by either electron-beam (EB) welding without a filler or GTA welding with Rene-41 used as the filler. Pertinent mechanical properties of three types of weldment are compared in Table 1.

There are several reasons why hitherto Rene-41 has not replaced Hastelloy-W as the filler: (1) Rene-41 filler imposes higher residual stresses on the heat-affected zone of the parent metal which thus becomes more susceptible to strain-age cracking. (2) Use of Rene-41 filler may possibly lead to strainage cracking of the center bead, especially if the weld is made flush with the parent metal. (3) Hastelloy-W as the filler has much better wettability (less-sluggish weld puddle) than Rene-41, and allows for more-lax pre-weld processing—greater mismatch, for example.

These objections to Rene-41 as the filler are weakened by not only these improved welding techniques; also it is shown (Table 2) that, when Rene-41 is used, resistance to strain-age cracking is greatly increased by post-weld solution annealing in an inert atmosphere such as argon. Generally Rene-41 can be used for filling without too many cracking problems.

Note:

Requests for further information may be directed to:

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No patent action is contemplated by NASA.

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(continued overleaf)

Table 1. Mechanical properties of three types of Rene-41 weldment

Test temp., °F	Stress rupture: Stress, 1000 lb/in^2	Stress rupture: Time to failure, hr	Elongation, %, in 0.5 in.	Elongation, %, in 1 in.	Elongation, %, in 2 in.	Larsen-Miller parameter [a]	Point of failure [b]	Tensile strength, 1000 lb/in^2: Yield	Tensile strength, 1000 lb/in^2: Ultimate
				Electron beam; no filler					
1400	65	39.2		4	4	40.2	W		
1400	85	6.2		8	7	38.8	W		
1400	90 (2) [c]	3.7		8	7	38.3	W		
1600	40	10.0		10	7	43.3	W		
1600	50 (3) [c]	2.1		8	7	41.7	W		
1600			14	14	11		W	75	86
70			9	8	7		W	133	168
				GTA; Rene-41 filler					
1400	65	43.3				40.4			
1400	80	7.0		25	15	38.8	PM		
1400	90	5.0		24	16	38.6	PM		
1400	95	2.6		20	13	38.0	PM		
1600	40	9.8		29	21	43.2	PM		
1600	50 (3) [c]	2.3		27	18	41.9	PM		
1700	40 (2) [c]	0.6		27	20	42.8	PM		
70			10	10	9		HAZa	132	179
1600			37	33	21		PM	73	87
				GTA; Hastelloy-W filler					
1600	65	0.03		5	3	38.2	HAZa		
1600	27.5 (3) [c]	5.3		15	8	42.7	HAZa		
1600	20	25.0				44.2			
70			16	10	6		HAZb	98	134
1600			20	12	6		HAZa	58	74

[a] $p = \underline{T}(\log \underline{t} + 20)10^{-3}$ where $\underline{T}$ is the temperature (°R), $\underline{t}$ is the time in hours, and 20 is the material constant. [b] W, within flush bead; PM, within parent metal away from weld; HAZa, within or beside proud bead; HAZb, within
[c] Within parentheses is the number of tests.

Table 2. Mill-annealed Rene-41: Weldability restraints with three fillers and two types of solution annealing (one test each).

Filler [a]	Heat, No.	Passes, No.	Heat energy input, J/in.: Circumf. weld	Heat energy input, J/in.: Cross weld	Post-weld heating: Rate, °F/min	Post-weld heating: Atmosphere	Total crack length, in.
HW	8180	11	63,000	5580	10	Air	None
HW	95353	11	63,300	5580	10	Air	6.9
R41	8180	11	72,750	6440	10	Air	6.6
50 R41–50 HW	8180	11	72,500	6300	10	Air	6.2
R41	8180	4	22,350	7050	10	Air	None
50 R41–50 HW	92353	4	20,120	6300	10	Air	None
R41	8180	11	64,900	5700	10	Ar	1-in. Microcrack
50 R41–50 HW	95353	11	71,420	6300	10	Ar	None

[a] HW, Hastelloy-W; R41, Rene-41