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---Solid State Joining, Brazing and Soldering, Surface Treatment, Advanced Packaging---

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Latest Study of Fe-Cr Based Filler Metals

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Background

- In automobile industry, Ni based filler metals have been used for many applications to meet system requirements.
- Recent past history of soaring Ni price, high volume users of Ni based filler metals had seen dramatic increase in their brazing cost.
- In response to these changing market conditions, a new high strength, low cost alternative to traditional Ni based filler metals needed to be developed.

  ⇒Fe-Cr based filler metal was developed.

Background

Service Conditions:

- High Operation Temperature
- High Thermal Stress
- Oxidative Environment
- Corrosive Environment

Structures:

- Compact & Lightweight
- Thin-Walled Sheets
- Metallic Foams
- Feltmetals

Materials:

- Stainless Steels
- FeCrAl
- Inconels
- Nickel Brazing Alloys

Components:

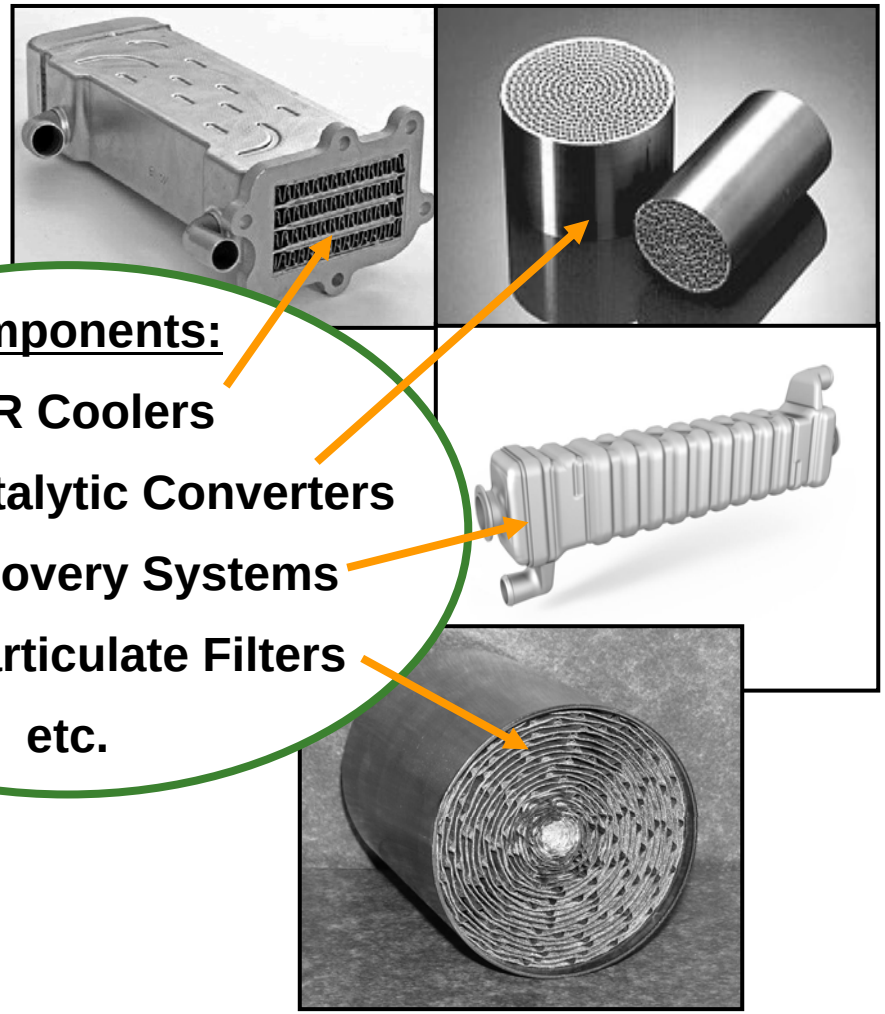
EGR Coolers

Metallic Catalytic Converters

Heat Recovery Systems

Diesel Particulate Filters

etc.



Background

LME Ni Historic Chart (Apr 2004 to Jan 2010)

Ni price jumped up almost 4 times higher since Oct 2005. The peak was June 2007 and price dropped down by the end of 2008.

Concept of filler metal design

Fe-Cr-Ni-Mo-Si-P System

Fe, Cr	Base elements and Cr content must be 20wt% at least to improve corrosion resistance
Ni	Main element and contains as less as possible with the balance of Fe and Cr
Mo	Elements added to form fine grain structure to obtain higher strength and improved corrosion resistance
P, Si	Main elements of temperature depressants

Developed Fe-Cr based filler metals

Type	Chemical Compositions (wt%)						Solidus	Liquidus	Brazing Temp.
IronBraze	Fe	Cr	Ni	Mo	Si	P	℃	℃	℃
TB-2720	27	20	43	-	-	10	1,010	1,065	1,100 – 1,120
TB-3025	30	25	30	2	6	7	1,010	1,065	1,100 – 1,120
TB-3520	35	20	30	2	5	8	1,010	1,060	1,100 – 1,120
TB-4025	40	25	20	2	6	7	1,030	1,085	1,120 – 1,140
TB-4520	45	20	20	2	5	8	1,020	1,080	1,100 – 1,130
TB-5020	50	20	15	2	5	8	1,035	1,100	1,130 – 1,150
TB-5520	55	20	10	2	5	8	1,060	1,115	1,150 – 1,180
TB-6020	60	20	5	2	5	8	1,090	1,130	1,150 – 1,200

Current Fe-Cr based filler metals

IronBraze

Type	Chemical Compositions（wt%）						Solidus	Liquidus
IronBraze	Fe	Cr	Ni	Mo	Si	P	℃	℃
TB-2720	27 Bal.	20 20.18	43 43.90	-	-	10 8.90	990	1,040
TB-4520	45 Bal.	22 21.91	22 21.76	0.5 0.58	4.5 4.31	6 6.24	1,038	1,051

Foil form of TB-2720

Other Fe-Cr based filler metals

Product Name	Chemical Compositions（wt%）								Solidus	Liquidus
	Fe	Cr	Ni	Mo	Si	P	Cu	B	℃	℃
VZ2106	35	11	44	1.5	6.4	-	1	1.5	1,044	1,154
VZ2099	51	11.5	29	1.5	2.8	1.8	-	1.9	934	1,146
BrazeLet F300	34	24	20	-	5	7	10	-	B.T.:1,120	
BrazeLet F302	54	15	10	-	7	9	5	-	B.T.:1,100	
Amdry 805	38	29	18	-	7	6	RE:0.2		M.P.:1,104	
AlfaFusion	Bal	17	12	2.2	Mn:1.6		Si+B:?		B.T.:1,190	
FP-641	Bal	18	15	2	5	6.5	2	-	1,030	1,060
FP-642	Bal	18	20	2	2	8	2	-	1,030	1,060
FP-633	20	29	Bal	-	4	6	-	-	1,020	1,060

※RE: Rare Earth
※B.T.: Brazing Temperature
※M.P.: Melting Point

Current issues

- Price

  Not very competitive to conventional Ni based filler metals due to recent Ni price.

- Corrosion resistance

  Corrosion resistance characteristic changes depends on corrosion solutions and type of base metals.

- Joint strength

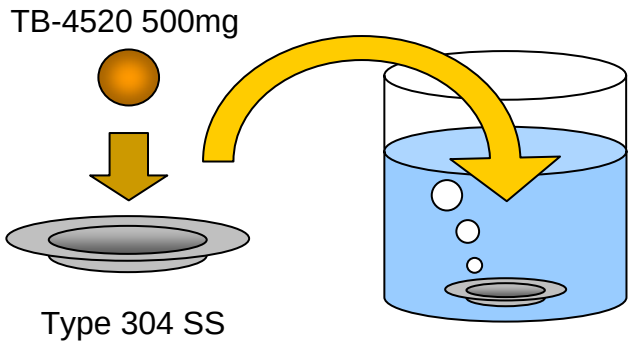
  It was found that the value of joint strength fluctuated due to brazing conditions.

Corrosion test results (Dipping test)

Appearance and weight loss after 72 hours exposure

Test Solutions	H_2SO_4 (5%)	NHO_3 (5%)	HCl (5%)	NaClO (5%)	NH_4OH (5%)
Appearance	No change	No change	Rust	Minute rust	No change
Weight loss (mg)	No change	No change	～10	Unable measure	No change
Results	Excellent	Excellent	Attacked	Good	Excellent

Dipping test method



Appearance after the test

H_2SO_4: Sulfuric Acid
NHO_3: Nitric Acid
HCl: Hydrochloric Acid
NaClO: Sodium Hypochlorite
NH_4OH: Aqueous Ammonia

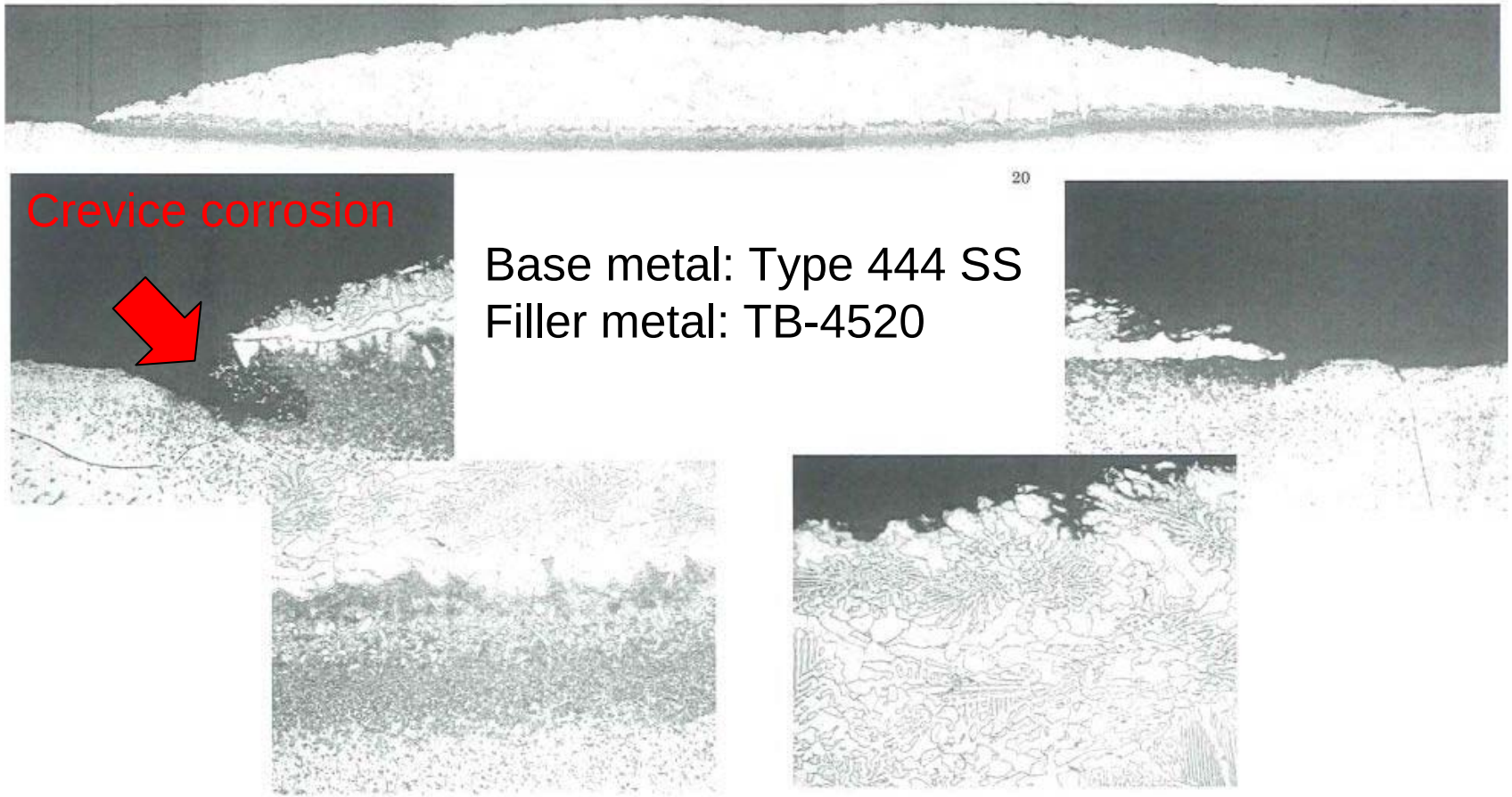
Corrosion test results (Salt splay test)

Appearance after 168 hours salt splay test

TB-2720 | TB-4520 | BNi-2 | BNi-5

TB-2720 and TB-4520 with type 304 SS show excellent corrosion resistance against to salt splay test.

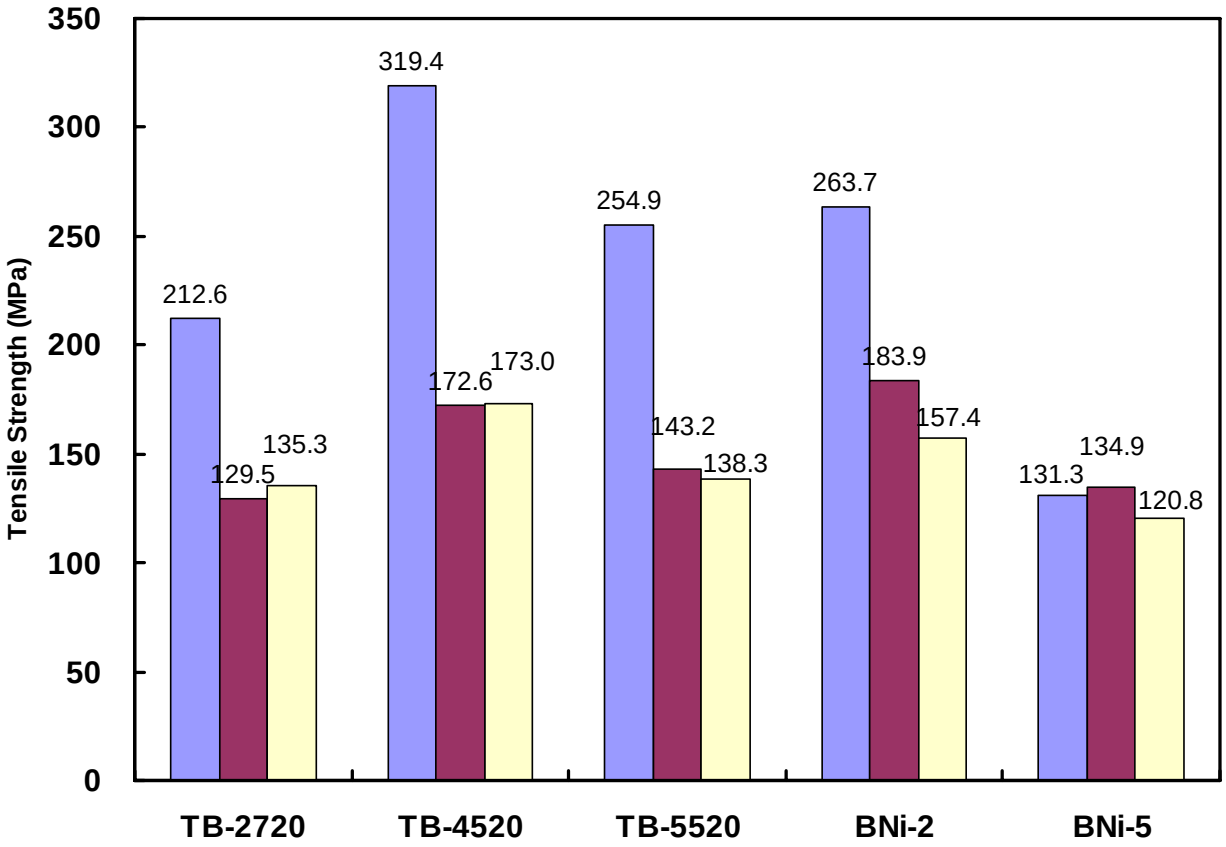
Corrosion test results (VDA test)

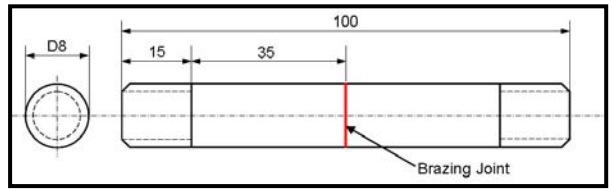


Base metal: Type 444 SS
Filler metal: TB-4520

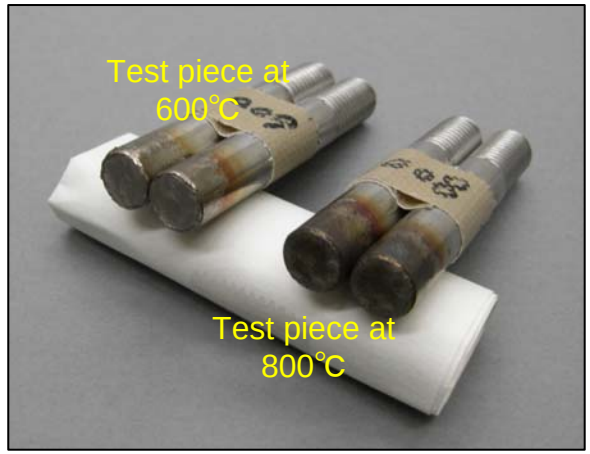
Crevice corrosion at the edge of filet and base metal on type 444 SS test piece was observed by artificial exhaust gas condensate.

Joint strength (Tensile test)





Schematic diagram of tensile test specimen



TB-2720 and TB-4520 obtain good joint strength compared to Ni based filler metals.

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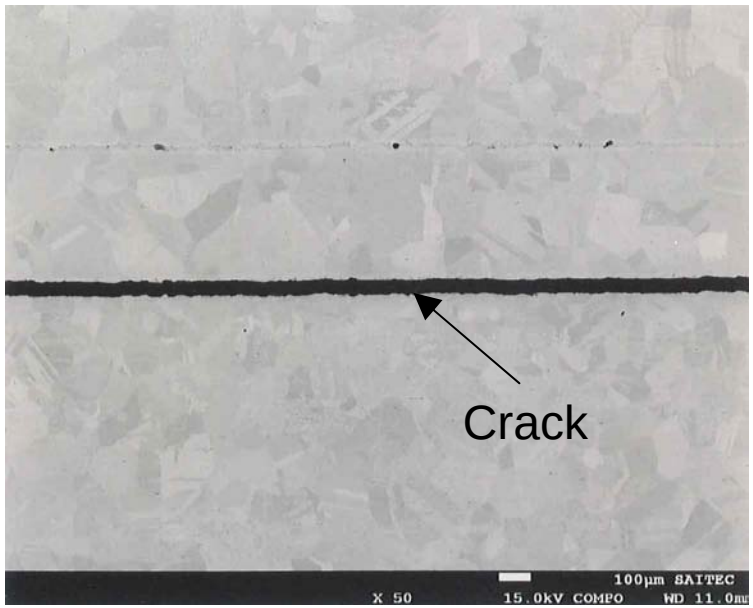
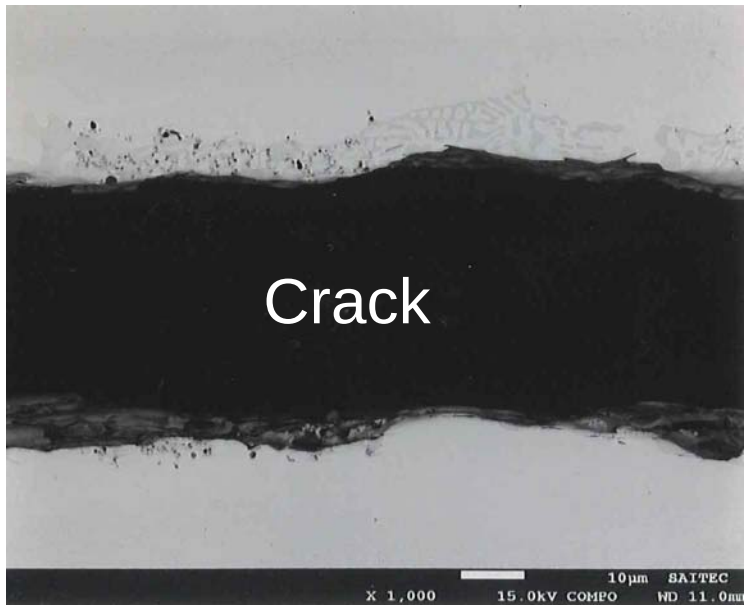
Poor joint strength

Cross-section at the fractured joint



100µm



10µm

Brazing conditions
Load: ≒10kgf/cm^2
Brazing temp & time: 1,120℃ & 60min

Base Metal: Type 316 SS
Brazing filler metal: TB-4520

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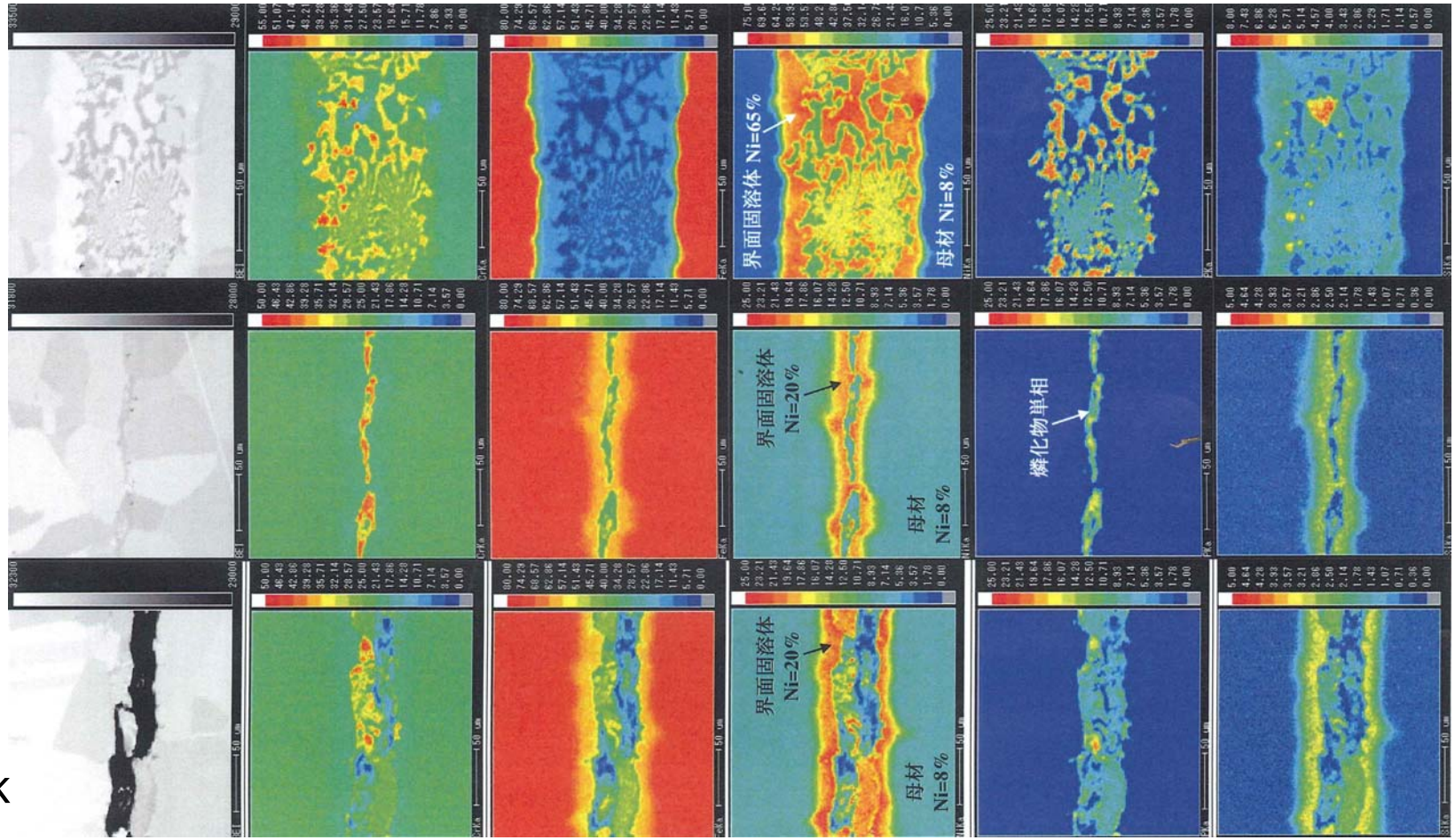
Poor joint strength



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Summery

- Fe-Cr based filler metals have good corrosion resistance, but corrosion resistance characteristic changes depends on corrosion solutions and type of base metals.
- Joint strength of Fe-Cr based filler metals fluctuate due to brazing conditions such as long brazing time and heavy load at the joint to form thin brazing layer.
- Fe-Cr based filler metals still need to improve or modify so that to know further basic information is necessary.