Superconducting Magnet Division

Magnet Note

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Title: OST wire of 54/61 Design: RRP-8220
Preliminary Results on Round and Extracted Strands

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OST wire of 54/61 Design: RRP-8220

Preliminary Results on Round and Extracted Strands

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Summary:

Preliminary measurements of round strands of RRP-8220 billet shows that the critical current density, Jc at 12T exceeds 3000 A/mm2 for typical reaction temperatures of 665C for 48 hrs. At low fields these wires have a stability current Ic which exceeds 1000 A. At a lower reaction temperature of 635C, the Jc drops to ~ 2600 A/mm2. An extracted strand from a prototype TQ-cable when reacted at 635C for 48 hrs, shows a similar Ic of 2600 A/mm2, with a low field stability current greater than 1200A.

Introduction

Earlier in the year, OST delivered 36 kg of RRP (Re-Stack Rod Process) wire to LBNL under the CDP purchase of strand for HEP. This billet is the "standard" 54/61-design wire with a copper fraction of 46%. It is remarkable that this billet processed in three pieces of the following lengths 2565, 4790 and 3421 m. Measurements from OST with the following HT: 210C/48h +400C/48h +665/50h, showed that the critical current at 12T of 618-639 A, that at 15T of 309-336 A. RRR for these wires ranged from 218 to 252. Below are OST's data as supplied to LBNL.

	8220-1 (BE)		**spec**	**8220-4 (FE)**	
B(T)	I_c(A)	n		I_c(A)	n
12	639	37		618	55
13	524	37		501	49
14	424	34		398	31
15	336	34		309	38
16	258	30		232	30
RRR	252		>40	218	
NonCu	53.6%		53% ± 2%	54.1%	
Twist	43		14mm ± 2mm	38	
12T Jc	**3101 A/mm^2**		**>2600 A/mm^2**	**2968 A/mm^2**	
15T Jc	**1631 A/mm^2**		**>1400 A/mm^2**	**1483 A/mm^2**	

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TQ-Prototype Cable

Using 0.7mm wire from spool 8220-1, LBNL manufactured 17m of a TQ-type 1.0 deg. Keystone cable. After annealing and re-rolling, the average angle was 1.078 deg, with a width of 10.40 mm and a mid-thickness of 1.267 mm. Initial microscopy (shown below) of the cable cross-section indicates that the wire distortion at the cable edges is minimal. However, there seems to be some sub-element distortion and shearing in the wire near but not at the minor edge. Also the strands are not deformed uniformly at the top and the bottom of the cable. Detailed report of microscopy will be available soon.

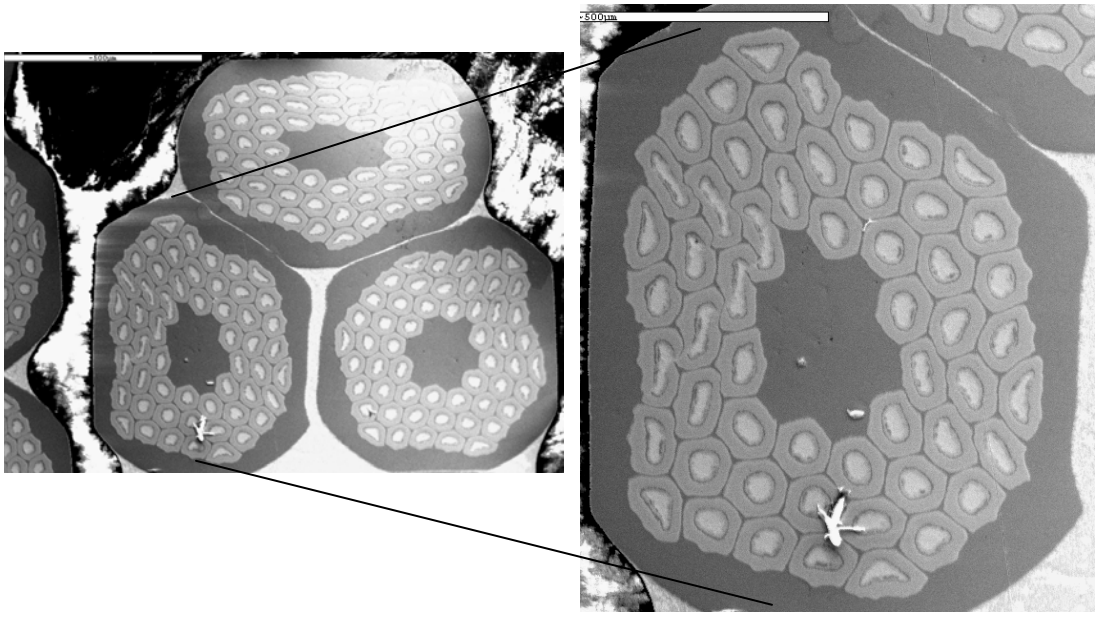

Fig. 1 Wires at the minor edge of the prototype cable B0933R.

I_c, I_s and RRR Measurements

Using wire from spool 8220-4, which is the back end of the billet, round wires were reacted at BNL on stainless steel barrels in vacuum at several temperatures and time. In each case the critical current is measured along with the low-field stability current as well as the RRR of the strand. We also measured a sample of wire (sample #6) that OST reacted on their Ti-barrel. The intent of the optimization was to maximize the stability current, even at the expense of I_c at 12T.

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The Table below summarizes the test data available to date.

Sample #	WireID	HT_Temp	HT_Time	Jc(12T)	Ic(12T)	Ic(11T)	Is	RRR	Comments
1	RRP-8220-4	635	48	2571	535	659	1112	364	
2	RRP-8220-4	635	48	2577	537	657	1175	357	
3	RRP-8220-4	650	48	2890	602	731	1075	305	
4	RRP-8220-4	650	96	3072	640	773	1125	233	
5	RRP-8220-4	665	50	2987	622	750	1125	171	
6	RRP-8220-4	665	50	3171	660	796	1012	190	HT by OST
7	RRP-8220-4	665	50	3045	634	761	1125	178	
8	RRP-8220-4	680	48	3132	652	773		111	
9	RRP-8220-4	680	48	3060	637	759	1025	109	
10	RRP-8220-1-ES	635	48	2612	539	665	1200	316	Extracted strand
11	RRP-8220-1-ES	635	48	2594	535	656	1200	324	Extracted strand
12	RRP-8220-1-ES	635	96	2846	583	712	1125	281	Extracted strand

As was found by OST, this wire is capable of Jc > 3000 A/mm2 at 12T. For these wires, the low-field stability current, I_s, is > than 1000 A. As the reaction temperature is lowered, Jc decreases, but the I_s is not significantly increased. This maybe due to the fact that the RRR is already quite high even for a typical reaction temperature of 665C, and not much is gained by the lower reaction temperatures. The limitation of I_s is predominantly due to the large effective filament diameter of ~ 70-80 μm.

The extracted strands reacted at 635C/48 hrs had an I_c similar to the round wire and exhibited a low-field stability current > than 1200 A. This result is encouraging in that the cabling does not seem to have a negative impact on both I_c and I_s. The plot below shows how the Jc decreases as a function of reaction temperature.

From these results we conclude that the new generation of 54/61 strands from OST have the capability of high Jc as well as lower tendency of Sn-contamination. In fact it would appear that reacting at a lower temperature of 635-650 C for 48hrs, still producers a Jc > 2600 A/mm2 at 12T with no contamination of the inter-filament copper as evidenced by the high RRR > 300. The stability current for these wires are all > 1000 A.

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In conclusion, the present RRP billet 8220 meets all the specification requirements for LARP conductor and should be considered as the baseline conductor for the TQ magnets.

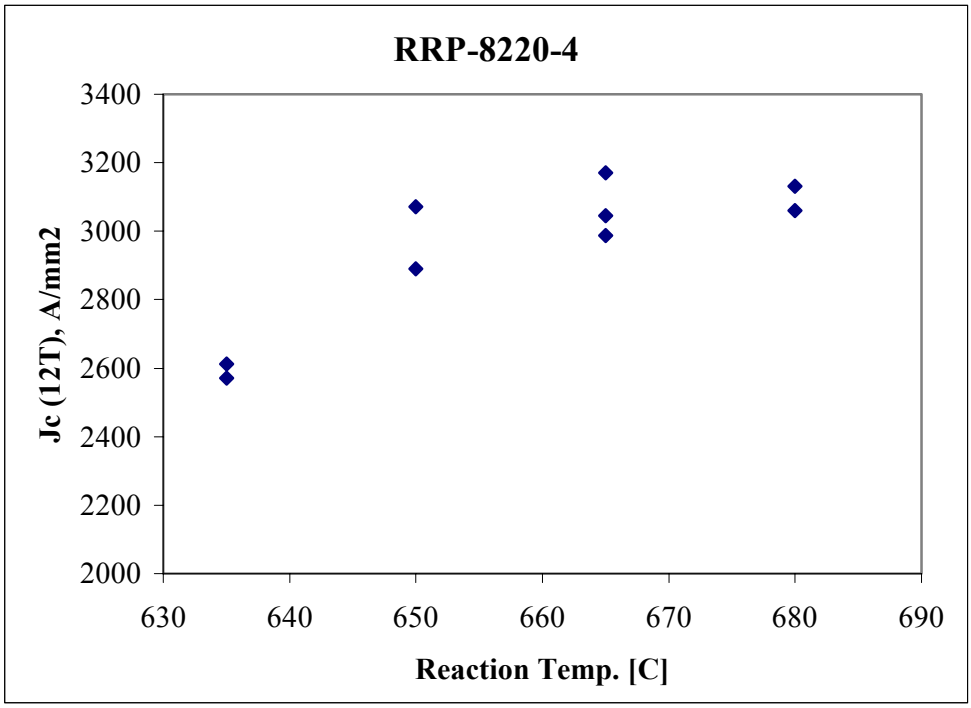

Fig. 2 Critical current density at 12T as a function of reaction temperature.