Stability characteristics of DyBCO coated conductor stabilized with stainless steel.

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Abstract: As high temperature superconductor applications became a reality due to increase in coated conductor performance, it is important to understand their stability behavior to design safe electrical power systems. We have experimentally studied the dependence of quench and recovery characteristics of coated conductors on the amplitude of current and duration time. The sample used in the present study is stabilized with stainless steel. Stability tests of 3 cm long sample were performed in a liquid nitrogen bath cooling condition by applying a short period over current pulses for 50 and 100 ms, with amplitude up to ~ 6 times of the critical current. The transport current that follows before and after the current pulse was fixed about ~85% the critical current. We analyzed the quench recovery using the current voltage characteristic.
Key words: Stabilizer, Quench, Recovery, Current pulse.

1. Introduction

As high temperature superconductor applications became a reality due to increase in coated conductor performance, it is important to understand their stability behavior to design safe systems [1-4]. One such application is in a resistive fault current limiter that utilizes the rapid rise in resistance above an HTSc material's critical current to rapid suppress fault currents. Generally coated conductors are stabilized with copper for applications like motors, magnets etc but for "resistive type" fault current limiter applications they should be stabilized with some high resistive and high strength stabilizer. Therefore stainless is a better candidate to be used as stabilizer. In this paper, we present our experimental studies for the dependence of quench and recovery behavior of stainless steel laminated DyBCO coated conductors on the amplitude of DC transport current and duration time at liquid nitrogen boiling temperature.

2. Experiment

The 3-cm long by 1-cm wide coated conductor sample is supplied by THEVA, which has 90μm-thick Hastelloy C substrate, 2.5μm -thick MgO buffer layer, 200 nm-thick MgO cap layer, 800 nm-thick DyBCO layer and 200 nm-thick Au cap layer. The sample is laminated with stainless steel 70μm-thick by soldering. Stability tests were performed in a liquid nitrogen bath cooling condition by applying a short period over current pulse for 50 ms and 100 ms, with amplitude up to about ~6 times of the critical current. The transport current that follows before and after the current pulse was fixed about ~85% the critical current of the sample. Two voltage taps were attached at a distance of 2-cm. One E-type thermocouple is attached between the voltage taps for temperature measurement.

3. Results and discussion

Using the creation 1μV/cm, the measured self field critical current, I_c of the sample is 62 A at 77 K. Each stability test begins with an operating current of 60 A then comes an over current pulse (2 to 6 times of I_c) for 50 / 100 ms and ends

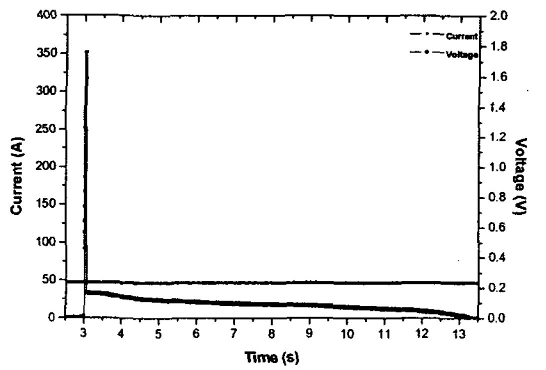

Fig. 1. I (t), V (t) trace for over current pulse of 360 A for 50 ms and cooled by nitrogen boiling at 77 K.

with the operating current of 60 A. Fig .1 shows the I(t) and V(t) trace for 6 times over current pulse (360 A) for 50 ms. The sample recovered after about 10 s with the peak temperature value of 104 K. The peak joule heating flux is 221 W/cm^2 which is about 22 times higher than the nucleate boiling heat transfer flux of Liquid nitrogen (~10 W/cm^2) therefore it took about 10 seconds to recovered completely.

Fig .2 shows the I(t) and V(t) trace for over current pulse (360 A) which is 6 times of I_c. The sample recovered after about 21 s with the peak temperature value of 136 K. The peak joule heating flux is 353 W/cm^2, which is about 35 times more the nucleate boiling heat transfer flux and therefore recovered in about 21 s. The sample burnout for the pulse of 370A for 100 ms.

During the over current pulse, the critical current of the sample is exceeded by pulse current and there is rapid increase in the resistance. This resistance dissipates the pulse energy as joule heating which is recovered in few seconds. In both the cases, 50ms and 100 ms for 360A pulse, the peak joule heating flux is 221 W/cm^2 and 353 W/cm^2 which is about 22 and 35 times higher than the nucleate boiling heat transfer flux of Liquid nitrogen therefore it took about 10 second and 21 seconds to recovered.

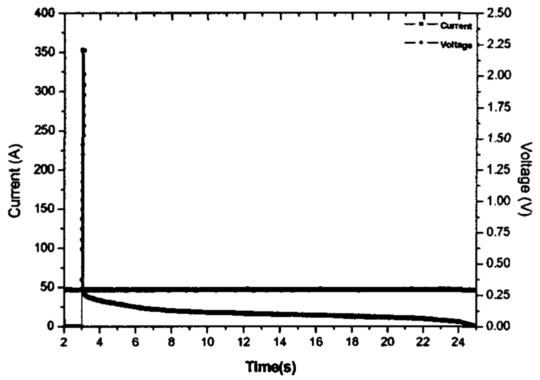

Fig. 2. I (t), V (t) trace for over current pulse of 360 A for 100 ms and cooled by nitrogen boiling at 77 K.

4. Conclusion

DyBCO coated conductor sample laminated with stainless steel was subjected to an over current pulse tostudy its stability behavior. The results have demonstrated the quench and recovery characteristic on the amplitude of current and duration time. It is clear that stainless laminated sample experiences a rapid increase in resistance when pulse current exceeds the critical current of superconductor. It also protects the conductor against large over current pulse up to 6 times the I_c for 50 ms and 100 ms and recovers the sample from normal state to superconducting state.

References

1. R.C. Duckworth, J.M. Pfotenhauer, J.W. Lue, M. J. Gouge, D.F. Lee and D.M. Kroeger, AIP Conf. Proc, Vol. 613, p.449, 2001.
2. J.W. Lue, M. J. Gouge, R.C. Duckworth, D.F. Lee, D.M. K roeger and J.M. Pfotenhauer, AIP Conf. Proc, Vol. 613, p.457, 2001.
3. Y Iwasa, H Lee, J. Fang and B. Haid, IEEE Trans. Appl. Supercond., Vol. 13, No.2, p. 1772, 2003.
4. H. M. Kim, J. Jankowski, H. Lee, J. Bascunan, S. Fleshler and Y. Iwasa, IEEE Trans. Appl. Supercond., Vol. 14, No.2, p. 1290, 2004.