INVESTIGATION OF THERMAL INSULATION FOR STATIC CRYOSTATS OF HTSC DEVICES

L.I. Chubraeva[1,2,a], S.S. Timofeyev[1,b]

[1] *Institute of Electrophysics and Electric Power Engineering of RAS, Saint-Petersburg, Russia*
[2] *Institute of Silicate Chemistry of RAS, Saint-Petersburg, Russia*
[a]lidiach@mail.ru, [b]sergio121@yandex.ru

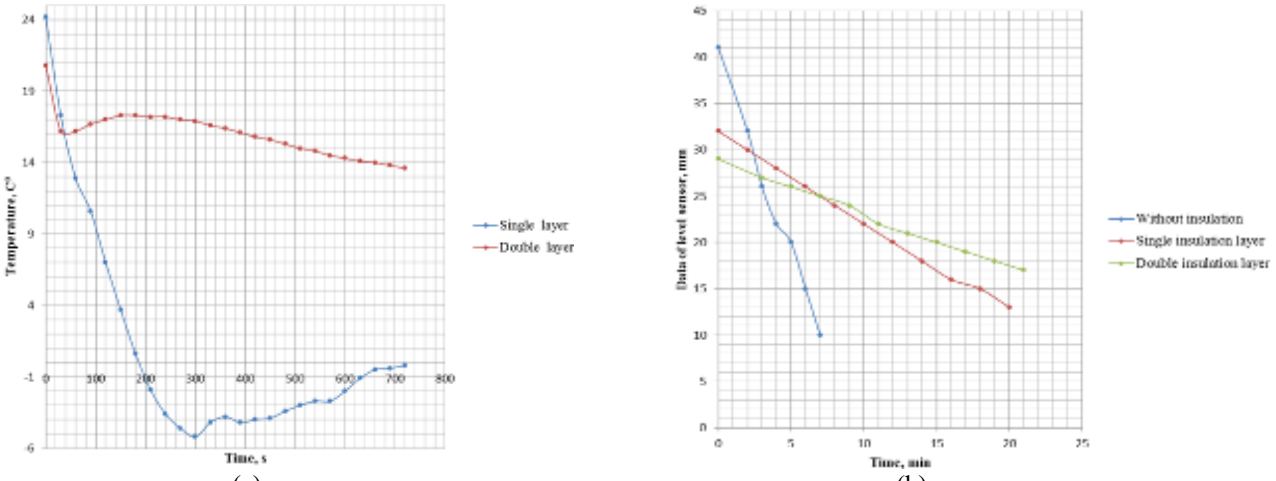
Abstract. Experimental investigation of HTSC electro-technical devices may be simplified substantially due to application of multi-layer thermal insulation. Presented below are test results for the foamed rubber K-FLEX, applied as an external thermal insulation of static cryostats intended for cryogenic devices, in particular, HTSC alternators

1. Introduction

At present thermal insulation for cryogenic electro-technical devices comprises two main groups: screen-vacuum and multilayer insulation. Static cryostats may be either metallic or non-metallic ones. If the investigated device has an external alternating magnetic field, which may cause eddy-current loss in the inner shells of metallic cryostat, facing the cryogenic coolant, non-metallic cryostats are preferable. We possess a vast experience with the application of non-metallic cryostats. We used them on the 1-st stage of our experiments with HTSC devices, cooled by LN_2. Application of plastic cryostats with vacuum insulation shows they cannot keep the vacuum for a long time and need practically constant vacuum pumping out. As far as we have proved absence of external alternating magnetic fields in electrical machines with axial magnetic flux, we started to apply thermal insulation for the outer frame of model alternators.

2. Experimental investigation results

The foamed rubber K-FLEX sheets are chosen for a set of preliminary investigations. Main advantages of this thermal insulation are listed in [1]. The main range of its application lies in between -40 - +85 ^{0}C. The tests covered two main aspects: determination of the thermal insulation optimal thickness for LN_2 experiments and evaluation of K-FLEX ageing process in LN_2. The model cryostat is made of stainless steel [2]. It is wrapped with the insulation layers fixed with special glue.



(a) (b)

Fig. 1 Test results: (a) - variation of the temperature on external cryostat surface, (b) - variation of LN_2 volume with a single and a double layer insulation

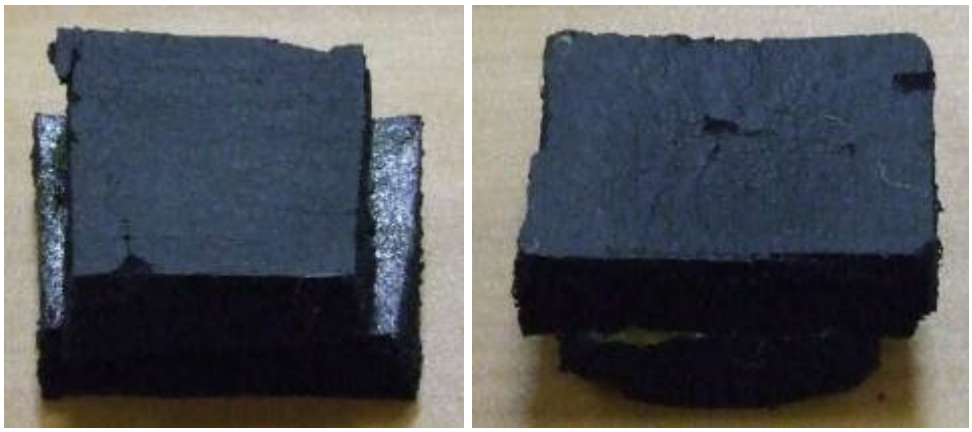
During the tests the ambient temperature was equal to +25 ^{0}C and the temperature of the coolant – appr. -196 ^{0}C. K-FLEX sheet thickness – 18 mm. The data presented in Fig. 1,a shows two layers of the thermal insulation are minimum for the static cryostat of electrical machine model in case of long-term experiments with LN_2 cooling. The velocity of LN_2 evaporation confirmed (Fig. 1,b) two layers are enough. The curve for 3 layers is practically similar to the one obtained with 2 layers of K-FLEX (36 mm).

Behavior of K-FLEX during thermo-cycling is as follows. Two layer sample (the layers were fixed by glue) was immersed in LN_2, cooled-down in it and then warmed up at ambient temperature 20 ^{0}C. The results

of thermo-cycling are shown in Fig. 1 b. The two layer glued sample before experiments is presented in Fig. 2, a. After the 1-st thermo-cycle there appeared cracks on the sample surface. It became less elastic and showed a tendency to crumbling. After the 3-d thermo-cycle there appeared a dent in the center of the sample (Fig. 2, b). The total amount of thermo-cycles equaled 10, but after the 3-d one there did not appear any visible changes.

The elasticity of the sample improves with the time, but not to the initial level. The material stays more rigid. It is necessary to be accurate during experiments with liquid nitrogen not to spoil the outer thermal insulation of the static cryostat of the device.

Experiments with a rotating electrical machine showed additional advantages of K-FLEX: it is a good acoustic insulation as well and damps the alternator vibrations [3].



(a) (b)

Fig. 2 Thermo-cycling experiment: (a) - prior to thermo-cycling, (b) – after 3 thermo-cycles

Conclusions

The K-FLEX thermal insulation is applicable for static cryostats of cryogenic devices, operating with LN_2. It permits to simplify the design and to decrease the expenses for the cryogenic models investigations.

References

[1] L'ISOLANTE K-FLEX GmbH web-site: http://www.kflex.com/en/#

[2] Andreev Eu. N., et al., Use of materials on the basis of foamed rubber as a thermal insulation of high-temperature superconducting devices, International Conference on Electromechanics and Robotics "Zavalishin's Readings" 2013, pp. 1-6

[3] Chubraeva L., Timofeyev S., Project of Autonomous Power Plant with High-Temperature Superconductive Devices, International Multi-Conference on Industrial Engineering and Modern Technologies (FarEastCon), Vladivostok, Russia, 2018, pp. 1-5. doi: 10.1109/FarEastCon.2018.8602671