Vol. A43 (1973) ACTA PHYSICA POLONICA No 2

CURRENT DISTRIBUTION IN HOMOGENEOUS TYPE II SUPERCONDUCTING CYLINDER

By S. Takács and I. Hlásnik

Electrotechnical Institute, Slovak Academy of Sciences, Bratislava*

(Received May 30, 1972)

From the earlier calculated magnetic-field distribution in superconducting cylinder under the influence of axial current without external magnetic field, the current distribution is derived and compared with experimental results on PbIn cylinder.

In [1] we calculated the magnetic-field distribution and the resistance of homogeneous type II superconducting cylinder under the influence of axial current in zero external magnetic field taking under consideration the magnetic-field dependent flux flow resistivity ϱ_f. Similar experiments were carried out in [2] for PbIn cylinder in the vicinity of T_c and the current density was determined from the distribution of the magnetic field in the cylinder. It seems that the state b from Fig. 2 in [2] (*i. e.* after redistribution of the current in the sample) means that the surface pinning was overwhelmed and one has the conditions considered in [1].

For this purpose, we derive here the formula and give the results for the current density, which can be calculated from the distribution of the magnetic field in the cylinder. For reduced fields $h = H/H_{c2}$ in the i-th region (for determination of the relevance to the regions see [1]) we obtained

$$h_i = \frac{1}{\xi}\left[c_i + \frac{2e}{A_i}\,\frac{n_i+1}{n_i+2}\,\xi^{n_i+2}\right]^{\frac{1}{n_i+1}},$$

where $\xi = r/a$ (a — radius of the specimen),

$$\varrho_f = \varrho_n A_i(t) h^{n_i(t)}$$

(ϱ_n — resistivity in the normal state). As we do not use explicitly the expressions for c_i, we do not give its form here (see [1]).

---

* Address: Elektrotechnický ústav SAV, Bratislava, Dúbravská cesta, Czechoslovakia.

The radial dependence of the current density is then simply given by

$$j = \frac{1}{r}\frac{\partial}{\partial r}(rH_\varphi) = \frac{B_{c2}}{a} 2e \frac{n_i+1}{A_i} \frac{1}{h_i n_i}.$$

This function is plotted in Fig. 1 for higher temperatures ($t = T/T_c \approx 1$) at low and high voltage (*i. e.* $E \lesssim E_{cr}$, where the normal state begins to appear at the surface). From [1] we have the following temperature dependence of E_{cr} at $t \approx 1$:

$$E_{cr} \doteq (1-t)E_0, \quad E_0 = 1.33\varrho_n \kappa H_c(0).$$

For the sake of completeness, also the results for $t \ll 1$ are plotted in Fig. 2. The current distribution in the neighbourhood of the critical temperature is insensitive to the change of κ, whereas for $t \ll 1$ it depends on κ and the deviations are considerable especially in the region of the cylinder axis.

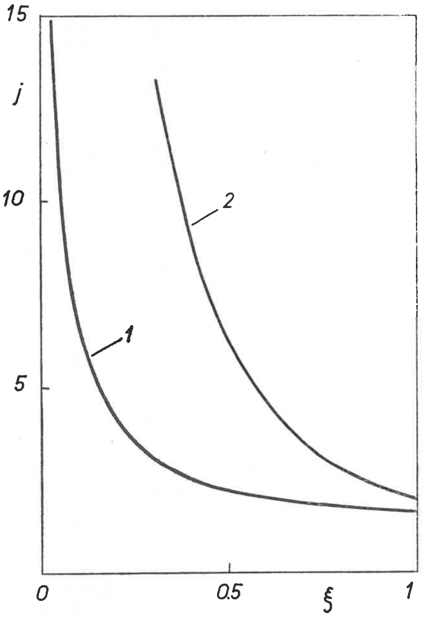

Fig. 1. The current distribution in the cylinder for low (*1*) and high (*2*) voltage at temperatures close to T_c ($\xi = r/a$)

Of course, we can compare the theoretical and experimental results much better by considering the function $1/j(r)$. As it can be seen from Fig. 3, the experimental results [2] lie between the both extreme theoretical curves.

We would not like to exaggerate the comparison of our results with the experiments of [2] (the heating and the pinning — as small as it can be — can cause considerable effects), but we think, it would be very interesting to compare not only the dependence of $j(r)$ on $H(r)$, but also that of $\varrho_f(H, t)$ on $H(r)$ for homogeneous type II superconductors to understand better the flux flow and other phenomena under the influence of current.

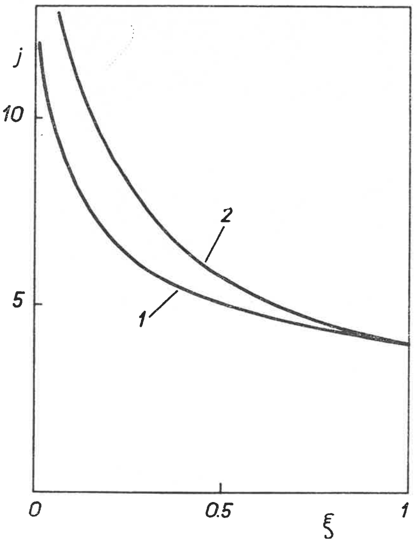

Fig. 2. The same distribution as in Fig. 1 at temperatures $t = T/T_c \ll 1$ for $\kappa = 2$ (*1*) and $\kappa = 5$ (*2*)

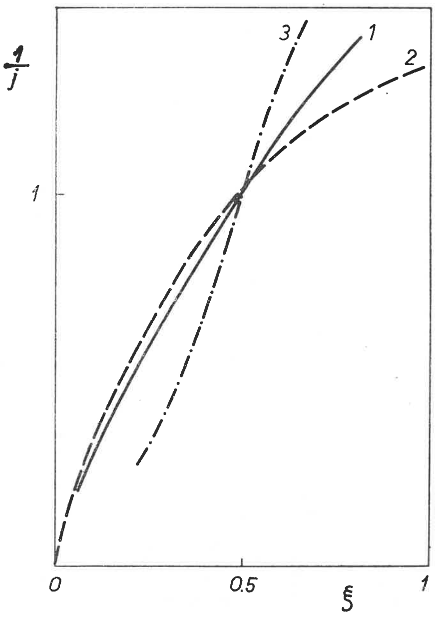

Fig. 3. The function $1/j$ for $t \approx 1$, reduced to the value at $\xi = 1/2$. *1* — experimental [2], *2* — low voltage, *3* — high voltage

REFERENCES

[1] I. Hlásnik, S. Takács, *Czech. J. Phys.*, **B19**, 59 (1969).
[2] B. Makiej, A. Sikora, E. Trojnar, *Acta Phys. Polon.*, **38**, 449 (1970).