DEVICE FOR INFRARED HEATING OF MOVING SYNTHETIC YARNS

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Heaters of the contact type have received principal circulation for yarn heat-treatment in the process of stretching, heat-setting, and drying in the manufacture of synthetic fibres. Studies connected with developing devices for infrared (IR) heating of moving fibres and yarns afford a basis for considering it advisable to continue work in this direction [1-3]. Infrared heating is more promising as compared with existing forms of heating in the heat-treatment of yarns which do not contact heatable surfaces, yarns for whose heating temperature in the range 300-600°C are necessary, and also for two-form fibres and yarns which are heated in multizone heating chambers.

A special feature of IR heating is the fact that uniform and bulk heating of the yarn material is ensured by the penetration of the IR beams into the irradiated material. The intensity of yarn heating in the IR device depends on many factors: the thermoradiation characteristics of the polymer being irradiated, the type of IR emitters, the number of these, and their mutual disposition with respect to the moving yarns, and constructional features of the IR devices. In turn, the construction of the IR device depends on its purpose and the factors enumerated above.

For correct selection of the type of IR emitter, optimum disposition of the emitters in the heating chamber, and to calculate the energy for heating fibres and yarns, we determined the thermoradiation characteristics of a number of polymeric materials [4, 5]. In distinction from available literature information, our studies were carried out with consideration of the intensity of distribution of not only transmitted radiation, but also of that reflected in all directions in space. Studies performed by tested procedures showed that the distribution of energy in reflection from Kapron films has a mirror-like character. In transmission through films, the energy is not scattered to the sides, but is transmitted as a narrow pencil. In the wavelength region of 2.8-3.5 μM (Fig. 1a), Kapron films have an absorption band, the maximum values of the absorption coefficients for films 7-33 μM in thickness approaching unity at wavelengths of 3 and 3.33 μM. With increase in the thickness of a film, the absorbing power increases, at an essentially constant reflecting power.

Fig. 1. Dependence of reflection coefficient $R$ and of absorption coefficient $A$ on wavelength: a) film 7 $\mu$ thick (1), 15 $\mu$ thick (2), 22 $\mu$ thick (3), and 33 $\mu$ thick (4); b) Kapron yarns, 18 l/mm (1); polyamide yarns, 6.6-16 l/mm (2); polyester yarns, 26 l/mm (3), polyamide T yarns, 61 l/mm (4); and fenilon yarns, 250 l/mm (5).

The space distribution of the energy reflected or transmitted by specimens of plane-parallel yarn systems has a complex character, and depends on the orientation of the stream of radiation with respect to the yarns. In the case where the system of parallel yarns is oriented along the stream of radiation (lengthwise source positioning), the incident radiation in reflection or transmission is scattered in all directions in space. If the direction of the fibres is perpendicular to the stream of radiation (transverse source positioning), the energy is reflected or transmitted as a pencil with only a small portion of scattering to the sides. The interaction of IR radiation energy with yarns is presented in detail in [5]. The dependences given in Fig. 1b show that the thermo-radiation characteristics of the investigated yarn specimens depend to a considerable degree on wavelength. Starting at 2.7-2.8 $\mu$, the absorption coefficients increase and reach a maximum at 3 $\mu$. The reflection coefficients depend greatly on the type of material. Yarns of Fenilon or Polyamide T have the greatest reflective power.

From an analysis of the thermoradiation characteristics of films and yarns in infrared heating devices, we used "bright" IR radiators which developed a pencil-like stream in the near infrared region (1-5 $\mu$), corresponding to the absorption maximum of the investigated polymers. "Bright" IR radiators are produced in the form of theromradiation lamps which have a high radiation density, $q = 10^5-2.5\cdot10^5$ W/m$^2$, and are used in various thermal processes for heating or drying materials (Table 1) [6].

In very general form, an IR heater consists of a housing, IR radiators, and shields which reflect IR beams. Two varieties of device have been developed for heat-treating yarns and fibres: IR heaters of the vertical type for treating individual yarns, and multizone IR heating chambers of the horizontal type for treating tow-type fibres and yarns (Inventor's certificates Nos. 771209, 867953, 1203150, and 1028742, USSR).

In Fig. 2 we show schematically the IR heater of a V-250-S80 machine for heat-treating synthetic yarns, plus the temperature distribution curve inside the chamber, with respect to its height. The basic element of the heater is the IR radiator, 1 (a KGP 220-1650 lamp). To concentrate the IR radiation energy, the lamp is surrounded by shield 2. On the basis of studies of the form of the shield in section, an oval type was selected. For convenience in setting up the yarn in the chamber, the heater was made in a separable form. The immobile part of the shield 2 was made hollow and was mounted in the housing 3 and the immobile part was fastened to the cap 4. Through pipe 5 in the hollow shield, a gas medium is delivered; this goes into the heating chamber through hole 6 in shield 2. Together with caps 7 and 8, the shield forms the heating chamber for the yarn 9. Regulation and control of temperature inside the chamber is effected from signals from resistance thermo-transformer 10. Pipe 11 serves to remove gaseous materials evolved from the yarn. Contact plate 12 is placed inside the chamber, above the radiator.