MICROWAVE ASSISTED BLOW MOLDING OF POLYETHYLENE-TEREPHTHALATE (PET) BOTTLES

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During the injection stretch blow molding or thermoforming processes, the PET preforms must be brought to a rubber-like state by supplying heat to them. This heating stage is critical because the final thickness distribution of the part is drastically controlled by the temperature distribution inside the preform prior forming. Furthermore, when solid and amorphous PET is biaxially oriented the stretching action and the temperature at which it occurs determine the level of crystallinity of the final product. In biaxial-stretch blow molding of bottles the outer and the inner stretching ratios differ by more than 50% during stretching.

For a given temperature the actual stress is higher on the back than on the front. As uniformity of stress is required, a good stretching process is obtained by deliberately inducing a non-uniform temperature profile throughout the preform before blowing. Heating by infrared radiation allows obtaining this non-uniform profile of temperature that ensures a good stretching process and this heating is a convenient and widely used method. The usual mechanisms of heat transfer by infrared radiation are explained in a previous study and are outside the scope of this work [1-2]. It is sufficient to notice that the Lambert-Bouguer law is used to describe the spectral absorption characteristics of the materials. Unfortunately, although much research has been devoted to optimize this process [3], in most industrial infrared ovens, the ratio between electric power and absorbed energy in the polymer is under 25% and the heating time is still high (25 s).

Owing to these reasons, the purpose of this paper is to show the feasibility of the microwave technology apply to the PET preform heating. The microwave power, which is a function of the electric field distribution in the medium, is acting as a volume source term. Only the thermal losses from the surface of the hot preform include convection and radiative heat transfers.

It is generally admitted that Lambert's law is valid for semi-infinite samples and has been widely used to predict temperature profiles during microwave heating. So in several computational studies of microwave heating [4], the heat generation has been modeled by Lambert's law, in which the microwave power attenuated exponentially as a function of distance of penetration into the sample. The limit of the previous assumption seems to be reached for samples thicker than three times the characteristic penetration depth of microwaves. More recently, Ayappa et al [5] have shown that Lambert's law even fails for thinner samples. As previously discussed [6], a more accurate temperature knowledge involves solving Maxwell's equations of electromagnetism and the heat conduction equation where all thermal, electric and magnetic properties of the material are non-linearly dependent on the temperature.

In this study, a single mode cavity operating in the TE_{103} mode using commercial microwave magnetron of 2450 MHz has been designed and used to heat PET tube-shaped parison. Dielectric measurements are performed at the corresponding temperature range with the method of Delmotte et al

[7] and an infrared camera is employed to measure the surface temperature of the preform. A modeling of the temperature profile is presented and some experiments are carried out.

Our first results indicate that this technique has a great potential for improving this heating stage but further researches are needed to optimize its application.

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