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Short Communication

Can the ASTM Heat Distortion Test Provide More than Just a Single-Point Measurement?*

SUMMARY

It is shown that the single-point heat distortion temperature value obtained under ASTM D648-72 can be used as a normalizing factor to coalesce heat distortion temperature versus stress curves for a generic type of polymer. The advantage of such curves lies in their ability to provide a quick estimate of the behaviour of the material at other stress levels useful for design purposes.

The practical importance of heat distortion temperature led to the development of tests in various modes such as flexural, tensile and torsion. At the heat distortion temperature, the polymer begins to stretch at a rapid rate over a narrow temperature interval.[1] This temperature is near the glass transition temperature for amorphous materials, whilst for highly crystalline polymers it is close to the melting point. Quite often it is taken as a temperature at which the elongation reaches a particular value, such as 1%. The low- and high-temperature parts of the heat distortion curve may be approximated by two straight lines: the extrapolated intersection of these two lines is sometimes taken as the heat distortion temperature.

In the ASTM D648-72 test,[2] a rectangular plastics bar 12·7 cm × 1·27 cm × 1·27 cm is supported at two points while a load is applied at the mid-point between them to give maximum fibre stresses of 455 kPa (4·6 kg/cm^2) or 1820 kPa (18·5 kg/cm^2). The specimen is immersed

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under load in a heat-transfer medium provided with a means of raising the temperature at $2 \pm 0{\cdot}2$ °C/min. The heat distortion temperature is taken as that temperature at which the test specimen has deformed 0·25 mm (0·01 in).

An increase in applied stress causes a decrease in HDT.[3] The stress dependence of the distortion temperature is greater at low stress than at higher stress. The HDT of polystyrene decreases at a rate of about 6 °C/(7·0 kg/cm^2) for loads near zero, whilst the rate is only about 2 °C/(7·0 kg/cm^2) for loads of 35·1 kg/cm^2.[4,5] The ASTM heat distortion test basically provides a single point on the deflection–temperature curve at a specific level of stress. Thus, the test is particularly suitable only for quality control and selective comparisons during development work. It cannot give an indication of the behaviour at other stress levels and hence cannot be used for design purposes.

It is shown in the following that the single-point heat distortion temperature value obtained under ASTM D648-72 conditions can be used as a normalizing factor to coalesce heat distortion temperature versus stress curves for different grades of a specific type of polymer. Such a unification has a distinct advantage in that further experimentation is curtailed and the heat distortion curves for the grade of interest can be generated from the master curve through the single ASTM D648-72 measurement.

Figure 1 shows the variation of the heat distortion temperature with applied stresses for Noryl resins of three different grades. We have in particular chosen Noryl resins for the demonstration of the coalescence technique because they are distinguished by their outstanding thermal endurance properties in comparison with most other polymers.

The heat distortion temperatures at 4·6 kg/cm^2 and 18·5 kg/cm^2 each represent a point on the individual curves in Fig. 1. It is proposed that these values may be used as a normalizing factor such that revised plots are made of HDT(S)/HDT(4·6 kg/cm^2) versus stress × HDT (4·6 kg/cm^2) as well as HDT(S)/HDT(18·5 kg/cm^2) versus stress × HDT(18·5 kg/cm^2) as shown in Figs 2 and 3. It can be seen that irrespective of the stress level chosen for the reference HDT used in normalization, a unified curve results from the coalescence of the data in Fig. 1. Plots in Figs 2 and 3 can be used for generating the heat distortion curves for any grade of Noryl merely by substituting the value of HDT determined under conditions prescribed in ASTM D648-72.

Thus, once curves such as those developed in Figs 2 and 3 have been generated for various polymers, ASTM D648-72 will have achieved an

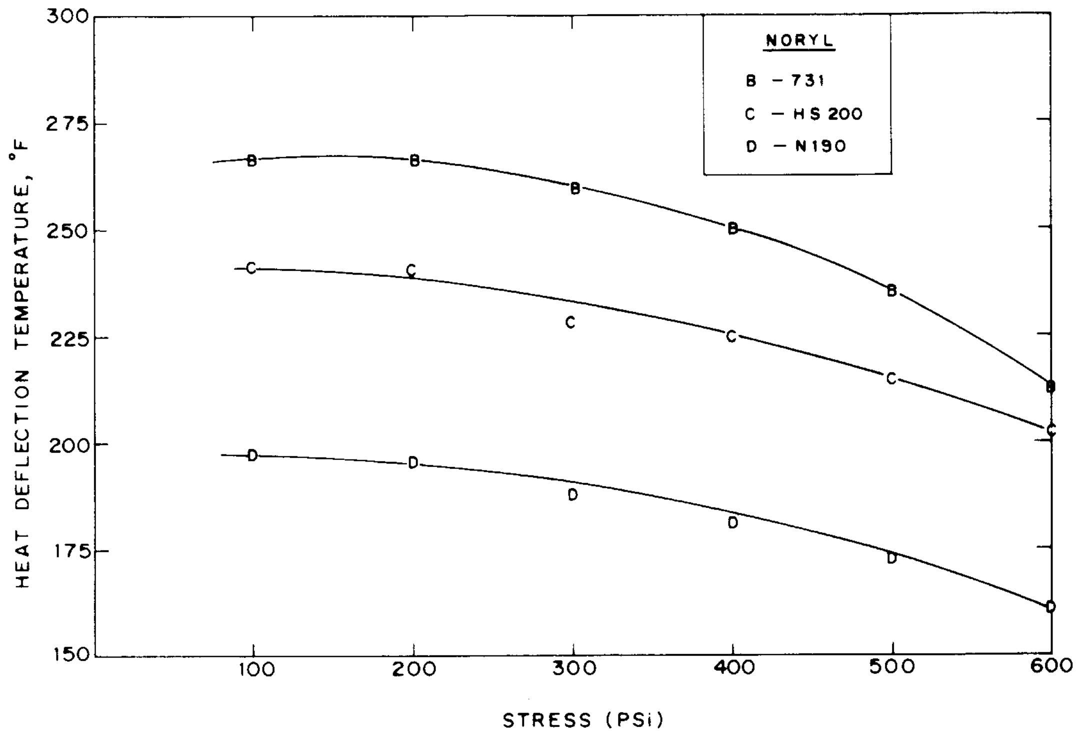

Fig. 1. Heat distortion (deflection) temperature versus stress for Noryl.

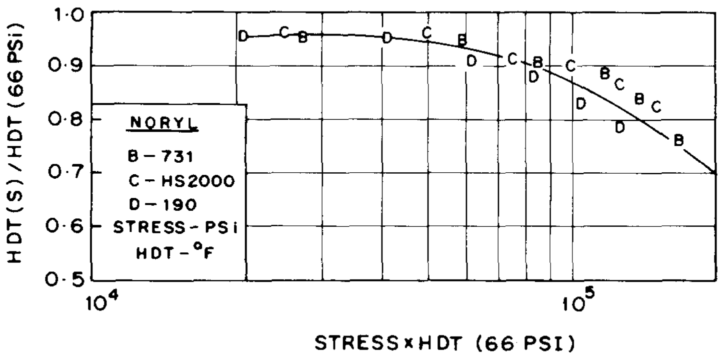

Fig. 2. Coalesced curve for HDT versus stress that is grade invariant using HDT as the normalizing factor under a test condition of 66 psi (4·6 kg/cm^2).

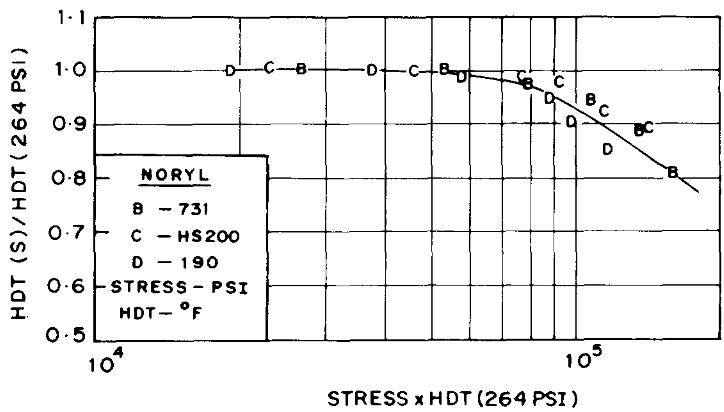

Fig. 3. Coalesced curve for HDT versus stress that is grade invariant using HDT as the normalizing factor under a test condition of 264 psi (18·5 kg/cm^2).

upgraded status as it will then be able to provide more information than just a single-point value.

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D. R. Saini
Polymer Science and Engineering Group,
Chemical Engineering Division,
National Chemical Laboratory,
Pune 411008, *India*

and A. V. Shenoy
Department of Materials Science and Engineering,
University of Florida,
Gainesville, Florida 32611, *USA*

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