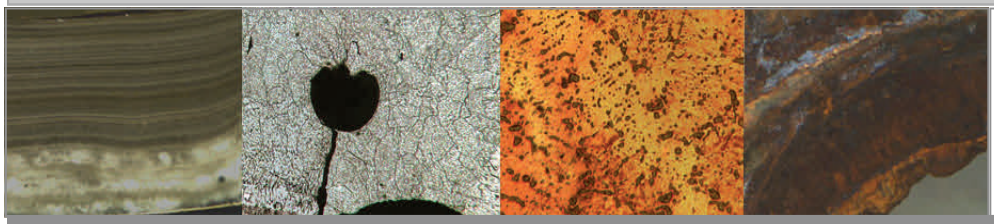
NUTS & BOLTS



New Hampshire MATERIALS LABORATORY, INC.
Your Problem Solving Partner

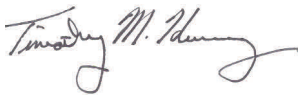
Polycarbonate Residual Stress **JUNE 2017 SUPPLEMENT**

Welcome to New Hampshire Materials Laboratory

Over the years, NHML has dealt with a number of industries and companies in the assistance of identifying contaminants, unknown materials or help them better understand their products. We're able to confirm the identity of products or to detect specific impurities. In this months Nuts & Bolts supplement, we give a brief overview of polycarbonate residual stress and explore annealing.

For more information or to find out more on how we can be "Your Problem Solving Partner", please visit our website at www.nhml.com or call our toll free number 800-334-5432.

Tim Kenney
Laboratory Director



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Polycarbonate Residual Stress

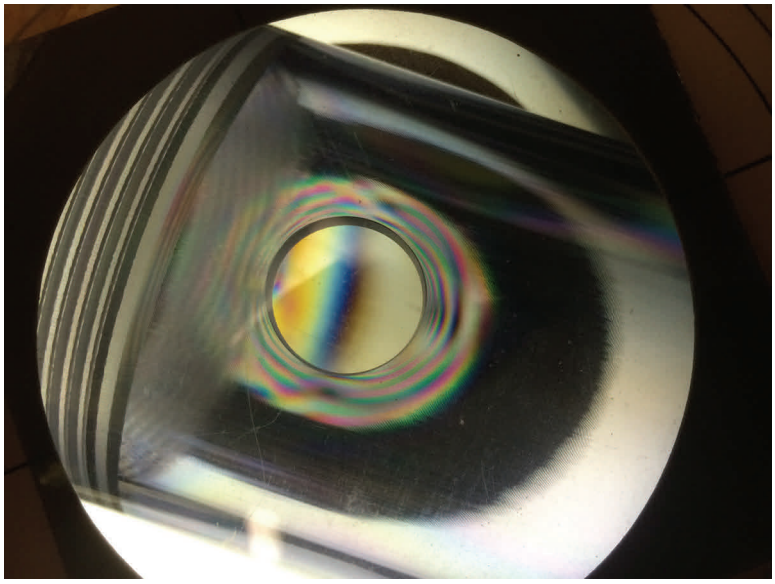
By: Tim Kenney

Knowledge of residual stress in machined and molded polymer parts is important in terms of understanding both dimensional stability and susceptibility to chemically assisted cracking.

Residual stresses can be present in extruded stock shapes, molded parts and thermoformed products. These stresses may be a normal part of the manufacturing process due to thickness changes or uneven cooling Residual stresses can also be present due to non-uniform flow rates or inclusions. Machining or subsequent thermal treatments can result in distortion, including warpage and crazing, changing the pattern of residual stress.

A qualitative evaluation of stress in a molded or extruded part can be performed inexpensively using polarized light. The resulting birefringence patterns are a qualitative indication of residual stress in the sample. Examples are shown in the attached photographs.

ASTM D4093 (photoelastic measurements) deals with quantitative analyses.



Residual Stress Pattern around a Drilled Hole

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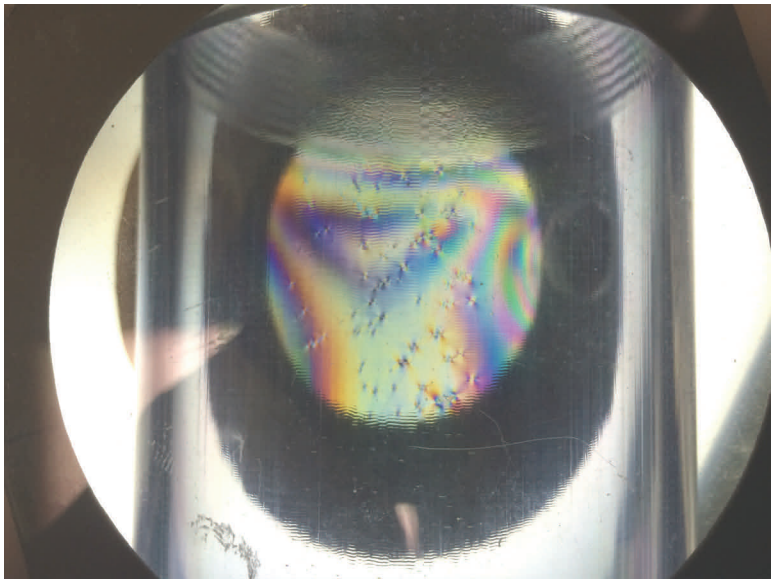
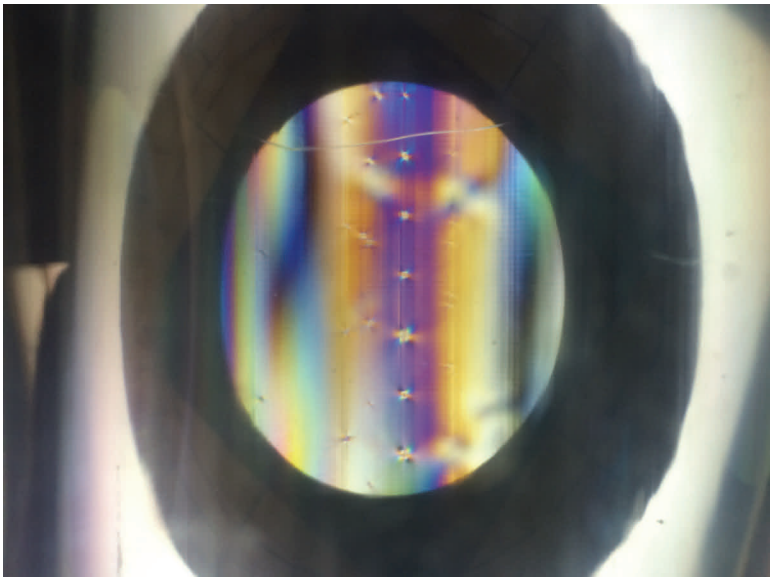


Random Defects in an Extruded Tube



Linear Defects in an Extruded Tube

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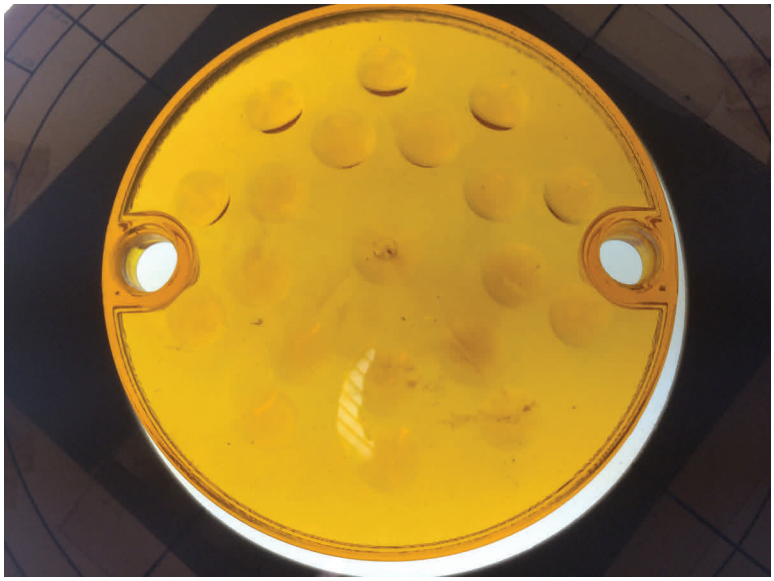
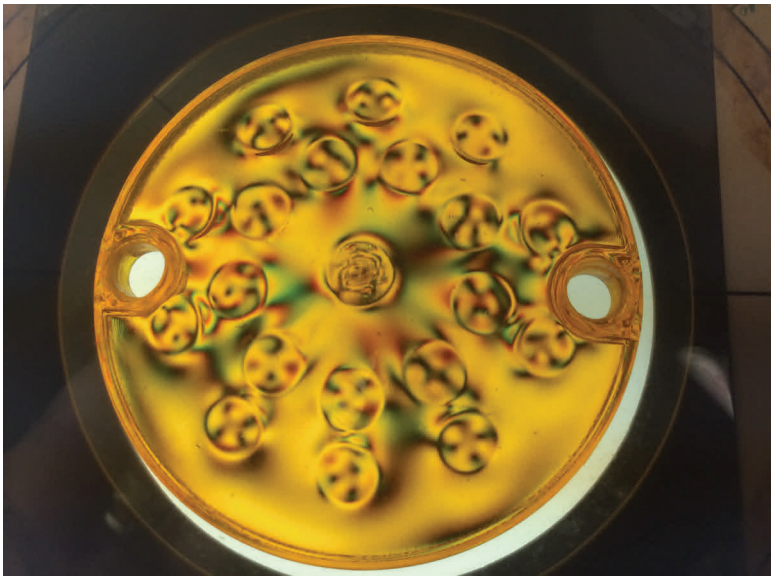


Molded Polycarbonate Part-Natural Light



Molded Polycarbonate Part-Polarized Light

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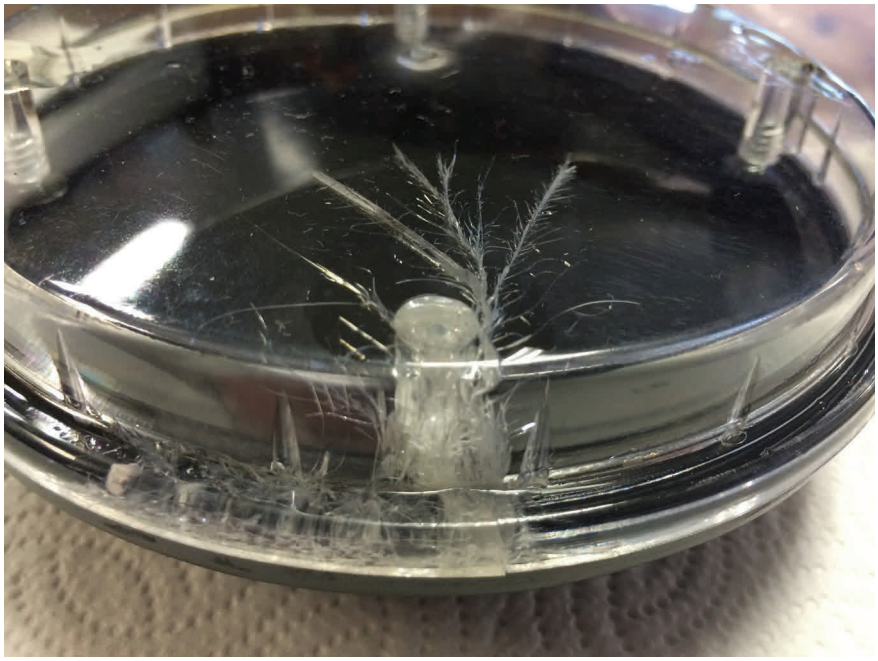
Quantitative determinations of residual stress in polycarbonates can be performed using two solvents, ethyl acetate and methanol, in various ratios. Ethyl acetate readily attacks polycarbonate at a critical stress level, residual or applied, of 500 psi. Methanol is significantly less aggressive and will result in crazing at a stress level of about 3400 psi after three minutes.

Accordingly, solutions of ethyl acetate (0-50%) in methanol can be placed in contact with the polycarbonate and there is a good correlation between the time to craze in three minutes and the level of stress in the polycarbonate.

See Figure below.

Note that typical molded parts have residual stress levels of about 1000 psi.



Crazing of a Polycarbonate Part after Solvent Exposure

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Annealing

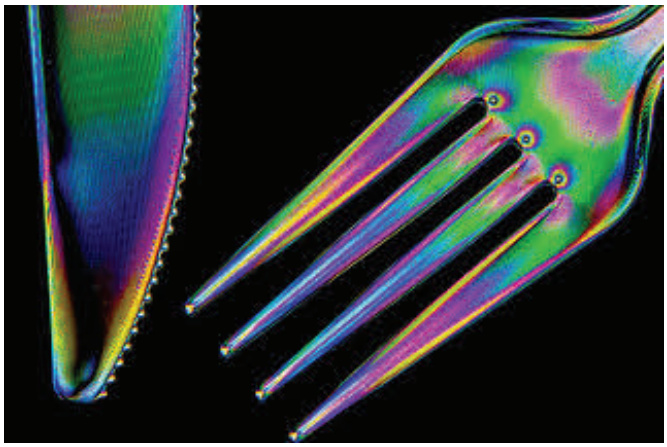
If sufficient material is removed from a stock shape, annealing of the plastic may be required to remove residual stress and machining stress.

During extrusion shaped stock is compressed through a die. This process results in a compressive stress when the material solidifies as it comes out of the die. Because of this unrelieved stress:

- The mechanical properties may differ from the standard published data.
- The material may crack or warp.
- Finished part dimensions may change.

Annealing consists of heating the polycarbonate to a point above the glass transition temperature, allowing a relaxation of stresses in the material. In a typical annealing cycle the parts would be loaded in a circulating air oven and slowly heated to 250^0F. The parts are held at temperature for 30 minutes plus an additional 15 minutes for each 1/8 inch of section thickness. The parts would be subsequently cooled slowly to 150^0F over approximately 10 hours. At this point the furnace can be shut off and the parts removed when they reach room temperature.

This information is given without obligation or liability.



Residual Stress Patterns in Common Objects

Residual Stress Patterns in Common Objects

If you have any questions regarding this topic, please don't hesitate to contact us at info@nhml.com or you can call on our toll free number 800-334-5432.

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