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Spin Casting of Polymer Films

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Synopsis

A versatile technique for spin casting of small polymer films within a cylindrical open faced mold is described. The high centripetal acceleration, about 500*g*, provides outstanding thickness uniformity and freedom from interior defects. The casting apparatus may be provided with pressure, temperature, and atmosphere control. A compact unit for simultaneous casting of four films is illustrated.

Centrifugal casting is employed in the metals[1] and glass industries[2] to produce homogeneous castings of high thickness uniformity. The plastics industry has adopted this technique, with about 100 firms commercially engaged in centrifugal casting in the United States.[3] It is somewhat surprising that this technique has not received more attention as a laboratory tool for preparing nonoriented polymer films for rheological or surface properties studies.

A convenient means of preparing solution or melt castings of polymer films involves spin or centrifugal casting in a cylindrical mold. A particular form of this technique has been developed and used in our laboratories for several years with good results. Spin casting has been applied in preparing thin films of elastomers from polymer solution or latex emulsion, melt casting of thermoplastics such as polyethylene, and simultaneous casting and curing of thermoset resins such as epoxies. These castings produce films, for testing purposes, of unusual thickness uniformity, surface smoothness, and freedom from interior imperfections.

Figure 1 depicts the cross section geometry of the open-faced casting cylinder, interliner, and motor shaft. As illustrated in Figure 1, the casting cylinder is simply a straight-walled cylindrical cup with a beveled retaining lip at the open end. The casting cylinder may be machined as a single unit or made with a detachable retaining lip and cylindrical center section for ease of film removal and cleaning. Aluminum has shown itself to be a very satisfactory construction material.

The interliner upon which the film is cast is usually a high density, low adhesion polymer film, which is inert to ordinary solvents. Commercial films of either polytetrafluoroethylene or polytrifluoro-chloroethylene serve well as interliners. The interliner is cut to fit the inner cylinder wall and provide a smooth butt as its joining ends. The interliner provides a smooth

substrate surface for casting and acts as a mechanical support for very soft polymer films. In certain cases where extreme substrate smoothness is of importance and mechanical support not required, a high density inert liquid provides a very satisfactory interliner.

This cylindrical casting technique offers several advantages over normal panel casting or spinning disk casting techniques.[4] These advantages arise from the high accelerations one achieves in a direction normal to the film surface. This normal acceleration minimizes inequities in film thickness due to surface tension and viscosity effects permitting casting of very thin films of high thickness uniformity. The high normal acceleration also frees the film of entrapped bubbles during drying. A standard cylinder diameter of 3 in. spinning at 3600 rpm provides a centripetal acceleration of 17,700 ft./sec.^{2} or 550g.

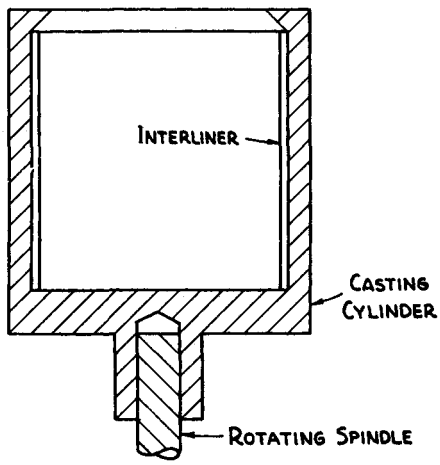

Fig. 1. Cross-section schematic of a spin casting mold.

This spin casting technique and these resultant effects of the high normal accelerations permit more rigorous drying conditions and appreciable shortening of drying times. Operating the shaft through a pressure sealed bearing, film casting and drying can be conducted within a temperature controlled vacuum oven. This control of temperature, pressure, and atmosphere about the rotating cylindrical mold provides an extremely versatile system for either solution or melt casting of polymer films.

Figure 2 presents a photographic view of a four-cylinder spin caster. Two driving motors are tandem mounted on a pivoted base plate. Extending from either end of the base plate are end plates fitted with cylindrical extensions that protrude into the rotating cup. The end plates, as Figure 2 indicates, prevent the cylinder from climbing off the shaft. They also simplify the pouring of fluids into the spinning molds. A bored rubber stopper fitted with metal tubing may be inserted into the circular open-

ings of the end plate. Connection by flexible tubing to a suitable source of compressed gas permits forced circulation within the rotating cylinder.

The equipment of Figure 2 is assembled as shown with the plastic film interlines placed in the casting cylinders. The motors are started and predesignated amounts of the polymer solution poured into the two upper cylinders through the end plates. The motor base plate is then unlocked and rotated 180° to bring the rotating lower cylinders to the upper vertical condition. These cylinders are filled with the casting solutions. If it is

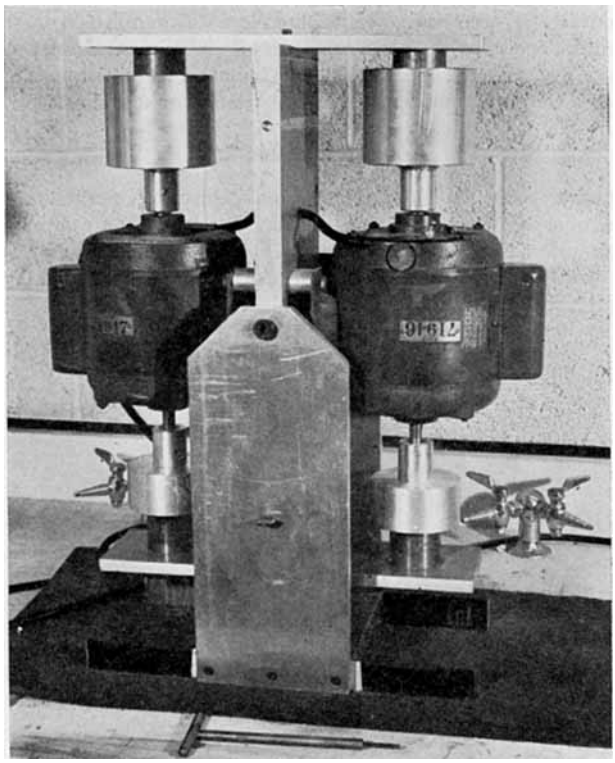

Fig. 2. Photographic view of a four-cylinder spin casting unit.

desired to use an inert liquid interliner rather than a plastic film, this material is added to the casting cylinders prior to adding the casting solution. On this apparatus, melt casting is accomplished in a generally similar manner to solution casting except that the granular polymer is added to the rotating cylinder and heat applied either to the cylinder outer wall or to the internally circulated atmosphere.

The removal of a very soft elastomeric casting from a plastic film interliner may be difficult at room temperature. Chilling this laminate to Dry Ice temperature and cold stripping provides, in most cases, an easy means of separation.

References

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Résumé

On décrit une technique varié pour la fabrication de films de polymères dans un moule cylindrique ouvert. L'accélération centripète élevée d'environ 500*g* assure une excellente uniformité d'épaisseur et l'absence de défauts intérieurs. L'appareil de moulage peut être équipé avec un contrôle de pression de température et d'atmosphère. On décrit aussi un appareil compact pour le moulage simultané de quatre films.

Zusammenfassung

Ein brauchbares Verfahren zum Drehguss von kleinen Polymerfilmen innerhalb einer zylindrischen, offenen Form wird beschrieben. Die hohe Zentripetalbeschleunigung, etwa 500*g*, garantiert eine ausserordentliche Dickeneinheitlichkeit und Fehlen innerer Fehlstellen. Der Giessapparat kann mit Druck-, Temperatur- und Atmosphärenregelung ausgestattet werden. Eine kompakte Einheit für das gleichzeitige Giessen von vier Filmen wird gezeigt.

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