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CENTRIFUGAL CASTING PROCESS

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This invention relates to a centrifugal casting process, more particularly to a centrifugal casting process wherein the rotation rate of the mold is varied.

When a liquid material is charged in a rotatable mold and the upright mold is subsequently set to rotation about its vertical axis, the liquid material will move upward along the walls of the mold, due to the resulting centrifugal force, as far as the walls do not converge inwards towards the axis. The outer surface of the resulting liquid rotational shape conforms to the walls of the mold cavity, while the interior, exposed surface of the liquid tends to assume a more or less paraboloidal shape, the shape depending on the rotational velocity and the surface tension of the liquid. This does not present problems as long as the walls of the mold cavity are also of a paraboloidal or near-paraboloidal shape. However, if one intends to form uniform wall thickness items of a shape markedly deviating from a paraboloid, such as a straight-walled funnel or a cylinder, the control and the uniformity of the wall thickness becomes increasingly difficult, or even impossible.

Another factor in the difficulty of accomplishing uniform wall thicknesses of centrifugally cast articles, in general, results from a nonuniform wetting of the mold walls by the material due to a great variety of possible reasons. This problem becomes especially aggravated when one attempts to centrifugally form articles from materials having a very low viscosity in the casting stage, such as in situ polymerized polyamide resins, i.e. resins polymerized in the mold during the centrifugal forming process. These resins polymerize and set up within a given time; therefore, the complete deposition thereof on the mold walls and in the desired distribution has to be accomplished within that time, otherwise the nondeposited material will set up as one or more solidified puddle or puddles, respectively.

If the rotational speed of the mold is fast, mold surfaces closer to the bottom tend to be starved and remote surfaces overloaded; if it is attempted to overcome this lack of uniformity by employing a lower rotational speed, the liquid charge may remain at or near the bottom of the mold so that higher areas are starved; and if the mold surface is not a continuous smooth one, but is interrupted by angles, crevices, curvatures, or protrusions, a heavy or insufficient material buildup occurs in these parts. Additionally, nonuniform distribution of the material on the walls of the mold cavity is often more pronounced in the case of such low-viscosity materials.

In attempts to overcome the above-mentioned difficulties, complicated centrifugal casting machines have been constructed to impart a compound centrifugal motion to the mold and the liquid charge therein, such as proposed, for instance, in United States Patent No. 2,961,703. Various attempts made heretofore resulted only in a partial alleviation of the problems.

It is an object of the invention to provide an improved centrifugal casting method eliminating the above-mentioned drawbacks of the prior art methods.

According to the improved centrifugal casting process of the invention, a charge of the liquid material to be molded is inserted into a stationary or rotating mold and, subsequently, depending on whether or not the mold is already rotating, rotation is commenced. After

the mold has accomplished acceleration to the maximum r.p.m., its rate of rotation is alternately decreased and increased. In the alternative, the mold can be alternatively rotated in a clockwise and counterclockwise direction.

As a result of the alternating acceleration and deceleration of the mold, or the alternative method, whereby the acceleration and deceleration are coupled with a directional change, the material charged into the mold cavity will first have a speed less than the speed of the mold. Due to the friction between the mold and the material, the latter will accelerate until an equilibrium is established between the speed of the mold and that of the material. When the mold rotation is braked, the material, due to inertia, will continue rotating by its momentum at a speed higher than the speed of the decelerating mold, resulting in a lateral relative shearing displacement between the material and mold, the material thereby washing the mold walls in a lateral direction. The mold deceleration is followed by a more gradual deceleration of the material, and the lateral slippage or displacement of the material relative to the mold diminishes in degree in time. If the mold is now accelerated again, a second lateral relative displacement between the material and the mold walls occurs due to the friction of the material against the wall, the second relative displacement being in an opposite sense as the displacement which occurred during the deceleration. A similar alternating relative displacement between the material and the mold walls can be accomplished in both directions when the direction of the mold rotation is reversed. As a result of these lateral relative displacements, a greater wall thickness uniformity of the material of the object thus molded, along any horizontal cross section, can be accomplished. Due to the alternating accelerations and decelerations and the attendant increases and decreases in the centrifugal force acting on the material, it will, in addition to the lateral displacements referred to above, also move up and down along the mold cavity, and thereby repeatedly wash the mold walls to permit the forming of items, the inner cross-sectional shape of which markedly deviates from a paraboloid. In addition, a better and more uniform "layup" or mold-wall coverage with the material will also result.

In the prior art continuous rotation centrifuging techniques, slight variations in material characteristics and temperature required a constant readjusting and close control of the material temperature and mold rotation. By employing the alternating rotational process of this invention, the strict control requirements necessitated by the prior art methods may be relaxed.

If the item to be molded is desired to be formed with stratified walls, wherein successive layers of different materials form the composite wall cross-section, the materials forming the different layers may be charged into the mold at successive stages. Such layers may include alternating deposited layers of materials having varying physical properties complementing each other, alternating layers of resins, fillers, pigments, etc.

Undue material buildup in corners and crevices of the mold is avoided because only a relatively thin layer of material is deposited within one acceleration and deceleration cycle as the material shifts up and then down along the walls, and the thin layer is well distributed in such places before another layer of material is deposited thereon in a subsequent cycle.

The rate of deceleration or acceleration is limited by the possibility that at higher rates the liquid material may tend to splash or form waves, and if this occurs at a point where the liquid starts to solidify or polymerize, the irregularities may be "frozen" into the final molded body shape. This limiting rate has to be determined individually

3 for the particular material used, in view of its viscosity, surface tension and mold shape.

The rotational speeds employed will greatly vary from one material and mold shape to another, but in the case of very fluid materials, such as anionically polymerized caprolactam, the rotational speed usually always exceeds 50 r.p.m.

In the following, by way of example, an embodiment of the process of the invention is given, as applied to centrifugal polymerization of liquid lactams while casting 10 objects thereof, the lactams generally having a viscosity of about 10 centipoises in the monomer state; however, it is to be understood that the process of the invention is also applicable to the centrifugal casting of other materials which have different viscosities. The minor adjustments of the processing parameters for any given material may be determined by routine experimentation.

Example

An aluminum vessel 11 inches in diameter and 7 inches deep and having a flat bottom joined by a gentle curve to the slightly tapered, almost cylindrical sidewall was mounted in an electric oven as a mold for rotation about its axis. The mold vessel was covered and sealed except for a 1-inch hole in the center for purging the mold cavity with an inert gas and for introducing liquid resin therethrough. The mold was preheated to 175° C. and the cavity purged with dry nitrogen.

With the mold rotating at 500 r.p.m., 250 g. of a mixture consisting of 247 g. caprolactam, 2¼ g. lithium caproylimide, and 0.63 g. triphenoxy-s-triazine as polymerization catalyst and promotor at 100° C. was charged through the filler opening. Materials of this type are described in greater detail, for instance, in Belgian Patent No. 623,840. During the handling and pouring, the mixture was blanketed with dry nitrogen to prevent its exposure to atmospheric moisture and oxygen.

As soon as the mixture was fully charged into the mold, the mold rotation was braked from the original 500 r.p.m. to a full stop in 5 seconds. After a 10-second rest the mold was accelerated again in 5 seconds to 500 r.p.m. by a torque motor driving the mold through a belt. As soon as the mold reached the full speed, it was again decelerated, and this 20-second cycle was repeated for a period of 5 minutes.

A second 250 g. charge of the mixture at 100° C. was then poured into the mold rotating at 500 r.p.m. and the above 5-minute acceleration—deceleration cycling was repeated. After the mold was stopped, it was maintained at 175° C. for 15 minutes. The resulting saucepan-shaped item had excellent circumferential wall thickness uniformity; the vertical wall thickness distribution was also satisfactory. The two successive charges gave a cross-section that appeared as if only one charge had been made.

It is to be understood that the invention is disclosed by way of an example and, depending on production requirements and material characteristics, a number of

modifications may be employed. Different materials and different production rates would require different processing temperatures and durations, while some materials, such as thermoplastic resins may also require cooling during the process. Depending on the viscosity characteristics of the material to be molded, a variety of acceleration and deceleration rates as well as rotation times may be used. The process of the invention is not limited to centrifuging only about a vertical mold axis, the process is also applicable to the centrifugal casting of articles in which the walls above the bottom plane converge inward at any point. In this case the rotational axis of the mold has to be inclined from the vertical at some point during the rotational cycle. In view of the foregoing, the scope of the invention is to be interpreted from the appended claims.

I claim:

1. In a centrifugal casting process wherein a mold is charged with a material to a molded, and the material is converted therein from a fluid liquid to a solid phase, the improvement which comprises a repeated cycle of rotating said mold about its vertical axis to a desired rotational speed of at least 50 r.p.m. and quickly braking said rotating mold when it attains said desired rotational speed, each cycle comprising about 10 seconds of rotation followed by about 10 seconds in which the mold is not rotated.

2. The process of claim 1 wherein the direction of rotation is reversed about each braking.

3. The process of claim 1 wherein the desired speed of rotation is in the range from 50 to about 500 r.p.m.

4. An improved centrifugal casting process which comprises charging a mold with a mixture consisting essentially of caprolactam, an anionic catalyst and a polymerization promotor followed by the repeated cycle of rotating the mold about its vertical axis to a speed of about 500 r.p.m., quickly braking the rotation within a period of about 5 seconds when it attains the desired rotational speed and permitting the mold to remain at least for about 10 seconds prior to repeating the cycle.

5. The process of claim 4 wherein the direction of rotation is reversed for each succeeding cycle.

References Cited

UNITED STATES PATENTS

2,325,019	7/1943	Rubissow	264—311
2,466,277	4/1949	Rubissow	264—71
2,629,130	2/1953	Rempel	264—311 X
2,971,223	2/1961	Grunen et al.	264—71
3,048,896	8/1962	Marlo	264—311
3,161,712	12/1964	Hungerford et al.	264—310
3,164,654	1/1965	Spencer	264—311

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