Large Diameter Rings Fabrication

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Nafaa Mekhilef, Saint-Gobain Mobility

Abstract: A process of forming large diameter polymeric rings is disclosed involving providing a heated filament or tape to a rotating drum at an adequate temperature. Once deposited, process parameters (such as extrusion temperature, extrusion speed, drum temperature, and speed) are optimized to achieve a desired thickness, inner diameter, and outer diameter for a polymeric ring formed without a weldline. Such rings offer a myriad of applications in industrial equipment while reducing cost, material, and complexity of fabrication over existing ring production methods.

Large diameter polymeric rings are used in a myriad of applications in industrial equipment. However, their fabrication may not be trivial as they cannot be produced by compression molding in a single piece. This is due in part to the complex fabrications processes and material cost. For small diameter rings, compression molding is often used by cold or hot molding a slab with the desired dimensions followed by machining a ring of various thicknesses to produce the finished parts. This approach requires a balance between the cost of fabrication and the cost of the material used. For medium size rings, the balance between the fabrication and material cost may be unfavorable as the waste produced is often larger than the product itself. For even larger diameters, the balance becomes even more disadvantageous, though molding and machining from large slabs can be leveraged by machining rings of different diameters and thus reducing waste. This however, requires that the demand for such diameters exists.

Alternate processes have been developed by different companies to address this challenge and reduce the amount of material wasted due to machining. One known process is compression molding of a near net shape rings using an annular tool with a main tool having a specific diameter (OD) and an inner core with a smaller diameter (ID). The complex tool assembly is typically used to produce a ring but in a form of a tube to allow cutting several rings or washers along its height. While this technique allows reduction of the material used, it requires larger molding presses for larger diameter rings.

Technologies such as extruding short profiles, typically rectangular in cross section, and bending them into an arc of a specific radius are currently practiced. Combining four pieces of this shape allows the fabrication of a full ring with the desired shape. Similarly, the rings can also be produced by extruding a long profile equivalent to the perimeter of the desired ring followed by heating and bending the bar in a tunnel oven and then joining the ends similar to a butt joining process **[1]**. However, in both of these processes, the welding of the ends creates one or up to four weldlines, which may present a higher risk of failure during the life of the application. Weldlines are known to be a critical parameter that depends on the process conditions, whether it is butt fusion where two ends of a profile (rod, tube, pipe) are joined together after heating the ends beyond the melting point of the polymer **[2,3]**, or in injection molding of large objects whereby multiple injection gates are necessary to fill the cavity in a short time **[4]**. The issue of weldlines can be even more critical if the material is known for its notch sensitivity, in other words, the material is sensitive to defects in the parts. These can be micro-pores, a filler with different aspect ratio or another polymer blended within the matrix resin. In that case, the strength of the weld line becomes extremely weak **[5]**.

A newer technology has been developed by Saint-Gobain stemming from additive manufacturing and specifically fused deposition modeling (FDM). In this process, a filament or a tape of different width and thickness is heated and deposited onto a rotating drum that is heated to an adequate temperature. The drum can have an adjustable mechanism to define the desired inner diameter and the heated filament or tape is deposited at high output rate while it is in the melt state, thus building the desired ring thickness. This process can also be achieved by combining a single screw extruder and a take-up system. Extruding the heated filament or the tape directly onto the heated drum will allow the fabrication of a ring with the desired outer diameter. When the process parameters are adjusted properly (extrusion temperature, extrusion speed, and drum temperature and speed), a ring can be produced without a weldline. Furthermore, if the process parameters are adequate, the extruded profile can be fused together every drum rotation without creating an interfacial layer or defect between the layers. Such a process will not only reduce the amount of material needed, but also can produce a ring with any diameter (ID and OD), in addition to the higher productivity that can be achieved.

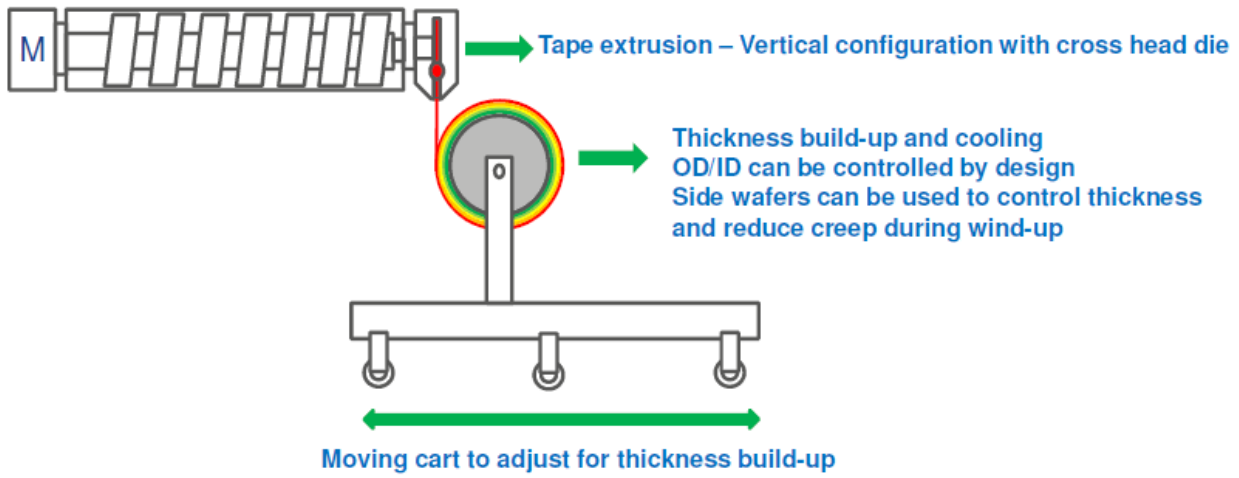

Figure 1: Image of Exemplary Process of Forming Ring

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