DESIGN SYNTHESIS OF INCREMENTAL DRAWING PROCESS FOR SYNTHETIC FILAMENTS

by

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CERTIFICATE

This is to certify that the thesis entitled "Design Synthesis of Incremental Drawing Process for Synthetic Filaments" submitted by Arup Kumar Rakshit for the award of the Degree of 'Doctor of Philosophy', has been prepared under our supervision in conformity with rules and regulations of the Indian Institute of Technology, Delhi. The research report and results presented in the thesis have not been submitted for any degree in any other university.

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ABSTRACT

Textile fibres/filaments in their as-spun state exhibit low strength and high extensibility which upon "drawing" result in high strength and low extensibility primarily due to the alignment of molecular chains and development of crystalline structure in filament axis direction. This post-spinning operation of 'drawing' or 'stre tching' is well established. The conventional method of drawing incorporates passage of filament over two or three pairs of cylindrical rollers which rotate at successively higher speeds. The ratio of surface speeds of the ultimate take-up roller and the feed roller gives the draw-ratio experienced by the fibre being drawn.

In the present work a process has been developed where the total draw is distributed over a number of small increments and has been termed as incremental drawing process. The filament, in this process, is constrained to follow a path leading over a pair of cones rotating at identical radial velocity and having finite steps of increasing radii machined over their tapering non-sliding surfaces. The filament enters the lowest diameter end and emerges from the bigger diameter end. Throughout the journey it experiences gradual acceleration determined by the respective diameter on which it rests and gets stretched to the predetermined extent when it emerges.

Different profiles of the drawing body have been developed, as the profile governs the style of stretch insertion in the drawing member. First is a linear profile drawing body where draw ratio between two respective stages gradually increases towards the bigger diameter end while the strain rate remains constant. To keep the draw-ratio constant throughout, a concave drawing profile body has been developed where the strain rate rises exponentially. Finally a convex profile drawing body has been designed which gives a decreasing rate of strain as well as draw-ratio along its profile. Following experimentation reveals the convex profile to be the best among all.

A model machine has been designed and constructed which can work upto a processing speed of 900 m/min in laboratory condition. To ensure no difference of speed among the two drawing bodies, both the shafts are tied with a positive drive belt. A swing back revolving dead centre arrangement was designed to get a vibration free working at higher speeds. Studies on different number of steps, surface characteristics, step configuration were carried out. The drawing bodies were made with different materials and methods. A wooden drawing body coated with epoxy resin, a reinforced cage metal filled epoxy drawing body and a die-casted aluminium drawing body were prepared.

Different heating systems have been designed to make the process suitable for hot drawn polymers. Chamber heating system, plate or band heaters and finally an internally heated godet have been designed. By virtue of operational ease the plate heating system was found to be the most efficient. The chamber heating system, though efficient, had to be abandoned due to inconvenient threading style, prolonged exposure of the filament at the same temperature and various other reasons. The internally heated drawing body is designed exclusively for PET-POY yarns and therefore, beyond the scope of the present investigation.

Experimental observation proves that the incremental drawing process (IDP) develops better mechanical and physical properties in fibres as compared to conventional drawing process (CDP). In cold drawn nylon 6 monofilament yarn tenacity value of 7.7 gpd has reached as opposed to 6.6 gpd in its conventional counterpart. It is found that IDP is capable of raising the draw-ratio value for a given sample than CDP. Lack of sensitivity is found in the study on effect of drawing speed on IDP. It can be said here that to develop equivalent property in a sample the processing speed can be raised on IDP.

Work on high tenacity grade nylon 6 and nylon 66 yarn reveals that the process is highly effective in the

preparation of high tenacity, high modulus yarns. A tenacity of 9.5 gpd and 9.0 gpd in nylon 6 and nylon 66 yarns has been reached with respective modulus valuesof 60.0 and 62.0 gpd. The same nylon 66 tyre cord exhibited tenacity and initial modulus of 8.2 and 52.0 gpd in its conventionally drawn commercial sample. IDP sample also reveal less shrinkage value and better dynamic mechanical behaviour.

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