Theoretical Extrusion Predictions

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It is often stated that the basic extrusion equations are a guide to predicting performance but never should be used for direct scaleup or prediction of performance. Over the past thirty years, I have confirmed the correctness of the equations, as published early by Bernhardt, and have conducted many tests with Newtonian fluids to confirm the predictions of both flow, as a function of rpm back pressure and viscosity. The problem seems to arise with the application of Non Newtonian fluids. When incorrect results are obtained the basic derivations are blamed. A study of the application of non Newtonian fluids to the extrusion theory discloses that the basic cause of incorrect application is in the backflow term (Beta x Delta press/viscosity x Length full). Most often the shear rate is assumed to be (3.14 x D x N/h) as given by the Bernhardt reference and as a consequence the incorrect value of viscosity is evaluated for use in the reference equations. Some investigators have used the metering zone of the extruder as a rheometer and back calculated the required value of viscosity, for a given resin, to make the equations better fit actual performance. In 1967 the author was a guest at the University of Stuttgart, West Germany, and reviewed this problem with Dr. G. Schenkel, who stated that the correct shear rate in the channel of the screw was approximately 3 x 3.14 x Dx N/h or 3 times the value given by the initial publication in Bernhardt. Subsequent laboratory test, by the author, have verified this factor. Later theoretical studies by Dr. M. L. Booy have confirmed this approximate correction value of 3.0.

Hence, when attempting to apply the theoretical development to predicting performance, it is essential to use the correct viscosity.

Additional errors frequently made when using the equations for prediction; are incorrect shape factors (Fd & Fp) and an incorrect shear rate used between the flight tip and the barrel wall. When correct values are used the author has found the theory to be correct without the need of correction factors. Future correspondence will discuss these additional factors.

- Frank E. Hoffman

See also:

- Designing high performance screws
- Scaling up the extrusion process

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