The Tandem Screw Extruder

Stephen J. Derezinski

Extruder Tech, Inc.

Every extruder provides two basic functions:

1) **a desired flow, and**
2) **a desired temperature.**

1) Flow Rate

Controlled by the screw speed

2) Product Temperature

Controlled by the barrel temperature

Design Point

At design rate, a conventional extruder has a specific product temperature that has optimum thermal uniformity.

Design Point

Off of the design point, extra barrel heating or cooling will be needed to provide the desired product temperature.

Design Point

Extra barrel heat transfer means thermal gradient and uneven melt temperature.

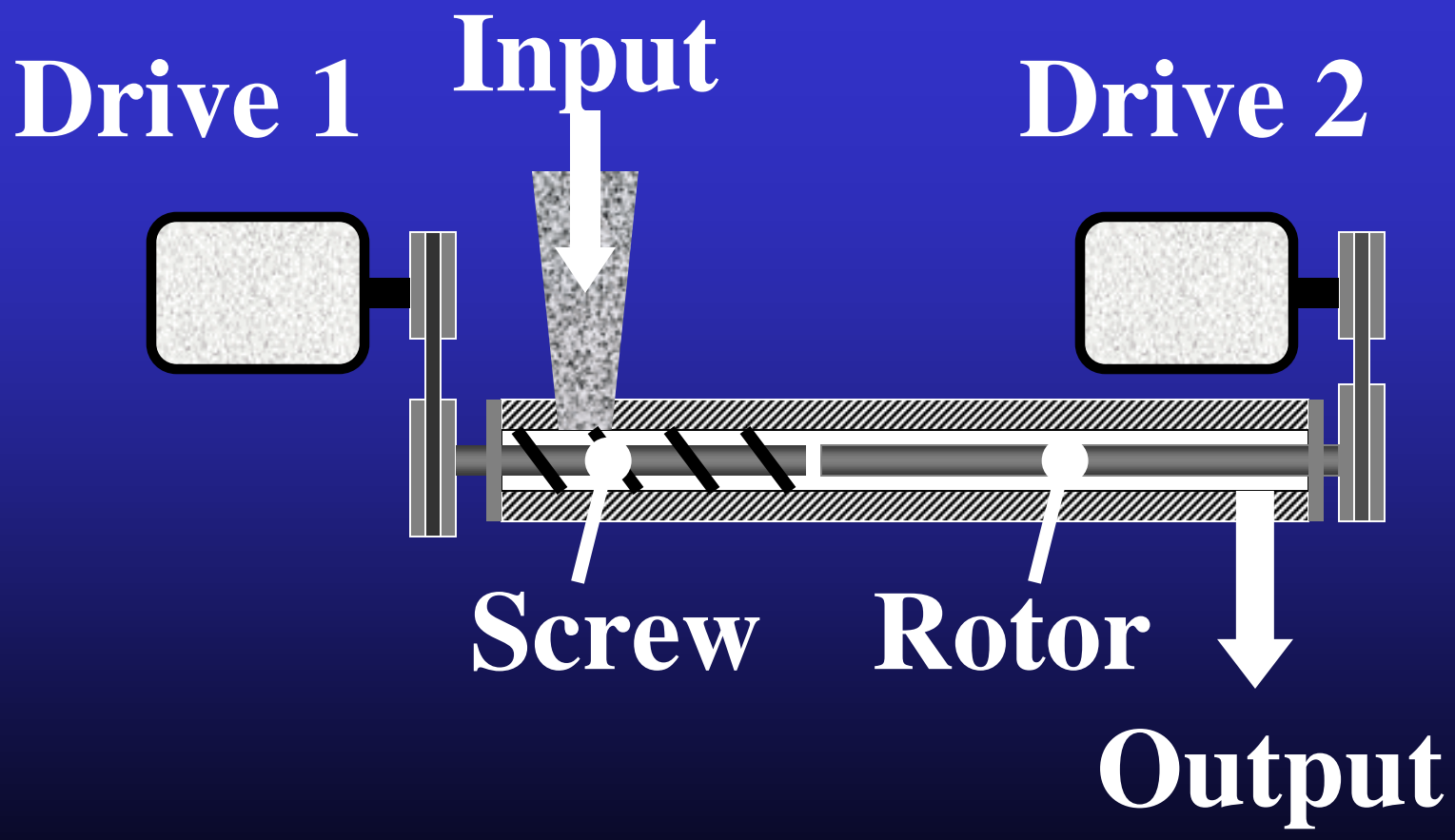
Tandem Screw Extruder Concept

The tandem screw extruder concept avoids unneeded heating/cooling.

Tandem Screw Extruder Concept

Two screws and two drives with a common barrel: One drive speed controls flow and the other controls product temperature.

Tandem Screw Extruder Concept



Tandem Screw Extruder Concept

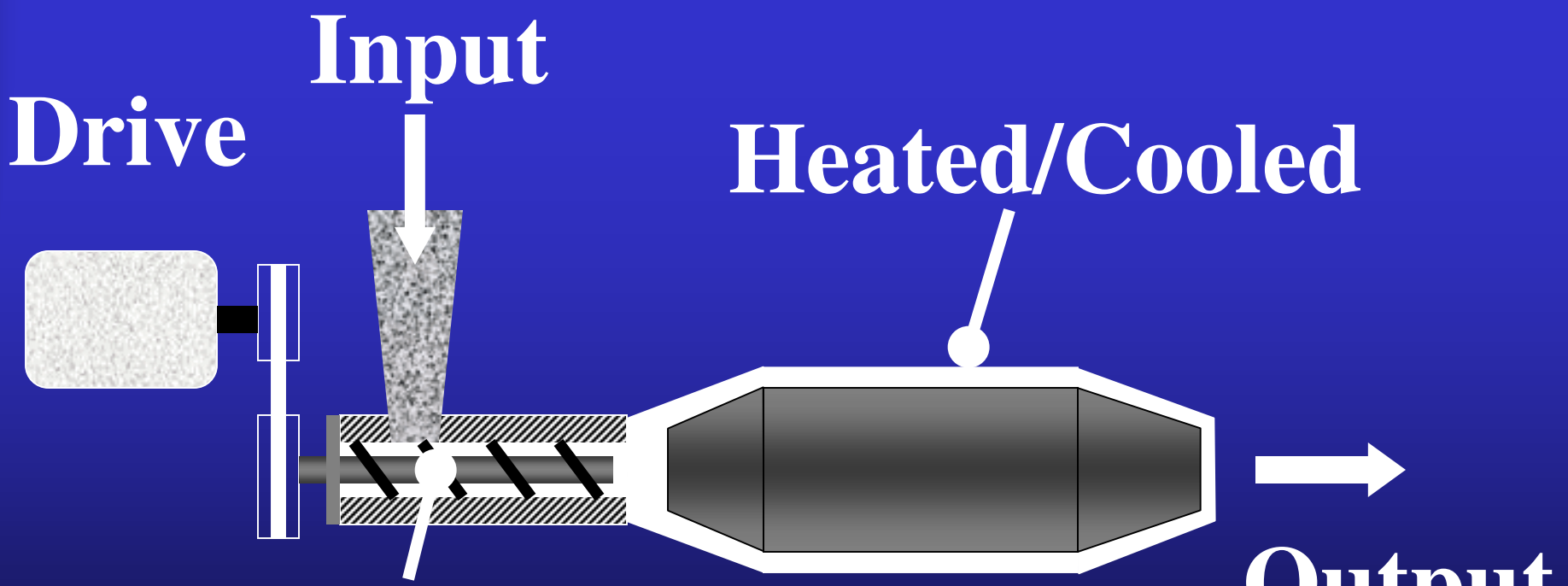
Drive 1 has flights to provide flow.

Drive 2 has no flights to only temper the flow.

Previous Work

Machen, James F. and John D. Schuster, "The Extrusor-A High Speed, Low Shear, Energy Efficient Extruder," *ANTEC 1985 Conference Proceedings, Society of Plastic Engineers*, pp 108 – 112, 1985.

Extrusor Concept



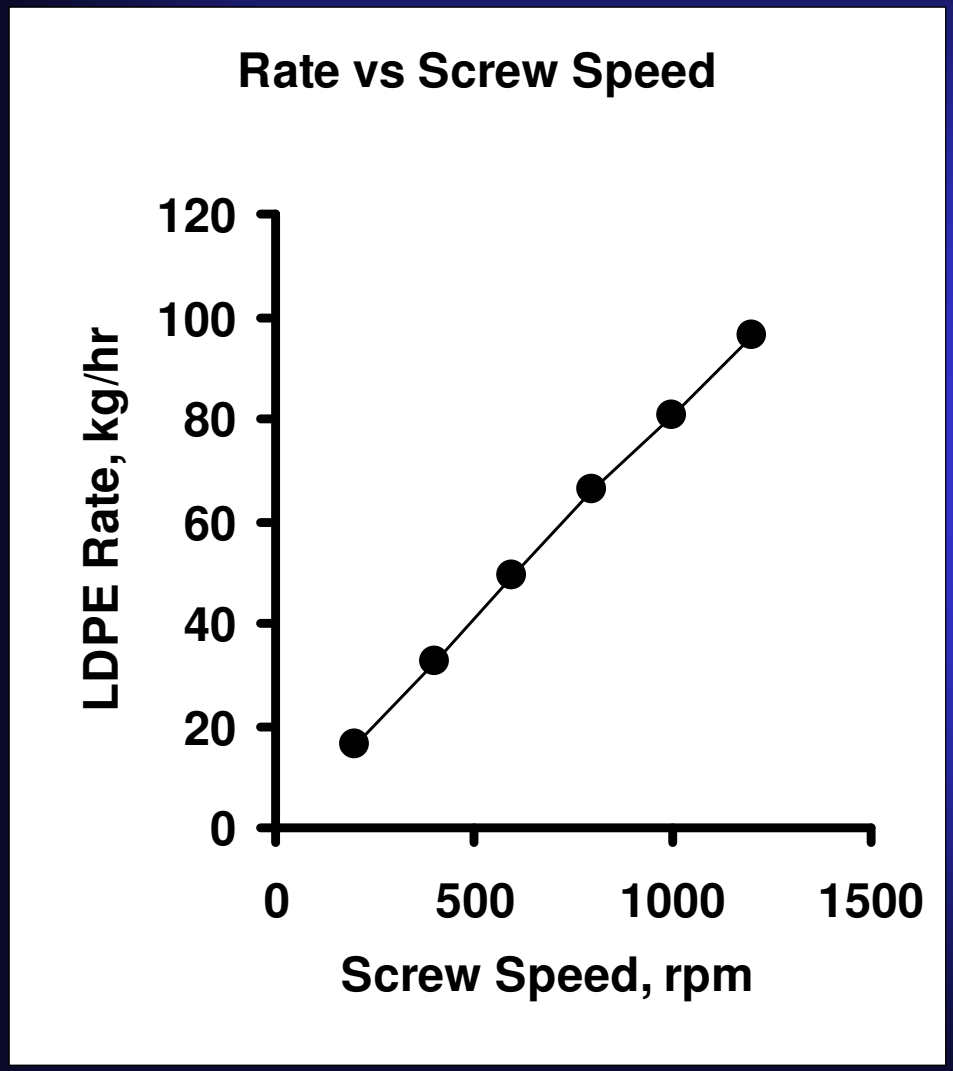
Extrusor Concept

The extrusor pumping screw data are used as basis for pumping screw analysis (drive 1) of the tandem screw extruder.

Extrusor Solids Conveying Screw

- 10 L/D
- 25.4 mm (1 inch) diameter
- 2.8 mm (0.11 inch) channel
- Square pitch
- Speeds to 1500 rpm

Extrusor Measured Rate



25.4-mm, 10 L/D

Solids Conveying

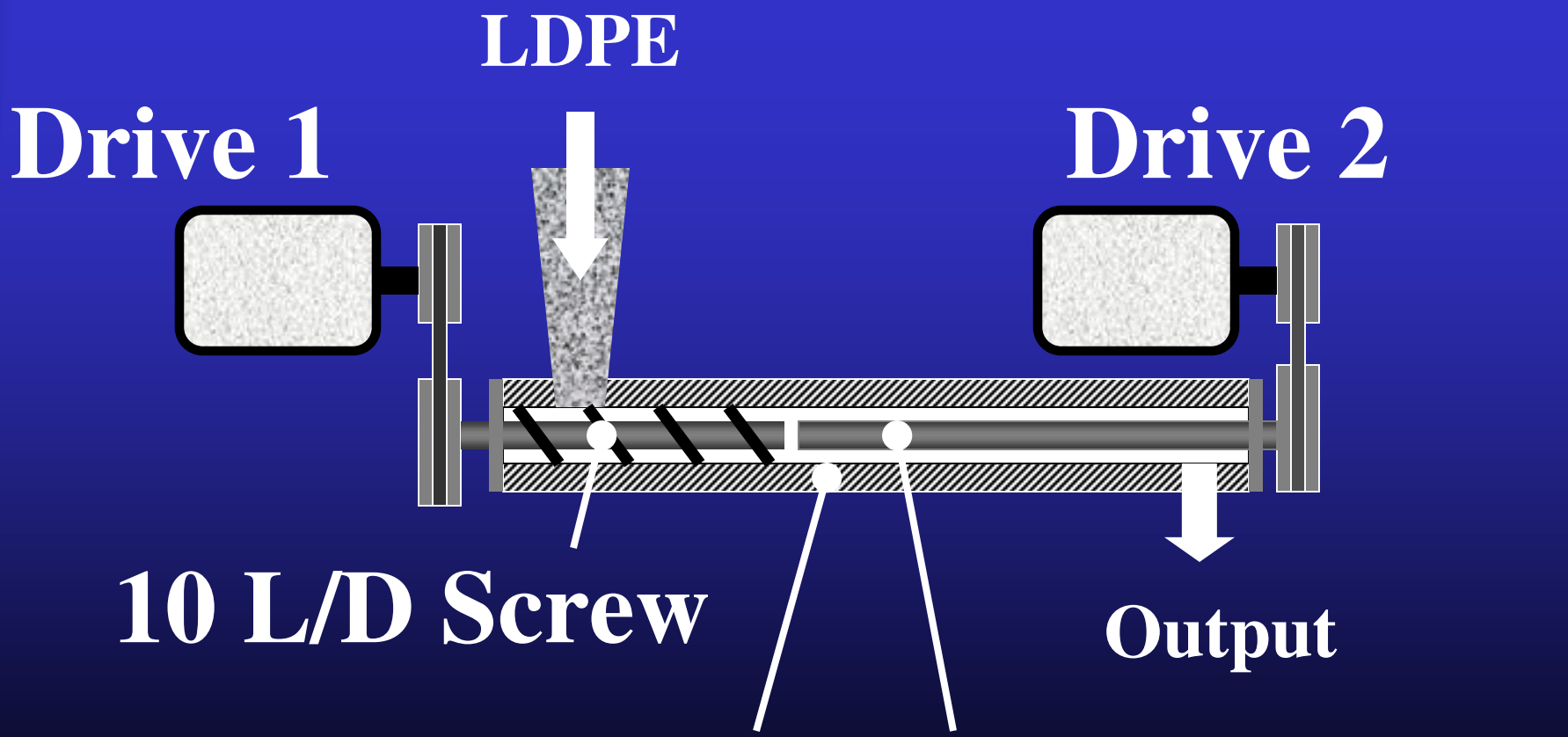
High screw speed provides rates comparable to a 63-mm extruder.

Direct drive or belt driven screw

Tandem Screw Flow

The extrusor data for the flow of the 25 mm (one-inch) screw will is used establish a model for the tandem screw extruder.

Tandem Screw Model



Tandem Screw Temperature

- Flow tempering is done with the smooth rotor powered by the second drive.
- Flow rate is unaffected.

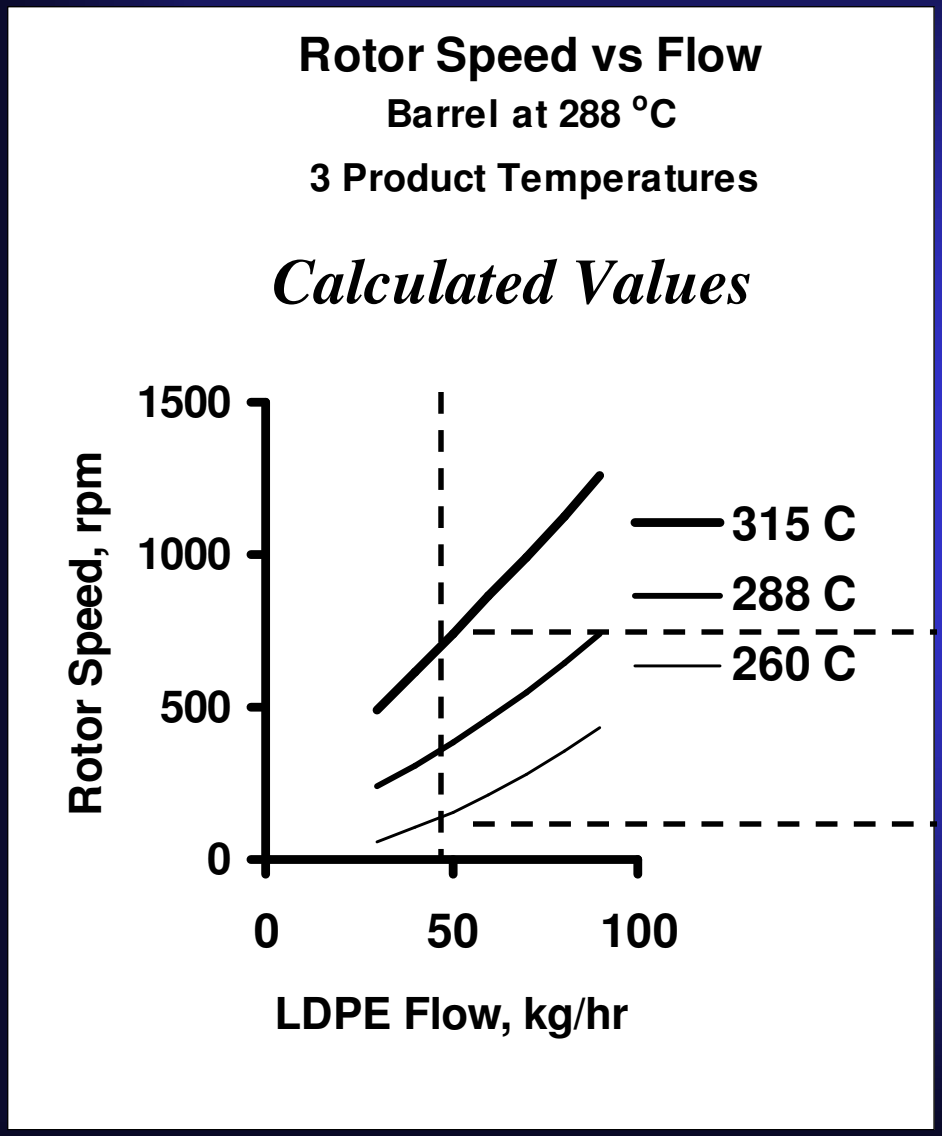
Tandem Screw Temperature

The speed of the second drive controls the product temperature.

Tandem Screw Temperature

A math model was used to calculate the temperature developed by the rotor.

Rotor Speed Vs Flow Rate



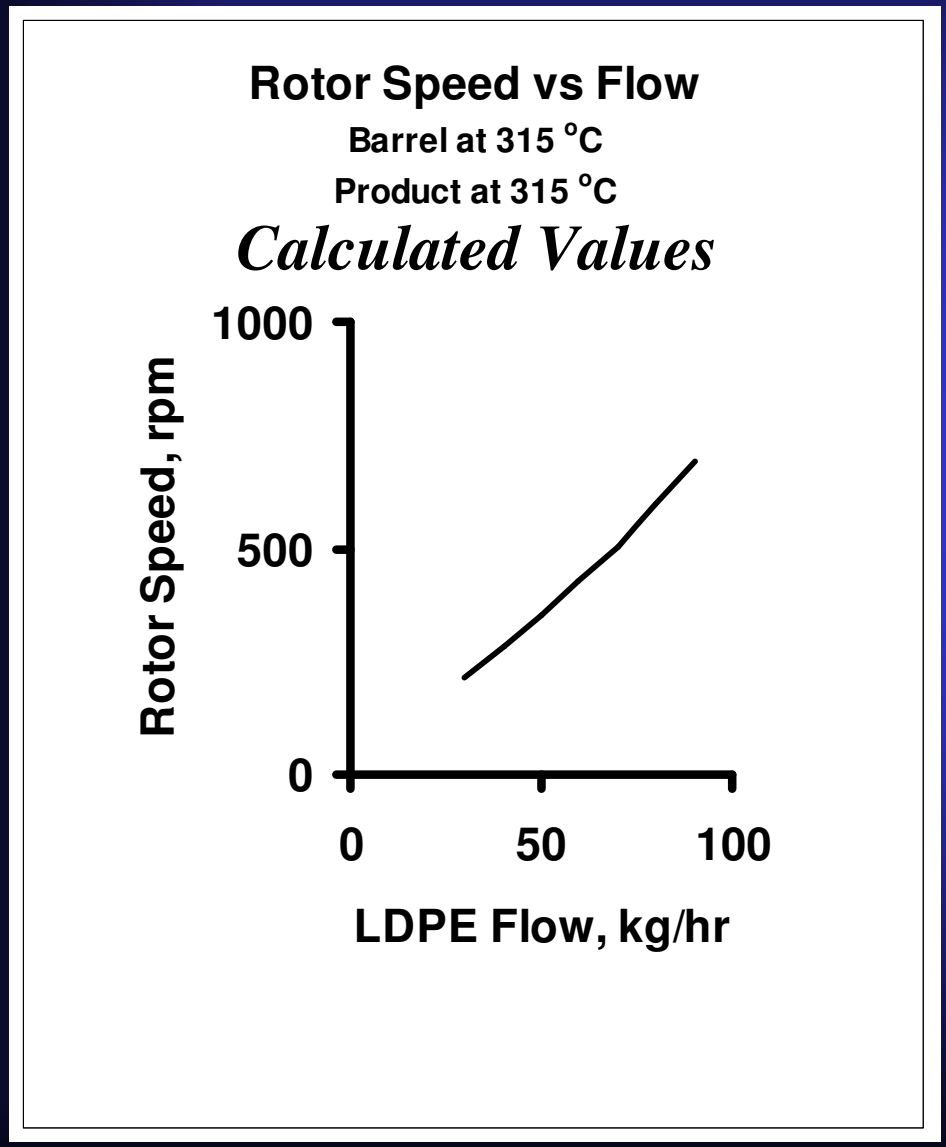
Temperature Control

(315-260)/(750-150) ~

0.1 °C/rotor rpm

Rotor direct drive or belt driven

Optimum Thermal Uniformity



Rate Versatility

Uniform thermal conditions over a flow range of over 2:1 are possible with reasonable rotor speeds.

Tandem Screw: Feedback Controls

- Drive 1 speed: Output pressure, rate
- Drive 2 speed: Product temperature

Tandem Screw: Advantages

Its relatively small size means smaller space requirements.

Tandem Screw: Advantages

Its smaller size (~1/2) lowers residence time by about 1/8.

Tandem Screw: Advantages

Its smaller size improves reaction time to control commands.

Tandem Screw: Advantages

Its smaller size lowers startup time or change-over time.

Tandem Screw: Advantages

Product temperature control by rotor speed provides much faster reaction time than by barrel temperature control.

Tandem Screw: Advantages

Make rotor hollow:

- **Minimize heat conduction for adiabatic operation**
- **Quicker thermal startup and response**

Tandem Screw: Advantages

Product temperature equal to barrel temperature and adiabatic rotor minimizes thermal gradients for optimum thermal uniformity.

Tandem Screw: Advantages

Rotor has no flights:

- **Uniformly distributed shear history**
- **No stagnant melt areas– uniformly distributed residence time and no places for degraded to build up.**

Tandem Screw: Advantages

A range of viscosities and rates can be efficiently processed with the same screw and rotor setup.

Tandem Screw: Advantages

The small simple screw and smooth rotor are inexpensive and easily changed.

Tandem Screw: Advantages

The high screw and rotor speeds require only belt drives, or they may be driven directly.

CONCLUSION

- **Small size,**
- **design simplicity, and**
- **fast, accurate, and uniform thermal response**

make the tandem screw extruder concept very attractive for many production operations.

CONCLUSION

- The feasibility of the tandem screw extruder concept has been demonstrated with a combination of data and modeling.
- The practicality of the tandem extruder needs to be developed and demonstrated with actual machine operation.

Extruder Tech, Inc.

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