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# TWIN SCREW REPORT

A technical review of compounding, devolatilization, reactive processing, foaming and direct extrusion via twin screw extruders



Leistritz manufactures High Speed, Energy Input (HSEI) twin screw extruders for compounding, reactive extrusion, devolatilization, foaming and direct extrusion, as well as providing a full range of technical services

Screw diameters range from 16 to 180 mm with rates from ¼ to 50,000 lbs/hr

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## The following is included in this e-tech-newsletter:

- Leistritz to host its' 40th Twin Screw Extrusion Workshop, December 2-3, 2009
- Comparative test data for ZSE HP series (1.55/1 OD/ID ratio) to ZSE MAXX series (1.66/1 OD/ID ratio)
- Technical paper: *Twin screw extrusion developments for processing masterbatches and compounds*
- Twin screw tip: Warm-up and cool down procedures to avoid degradation
- Upcoming exhibit/presentation schedule

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## Leistritz to host its' 40th Twin Screw Extrusion Workshop December 2-3, 2009

Leistritz will host its' 40th Twin Screw Extrusion Workshop on December 2-3, 2009. Since 1990, more than 4000 have attended Leistritz educational programs.

In addition to classroom sessions, a unique facet of the program is that classroom training is combined with "hands-on" twin screw extrusion operating experience. A partial list of topics is as follows:

- High speed, energy input (HSEI) twin screw extruder theory and design
- Comparison to low speed, late fusion (LSLF) designs
- Screw design and process techniques
- Techniques for dispersive and/or distributive mixing
- Sequencing of multi-stage process operations
- Devolatilization process techniques and practices
- Scale-up of the twin screw extrusion process
- Feeder and materials handling for pellets, powders and liquids
- Gear pumps and screen changers
- Pelletizing: strand cut, water ring, and underwater
- Direct extrusion for sheet, film, fibers and profiles
- Reactive processing
- Process troubleshooting
- Control and monitoring options
- Screw assembly and disassembly
- Machine maintenance

## **New technology areas that will be covered include:**

- Processing of bioplastics
- Combining recycling and compounding - new opportunities
- Nano-compounding of pharmaceuticals and nano-composites

## **“Hands-on” demonstrations at Leistritz NJ process laboratory:**

- Co-rotating and counterrotating twin screw extruders
- Devolatilization of polymers
- Downstream addition of fillers, fibers and additives
- Direct sheet/film extrusion with gear pump front end
- Foam extrusion via gas injection

## **Outside speakers will include:**

- Keith Larson, ACS Group
- Chris Case, Reduction Engineering
- Pete Palmer, Wolock & Lott
- Tom Cunningham, Extrusion Technical Services
- Others to be added

**Dates:** December 2-3, 2009

**Place:** Classroom sessions are held at the Holiday Inn Select in Clinton, NJ. Equipment demonstrations are at the Leistritz Process Laboratory. Transportation is provided to/from the machine demonstrations.

**Cost:** \$780 (includes handout materials, lunches, and dinner on day 1)

To register for this program contact Sarah Scovens at 908/685-2333, X614 or e-mail [sscovens@alec-usa.com](mailto:sscovens@alec-usa.com).

**To download a registration form for the Twin Screw Workshop... [click here](#)**

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### **Comparative test data for ZSE HP series (1.55/1 OD/ID ratio) to ZSE MAXX series (1.66/1 OD/ID ratio)**

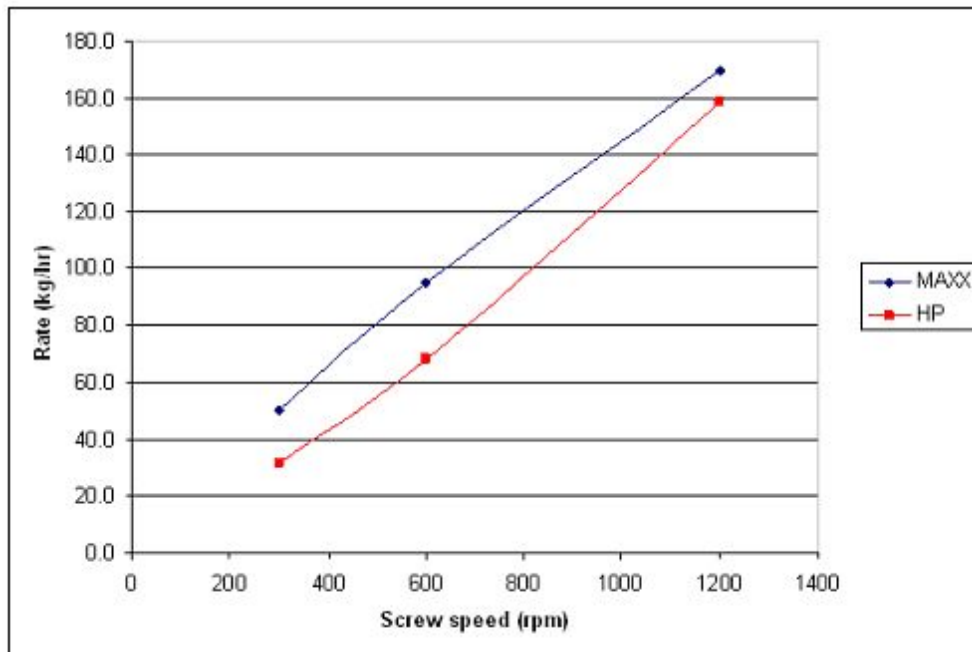
Free volume is an important design parameter for any HSEI twin screw extruder, and is directly related to the OD/ID ratio. The OD/ID ratio is defined by dividing the outside diameter (OD) by the inside diameter (ID) of each screw. The torque limiting factor for a HSEI twin screw extruder has historically been the cross-sectional area of the screw shaft. Deeper screw flights result in more free volume, but with less torque, since a smaller diameter screw shaft is mandated.

Based on the use of a symmetrical splined shaft, a 1.55 OD/ID ratio has been deemed to offer the best balance of torque and volume. In 2004 a HSEI twin screw extruder series was introduced by Leistritz with a 1.66/1 OD/ID ratio without sacrificing torque. In Leistritz nomenclature its' HP series has a 1.55/1 OD/ID, and the MAXX series a 1.66/1 OD/ID ratio.

Experimental data has been generated comparing the HP to the MAXX series. HP and MAXX process sections are interchangeable and can be mated to the same gearbox/motor. Initial tests were performed with neat resins with ZSE-27 HP and MAXX models with a 40/1 L/D process

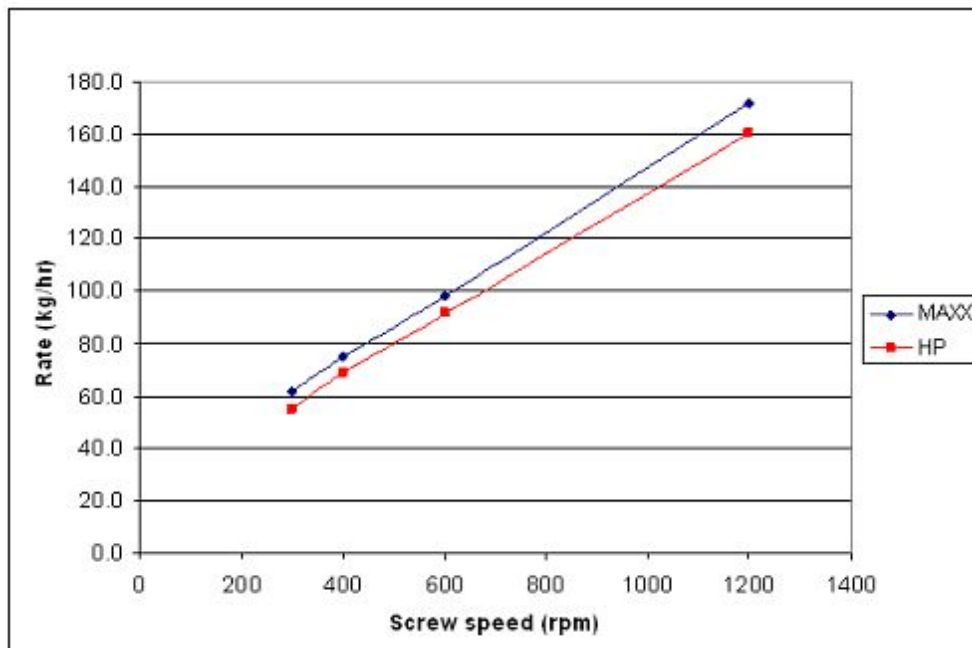
section and 50 HP motor:

**LDPE Powder:** LDPE powder feedstock with a 12 MFI was processed on ZSE-27 HP (27 mm dia. screws) and MAXX (28.3 mm dia. screws) models. The 1.66/1 OD/ID ratio made it possible to feed more material to the extruder before encountering feed limitation. In each instance, the rate limiting factor was the volumetric feed capacity of the feed throat. The process was not torque limited. Melt temperature was also significantly lower.



Rate Comparison: MAXX vs HP for 12MFI PE Powder

**PLA pellets:** PLA (Natureworks 2002D) processed at approximately 10% higher rates with lower melt temperatures on the ZSE-27 MAXX as compared to the HP. All samples were torque limited, not feed limited. It is probable that the melting mechanism inherent with the MAXX design allowed the slightly higher throughputs with a lower melt temperature.

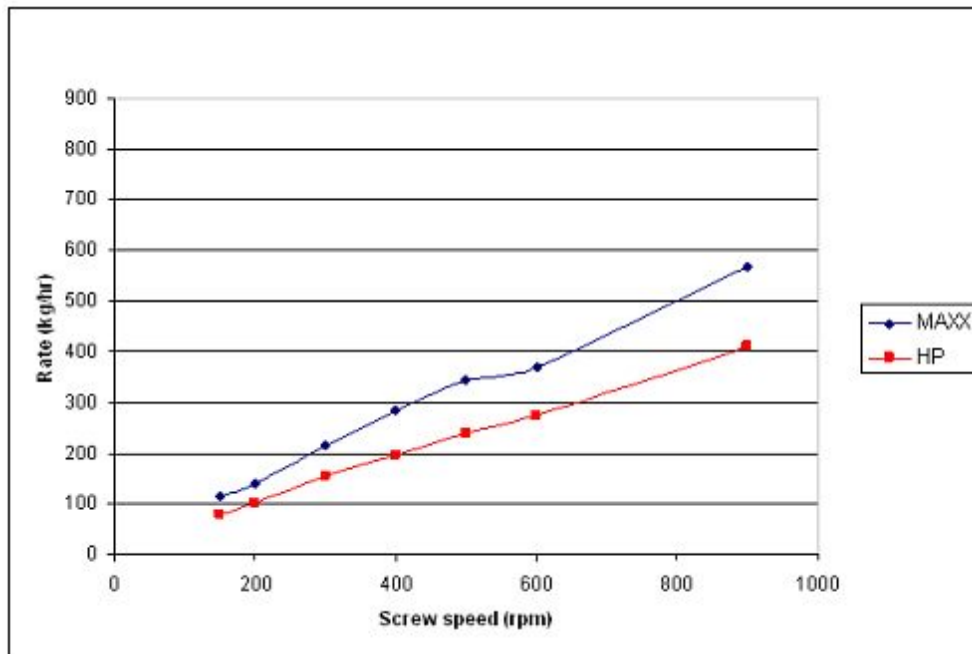


Rate Comparison: MAXX vs HP for PLA

Subsequent tests were performed comparing the ZSE-50 HP (1.55 OD/ID ratio and 1570 NM torque rating) and ZSE-50 MAXX (1.55 OD/ID ratio and 2144 NM torque rating) models with the

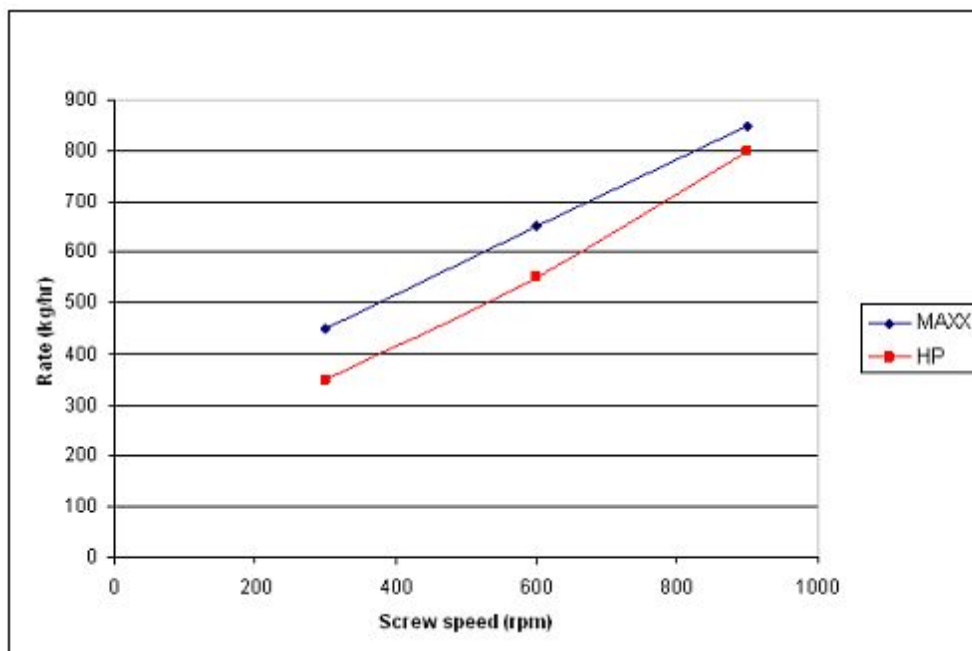
following results:

**Fractional melt HDPE with carbon black masterbatch:** Both pellet feed streams were metered into the main feed throat of a ZSE-50 HP (50 mm dia. screws) and ZSE-50 MAXX (51.2 mm dia. screws) models via loss-in-weight feeders. The ZSE-50 MAXX was able to process approximately 40% more throughput rates with equal or better end product mechanical properties. All rates were torque limited.



Rate Comparison: HDPE with Carbon Black Masterbatch

**Split feed highly filled masterbatch:** A formulation of 15% PP/additive and 85% CaCO<sub>3</sub> was processed on ZSE-50 HP and MAXX models. The PP/additive was metered into the main feed throat. The CaCO<sub>3</sub> was introduced sequentially into the main feed throat and via two (2) downstream side stuffers. The ZSE-50 MAXX processed this formulation with approximately 10 to 30% higher throughput rates. All rates were volume limited.



Rate Comparison: PP with 85% CaCO<sub>3</sub>

**Technical paper is available:** “*Twin screw extrusion developments for processing masterbatches and compounds*” that describes in more detail the HP and MAXX technologies and the above tests.

To download this paper... [click here](#)

Both ZSE HP and MAXX technologies are available for testing in the Leistritz New Jersey process development laboratory.

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### **Twin screw tip: Warm-up/cool down procedures to avoid degradation**

**Warm-up:** Extrusion users sometimes tend to keep the machinery hot, all the time. Operators often turn the heat zones on the minute they come in the plant at 7:00am. If you're really going to start the extruder at 8:00am, there's nothing wrong with this. But many times the extruder sits idle and is heated to full operating temperature for hours at a time.

This is not a recommended practice because it allows polymer to bake onto the screws and barrels. Once baked, the material will continue to degrade and carbonize. Purging will not remove this material. Even worse, as the extruder is running product, black specks will periodically flake off the screws and barrels, contaminating the product and causing customer complaints.

The best way to handle warm-up is to plan the extruder starting time and then start heating up only as far ahead of this time to allow for complete warm-up plus adequate soak time.

**Cool-down:** There are also preferred shutdown procedures to avoid problems with black specks. Before shutting the extruder down, it's good practice to fill the extruder and die to the maximum degree of fill with some inert polymer, such as HDPE, to “seal” the machine. The HDPE displaces oxygen, and coats the metal surfaces to greatly slow down oxidation and formation of carbon.

After the extruder has been “sealed”, it is better to crash cool the machine, rather than let it cool from ambient air. A crash cool involves turning all the temperature setpoints down to zero, to force the cooling solenoid valves to open to force cool barrel coolant through the barrels, bringing the temperature down quickly. A quick cool-down also doesn't give the polymer a chance to degrade and carbonize.



Close-up barrels cooling assembly

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## Industry events where Leistritz will participate

- Color and Appearance RETEC- 10/18-20/2009, Savannah, GA; presentation by Charlie Martin entitled, "Twin Screw Extrusion Developments for Colors and Compounds", tabletop display
- MassPLASTICS- 10/21-22/2009, Fitchburg, MA; 10' display
- SPE Extrusion Minitex- 10/22/2009, Pennsylvania College of Technology, Williamsport, PA; Presentation by Charlie Martin entitled "Twin Screw Extrusion Theory and Developments"
- AAPS- 11/9-11/2009, Los Angeles, CA; 20' display w/ extrusion system demo

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