

SER Universal Testing Platform

The Power of Extensional Rheology and Broad-Range Physical Material Testing in the Palm of Your Hand



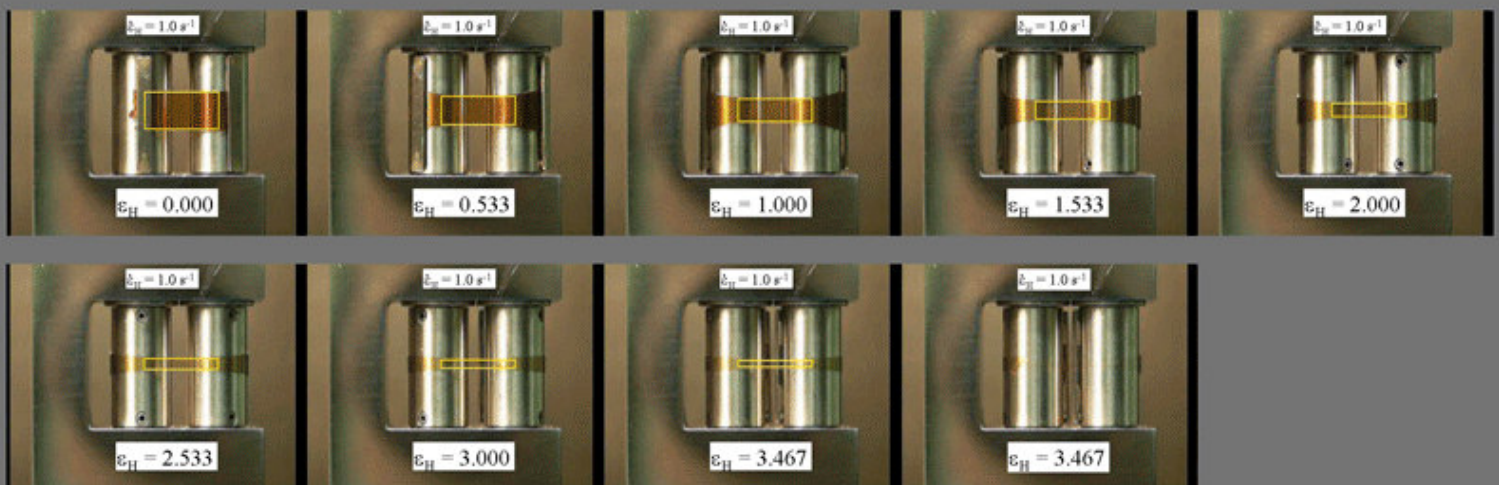
SER Universal Testing Platform...

The New Paradigm in Extensional Rheology

The SER (Sentmanat Extensional Rheometer) Universal Testing Platform available exclusively from Xpansion Instruments represents the new paradigm in extensional melt rheology and a breakthrough in the field of physical material characterization technology. The unique patented technology (US Pat. No. 6,578,413 & 6,691,569) first developed by Dr. Martin Sentmanat in his pioneering work at The Goodyear Tire & Rubber Company incorporates dual wind-up drums that allow for a truly uniform extensional deformation during material testing. Although first developed for use in characterizing the physical behavior of polymeric materials in uniaxial extension, the SER is not just an extensional rheometer. From extensional melt rheology to solids tensile, tear, fracture, peel, and friction testing, this miniature unit's unparalleled performance and capabilities can help you cover the broad spectrum of your physical material characterization needs.

Unique Patented Technology

The unique dual windup drum design of the SER allows for a truly uniform and controlled extensional deformation in a fixed plane of testing, which allows for easy strain validation and continuous visual access to the sample during the material deformation process. Because the deformation remains in a fixed plane at all times, other experimental visualization techniques such as flow birefringence and x-ray/neutron beam scattering can be incorporated with the SER regardless of the mode and kinematics of material deformation.

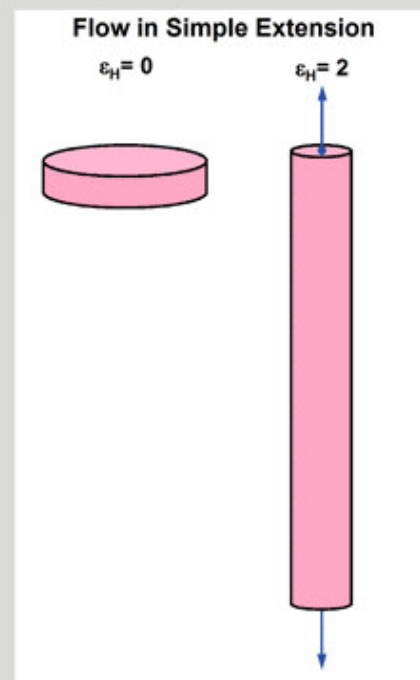
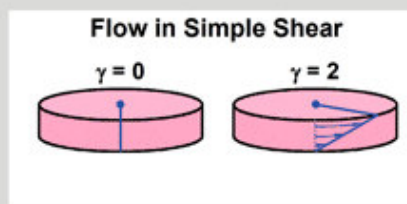


The superposition of the theoretical width evolution (shown as a yellow box) over the actual sample width evolution illustrates the true control of extensional deformation with the SER. The ease of sample deformation visualization and strain validation with the SER is also clearly demonstrated because the extensional deformation remains in a fixed plane.

Deformation Visualization AT ALL TIMES.

The Power of Extensional Rheology

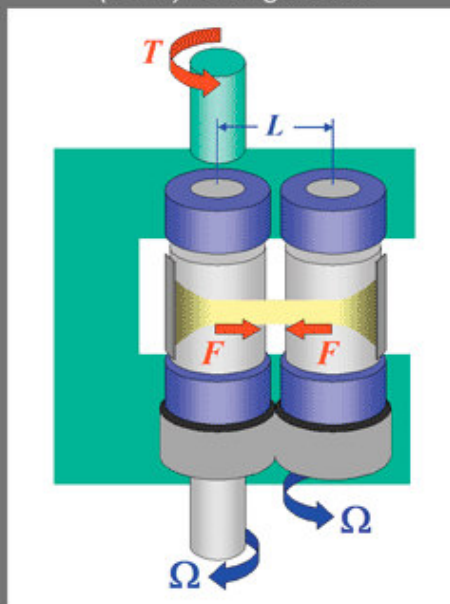
Flows in simple extension are said to be “strong” in the sense that they can generate a much higher degree of molecular orientation and stretching than flows in simple shear. Shown here are simple shear and extension deformations at an applied strain of magnitude 2 for samples of identical initial dimensions. As a consequence, extensional flows are very sensitive to crystallinity and macrostructural effects such as polymer long-chain branching. High-rate, transient extensional flow is also the dominant type of deformation in converging, squeezing, and stretching flows that occur in typical polymer processing operations. Although these types of transient extensional flow measurements have historically been difficult to perform on polymer melts, the revolutionary technology embodied in the SER Universal Testing Platform marks a true breakthrough in the field of polymer melt extensional rheology. Most notably, recent studies with the SER [*Rheol Acta* (2004) 43: 624–633; *Rheol Acta* (2005) 44: 1–15] have revealed the important role of high-rate extensional flow behavior in polymer melt processability, fracture, and flow instabilities.



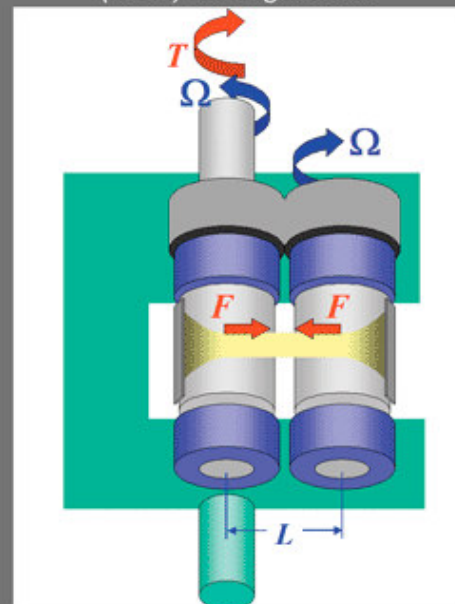
The SER Principle

The ends of a specimen are secured to the surfaces of two windup drums, such that for a constant drum rotation, Ω , a constant Hencky strain rate is achieved. As the specimen is stretched across the drum surfaces, it offers a resistant force, F , on the windup drums that translates into a torque, T , about the primary axis of rotation. Hence, for a given rate of extensional deformation, the measured torque signal is directly related to the extensional viscosity of the specimen being stretched in the isolated ‘stretch zone’ of length L defined by the tangent plane between the drums.

Controlled Rate Rheometer (CRR) Configuration



Controlled Stress Rheometer (CSR) Configuration



By virtue of its unique design and the fact that the specimen deformation zone remains in a fixed plane regardless of the kinematics of deformation, the SER can be used on rheometers comprised of a separate motor and transducer (CRR) or a single motor/transducer (CSR) module.

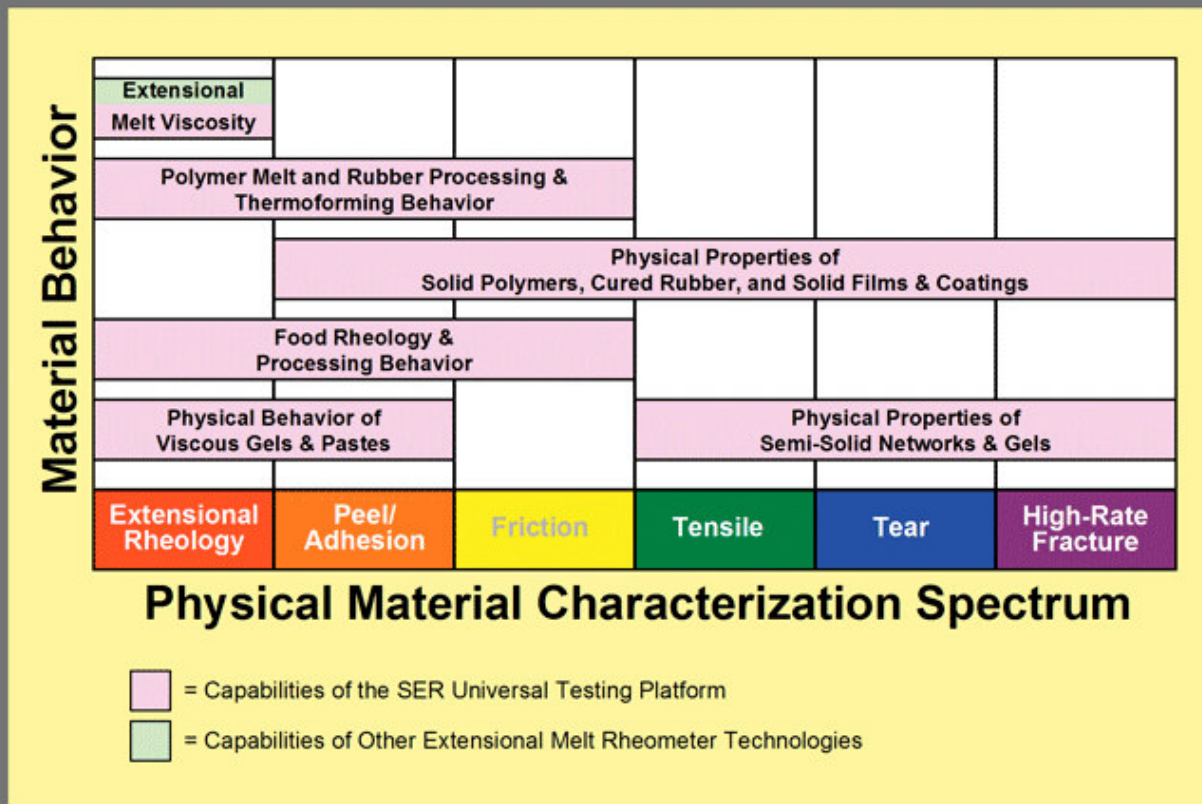
SER Technology... Performance in Controlled Rate AND Controlled Stress Modes of Operation.

Unleash The Full Potential of Your Rotational Rheometer System

Far more than just an extensional viscosity fixture, the SER Universal Testing Platform can transform your conventional rotational rheometer system into a multi-tasking test station capable of covering an unprecedented breadth of the physical material characterization spectrum. Whether its extensional melt rheology, peel/adhesion, friction, solids tensile, tear, or high-rate fracture testing, the SER can characterize the physical properties of complex polymeric materials and compounds from the molten state to the solid state.

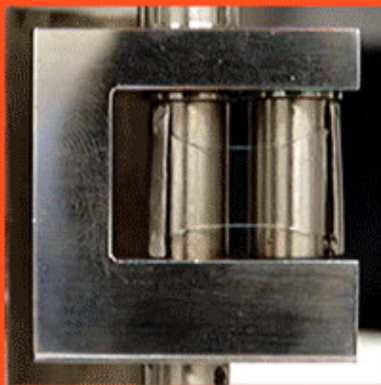
SER Multi-Tasking Performance

Although extensional rheology can provide valuable insight into polymer macrostructure and melt behavior, the characterization of extensional melt viscosity alone does not provide a comprehensive glimpse into a material's overall processing and physical behaviors. Because the SER can characterize such a broad range of physical behaviors of a material from the melt to the solid state, this miniature platform is capable of providing a comprehensive assessment of both melt processing and finished product material properties.



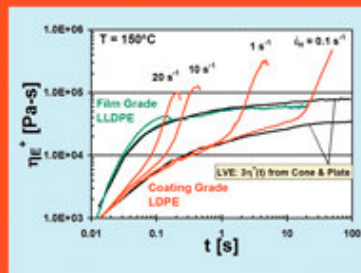
More Than Just An Extensional Viscosity Fixture...

A Multitude of Applications

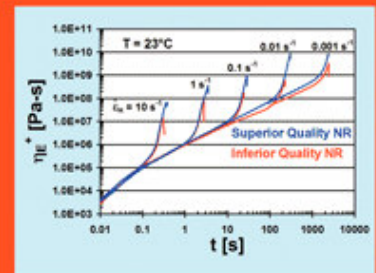
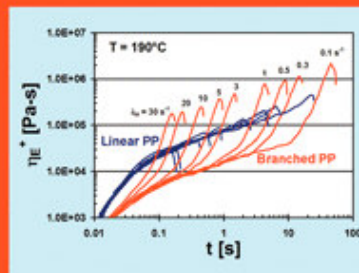


Extensional Rheology

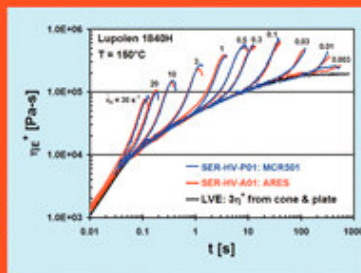
The miniature SER fixture can be easily attached to the rotational rheometer host station and configured to operate with the existing control software. By controlling the motor rotation and operating temperature of the host station, the SER can be used to characterize extensional melt flow. As illustrated by the data, the SER is a robust yet sensitive instrument capable of characterizing the flow properties of ultra high viscosity elastomers and low viscosity polymer melts.



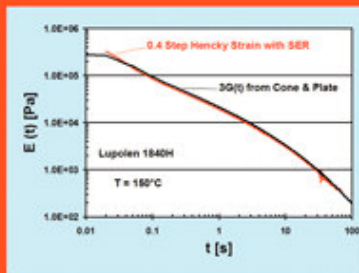
Differences between linear and branched polymer architectures are clearly evident from the melt tensile stress growth data. Note the broad span of rates and how the low strain portions of the tensile stress growth curves superpose with the linear viscoelastic envelope defined by the plot of 3 times the shear stress growth curves taken from cone & plate measurements.



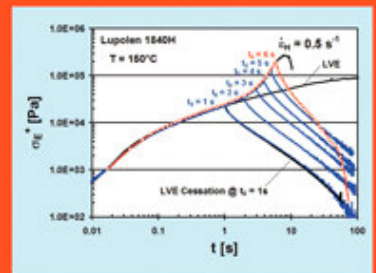
Even subtle differences in polymer architecture that are often difficult to detect from shear rheology data are clearly evident from extensional data.



Regardless of the host platform being used, the SER provides accurate and consistent results over a very broad range of rates and melt viscosities.



Although historically difficult to perform, the tensile stress relaxation modulus of polymer melts can be easily and directly determined from step extension experiments.



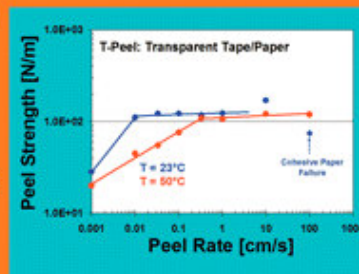
Cessation of extension experiments are useful in determining the strain dependence of relaxation behavior and in studying the onset of elastic melt instabilities.



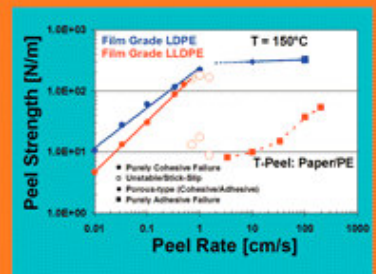
Peel/Adhesion Testing

The peel fracture front is confined to the region between the drums.

The SER can also be used to measure the adhesive properties of pressure sensitive adhesives, gels, and pastes against a variety of substrates over a very broad range of rates and temperatures. Using this same 180° peel geometry the SER can be used to measure the work of adhesion and the onset of cohesive/adhesive instabilities of polymer melts against various surface energy interfaces.



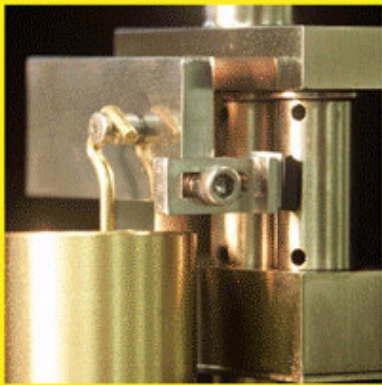
The peel properties of pressure sensitive adhesives can be characterized as a function of substrate, temperature, and rates unachievable with conventional testing.



The peel properties of polymer melts can be used to fingerprint polymer melt processing behavior and to elucidate the role of adhesive failure in melt processing instabilities.

A Broad Range Multi-Tasking Test Platform.

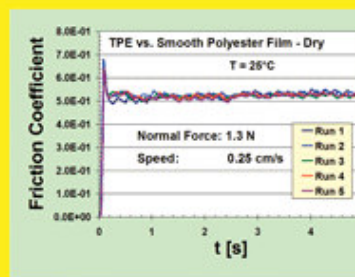
Miniature Scale Solids Testing



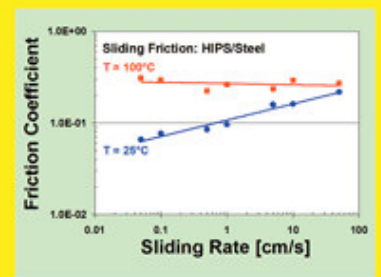
Friction Testing

Normal force is controlled with the use of weight on armature.

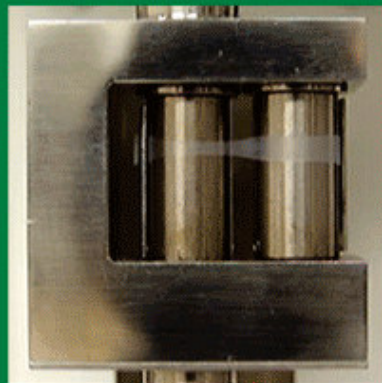
With the use of the friction armature attachment that comes with the SER, the dynamic slip/friction properties of solid and semi-solid media can be easily evaluated as functions of interfacial contact surface, rate, normal force, environment and temperature. Because of its miniature size, very small-scale friction testing at rates relevant to processing and product application is now achievable.



The friction properties of solid materials used in dynamic sealing/gripping applications can be characterized against substrates and/or coated surfaces at conditions relevant to end use.



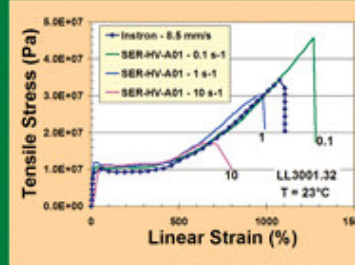
Friction coefficients of solid/polymer interfaces can be characterized over a very broad range of rates and temperatures relevant to polymer processing operations such as thermoforming.



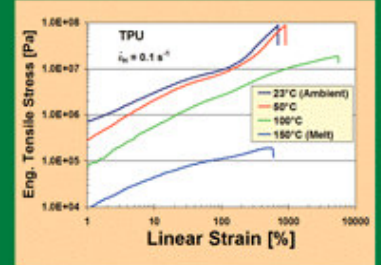
Tensile Testing

Sample necking and fracture are confined to the stretch zone.

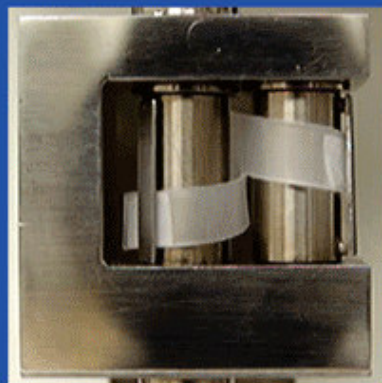
The SER can also be used to perform tensile testing on elastic solids and semi-solids over a very broad range of true strain rates unachievable through conventional testing methods. The tensile properties of complex polymeric materials may also be characterized over a wide range of temperatures from the solid state to the melt state on miniature samples weighing just a few milligrams.



The broad range and high speed tensile rates achievable with the SER clearly reveal the rate dependent tensile behavior of crystalline polymers not observable with conventional testing.

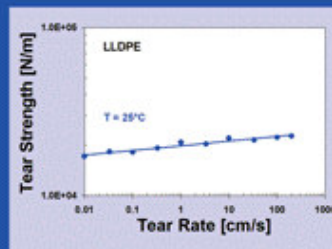


The tensile behavior of rheologically complex materials can be characterized from molten, to softened, to solid state in order to evaluate the strain dependence of crystallization.

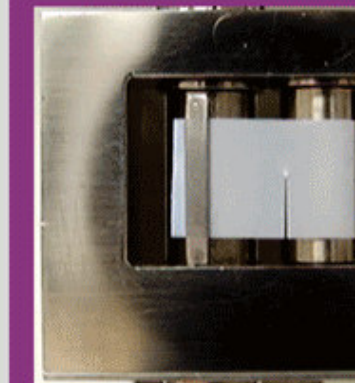


Tear Testing

The sample tear site is confined to the region between the drums.

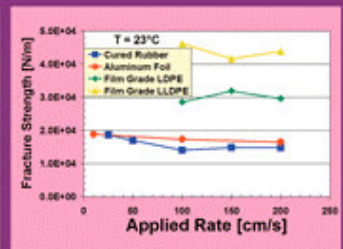


The tear behavior of solid materials can be characterized in pure shear (trouser tear) as a function of temperature at rates unachievable with conventional testing.



High-Rate Fracture

Sample fracture is isolated to the region between the drums.



The fracture behavior of thin gage solid polymers, cured rubber, composites, and metals can be characterized at rates unachievable with conventional testing.

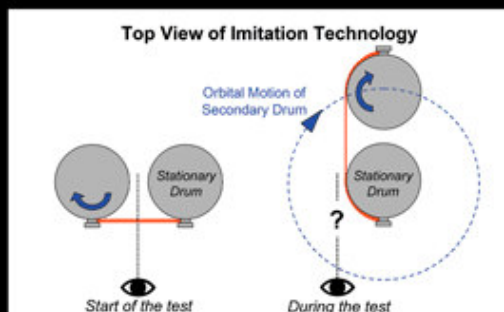
**Coming Full Circle in Material Characterization
... Bridging the Gap From Molten to Solid State.**

The SER Advantage

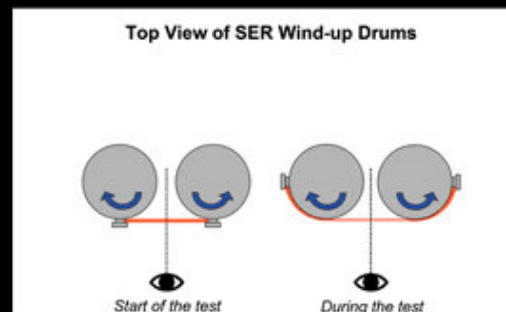
As described in various publications and worldwide patents dating from 1998, the SER Universal Testing Platform marks a true breakthrough and paradigm shift in the field of melt rheometer technology. Not only has the SER created a buzz of excitement in the world of melt rheology but in the world of physical material characterization technology as well. However, looking to capitalize on the early and proven success of the SER, an imitation technology has recently been introduced that is non-coincidentally similar in appearance but far less capable than the SER. As described below, the SER offers significant performance advantages over this imitation technology.

SER Advantage #1: Deformation Visualization

The imitation technology is incapable of a very important feature that is critical to all rheological measurements: **strain validation**. In an attempt to circumvent the U.S. and worldwide patented technology embodied in the SER, this imitation technology incorporates a secondary wind-up drum that orbits around a stationary wind-up drum, akin to the orbital motion of the moon relative to the earth. Unlike the SER fixture that remains fixed while only the drums rotate, the imitation fixture assembly twirls around within the oven and with its exposed gears presents a serious safety hazard to the skin and hands of the user operating anywhere near the fixture. Although the drum dimensions, securing clamp design, and sample geometry of this imitation technology are non-coincidentally identical to that of the SER, as a consequence of said orbital motion, the user has no clear access to the twirling sample as it undergoes deformation and hence real-time validation of the applied Hencky strain is near impossible.



The imitation technology has a rotating plane of deformation making real-time sample visualization and strain validation near impossible.



The SER has a fixed plane of deformation allowing for easy real-time sample visualization and strain validation AT ALL TIMES, which makes in-situ laser light, x-ray and neutron beam scattering possible during sample deformation.

Because only the drums of the SER rotate, the deformation zone remains in a fixed plane and the **sample deformation can be visualized AT ALL TIMES** regardless of the kinematics of deformation, whether the SER is used in extensional melt rheology mode, solids tensile, tear, high-rate fracture, friction, or adhesion/peel testing modes. Most notably, sample visualization is critical with the flow and deformation of any non-homogeneous polymer melt blends and compounds, semi-solid networks, and solid composite materials where the assumption of bulk deformation uniformity is typically invalid due to the localized regions of strain deformation within the sample. Additionally, because the deformation remains in a fixed plane, only the SER can be utilized with optical characterization techniques such as flow birefringence and laser, neutron beam & x-ray light scattering during an experiment regardless of the mode (melt or solid) and kinematics (uniaxial extension, tear, peel, or high-rate fracture) of deformation.

Accept No Imitation.

SER Advantage #2: Adaptability

Another critical shortcoming of the imitation technology lies in the fact that because the primary and secondary drums are completely de-coupled, the imitation fixture can only be used on a rotational rheometer in which the torque transducer and motor are completely separate. Thus, the imitation fixture CANNOT be used with a controlled stress/strain rheometer – it can only be used on one platform, the TA/Rheometrics ARES rheometer which is the only controlled strain rheometer still left on the market. As has been described in several publications, the **SER can be accommodated onto a multitude of host rheometer systems of either controlled strain or controlled stress/strain design**. Hence, as new rheometer technologies are acquired in favor of or alongside other legacy rheometer systems, the SER can be easily adapted to accommodate the available laboratory rheometer equipment.

SER Advantage #3: No Lateral Loading of Torque Transducer

Because its primary and secondary drums are de-coupled, ANY deformation with the imitation technology inherently places a potentially damaging lateral loading condition on the host rheometer's torque transducer. Due to the fact that the moment arm of the dangling stationary drum is much larger than the drum's radius, the torque transducer signal is sensitive/susceptible to lateral loads particularly if a Bendix-type transducer is being used. Additionally, since the imitation fixture assembly twirls around with the motor, this lateral loading effect is typically translated non-symmetrically about the axis of the torque transducer as a function of motor rotation. Thus, factoring out these lateral load effects from the "true" torque signal response presents a host of concerns, particularly at high rates of deformation and at elevated stretching forces. Because the primary and secondary windup drums of the SER are housed within a rigid chassis, the **SER places NO such lateral load condition on the torque transducer**. Hence, unlike the imitation technology that is limited to low tensile stress applications, the SER is capable of not only characterizing the extensional flow behavior of low viscosity polymer melts but is capable of measuring the physical behavior of high modulus solids.

SER Advantage #4: Versatility

Another clear distinction of the SER's performance advantages lies in its remarkable versatility. Unlike the imitation technology, the **SER is far more than just an extensional viscosity fixture**. The SER's broad spectrum of physical material characterization capabilities allows the user the luxury and freedom to pursue much more, **from extensional melt rheology to solids tensile, tear, peel/adhesion, friction, and high-rate fracture testing**. The SER is an extremely versatile, miniature device that can do anything a conventional linear test frame can do with solids but at rates ORDERS OF MAGNITUDE higher and with samples weighing just a few milligrams! Because of its broad performance capabilities, the SER eliminates the need for expensive testing instruments and platforms that are far less capable with regard to rates of deformation and physical material characterization capabilities. The SER's breadth of capabilities with regard to extensional melt flow rheology characterization is showcased when hosted on a controlled stress/strain rheometer such as the Anton Paar MCR501: transient extensional viscosity and cessation of extension results in the controlled rate mode of operation over a very broad range of Hencky strain rates is clearly exceptional, but tensile creep measurements in the controlled stress mode of operation even at low tensile creep stresses is remarkable.