The Aoki Katashi Award

SPIRAL LOGIC won the 2010 Aoki Katashi Award
from the Japan Society of Polymer Processing

**T-Rex Unit can be installed in
Sumitomo's SE-DUZ series of fully electric IMM**

T-Rex16
T-Rex22
T-Rex32
T-Rex45

SE18DUZ
SE30DUZ
SE50DUZ
SE75DUZ
SE100DUZ
SE130DUZ
SE180DUZ

T-Rex Unit
Non-compression Melting Screw

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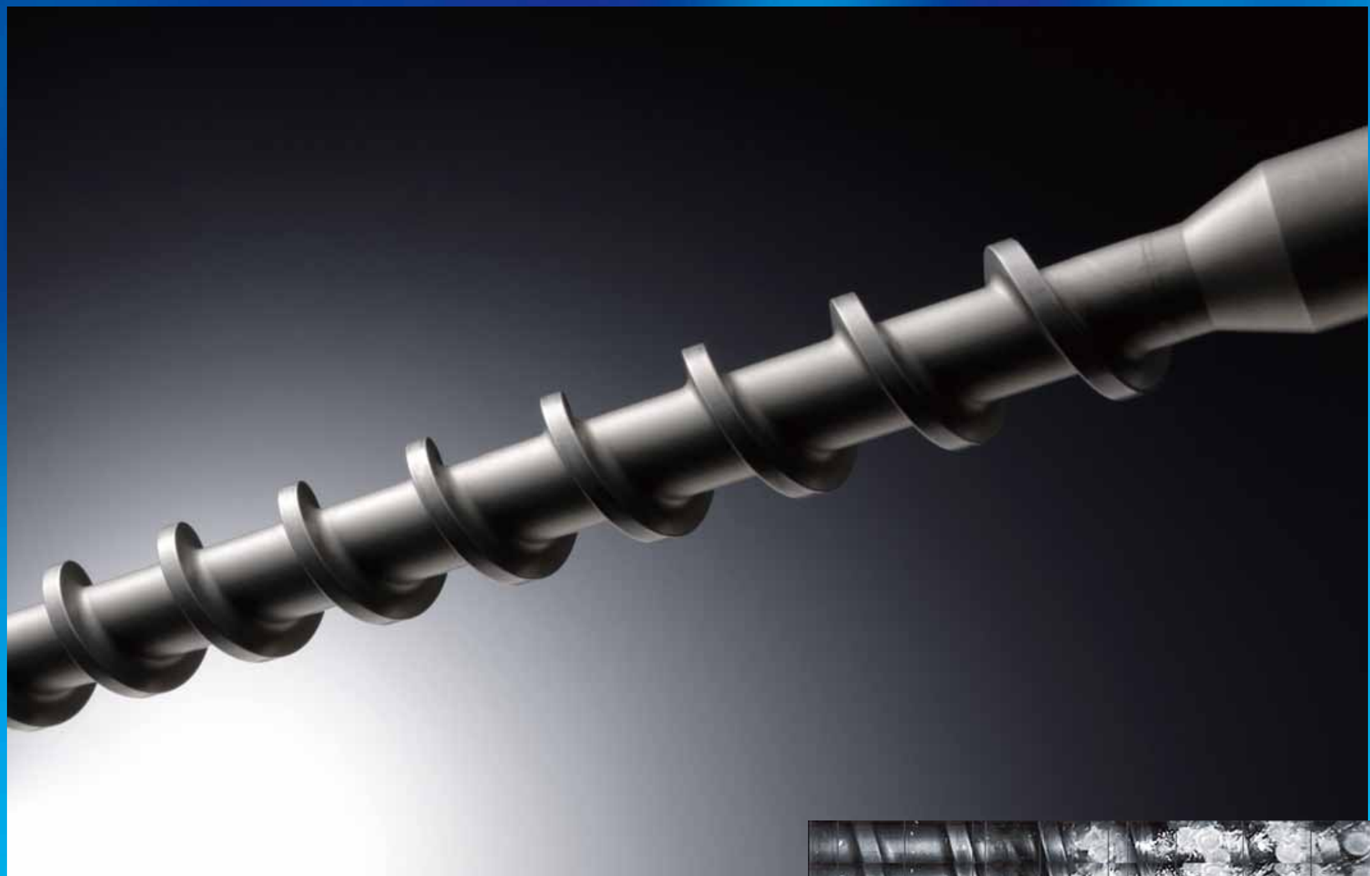
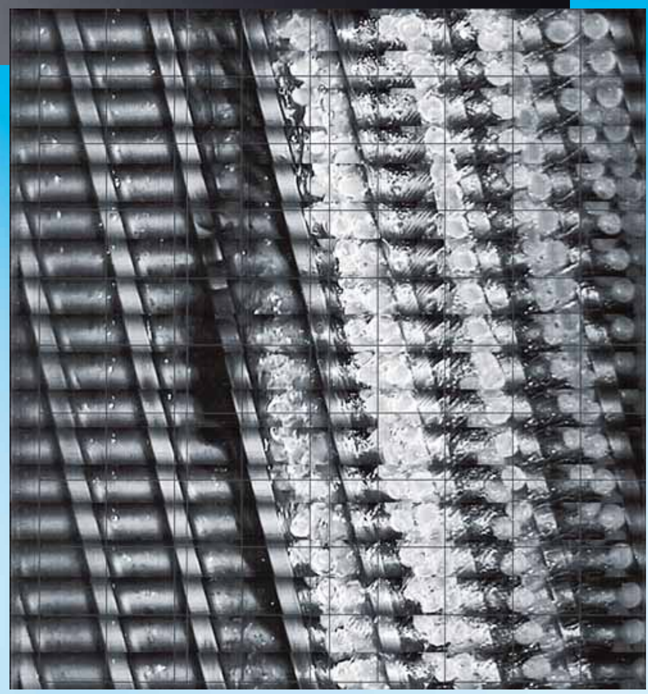
2012-02

SPIRALLOGIC
TECHNOLOGY & EVOLUTION

The SPIRAL LOGIC Melting Model

Not just an improvement,
but *A REVOLUTION* that will change the plastics world





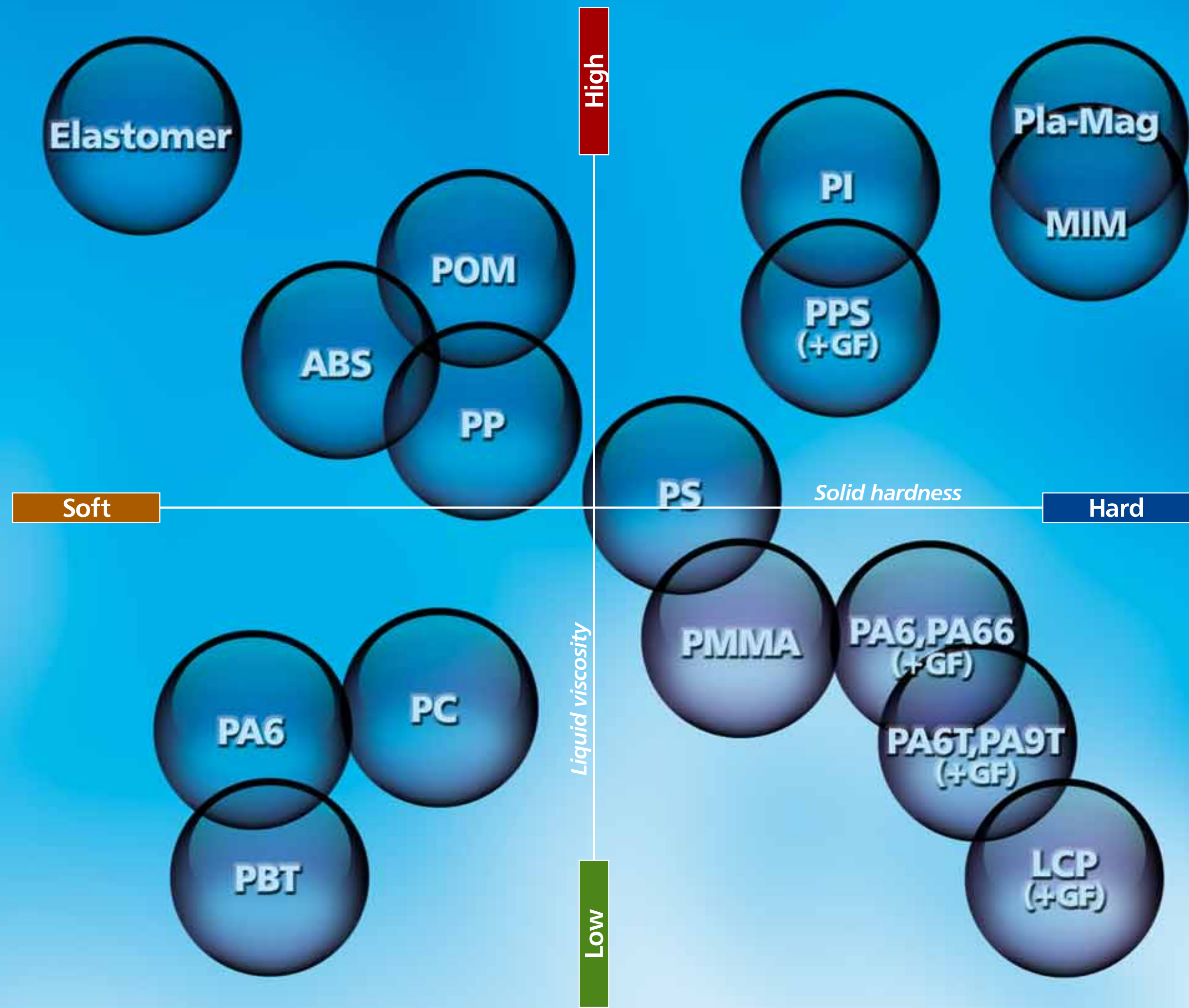
The Dynamic Uni-Layer Melting Model

For half a century, shear heating was believed to be the main melting method for plastics processing. The SPIRAL LOGIC screw design breaks this old standard by eliminating the need for a compression zone.

This design's high efficiency was proven by implementing The Sapphire Window Barrel which allows direct, real-time observation of the melting process. You can see the result, to the right, as a black pellet is melted and stretched among transparent pellets.

Material Matrix

SPIRAL LOGIC has also broken away from the old standard of designing plastics equipment based on one material, Polystyrene (PS). Engineering grade plastics include far too many variations to ignore their different processing requirements. For example, LCP has a very low viscosity and a very hard pellet. But elastomers are just the opposite. This presents significant challenges in processing a wide variety of materials with one machine design using a reciprocating screw.



Typical Problems

Using high viscosity material

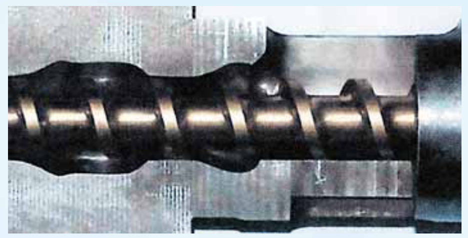
The screw head is easily worn because of the high pressure on the check ring.

Using soft pellet material

The soft pellets can easily jam under screw flights in the feed zone causing unstable plasticizing.

Using hard pellet material

The hard pellets can be squeezed in the feed zone causing barrel wear.



Using low viscosity material

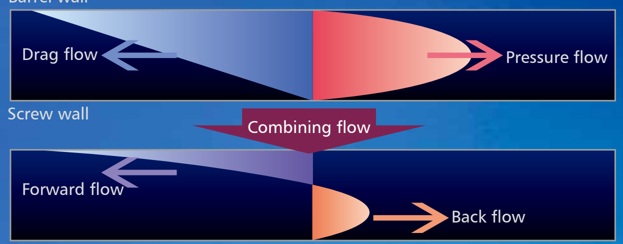
The difference in the speed of the plastic melt and the solid pellets can cause material throughput congestion.

SPIRAL LOGIC is not a step, but a leap forward to the new standard in plastics

It provides real-time melt flow quality control freeing the processor of typical chronic problems

Black Spot

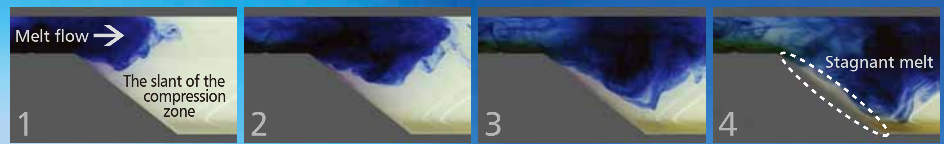
Typically the result of a pocket of stagnant material in the barrel degrading to the point of becoming carbon and breaking loose and entering the product.
SPIRAL LOGIC testing has shown degraded material build-up consistently forms in the compression zone of traditional screw designs. This indicates how the material flow is too slow or stagnant on the screw surface and results in degradation and black spots in the product.



Channel fluid flow
Screw rotation creates a drag flow down the screw channel, shown in blue. Pressure generated by material movement down the channel in turn causes a pressure flow backwards along the channel, shown in red.

Screw channel combined melt flow
Combining these two flows shows the resulting flow along the screw channel axis. This shows how all of the melt does not flow down the channel. The flow next to the screw moves backwards.

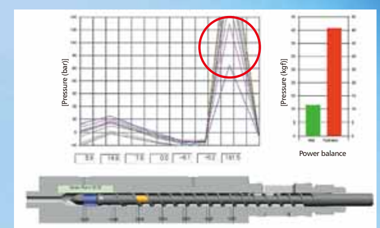
Comparison of the screw
The traditional screw (Top) and T-Rex Screw(Bottom) under the same molding conditoins. The black spots caused by degradation around the compression zone could never be created by T-Rex Screw.



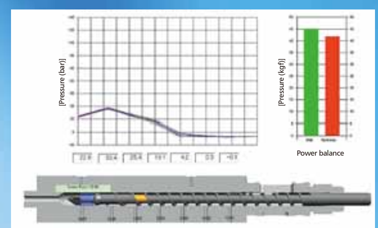
Analysis by a water flow simulation
The back flow pressure in the screw channel reduces when flowing backwards in the compression zone. This allows the melt to remain on the screw surface, degrade, and later break free into the product.

Random Short Shot

One traditional problem related to engineering grade plastics is producing the random short shot molded product. This chronic random problem can be as frequent as one defect per hour or one per day and is often thought to be connected to the reciprocating screw design in most injection molding machines.
SPIRAL LOGIC process analysis has developed data comparing conventional equipment (left) and our new melting model design (right). Free feeding material and miss-matched material speeds in the melting and feeding zones causes a large pressure rise in the feed zone. This can cause the pellets to compact and act like a nut on a rotating screw. This pressure results in the screw retracting based on the feed zone solid material pressure and not the melted material pressure in front of the screw head. This causes a large variation of the melt pressure as shown at the left side of the left graph. This fluctuation is the root cause of the random short shot.
As you can see in the right graph, the SPIRAL LOGIC design eliminates this random problem by controlled feeding with the GS Loader. Controlled feeding matches the pellet input with the melted material speed, eliminates the feed zone pressure spike and stabilizes the melt pressure from shot to shot. No more random short shot!

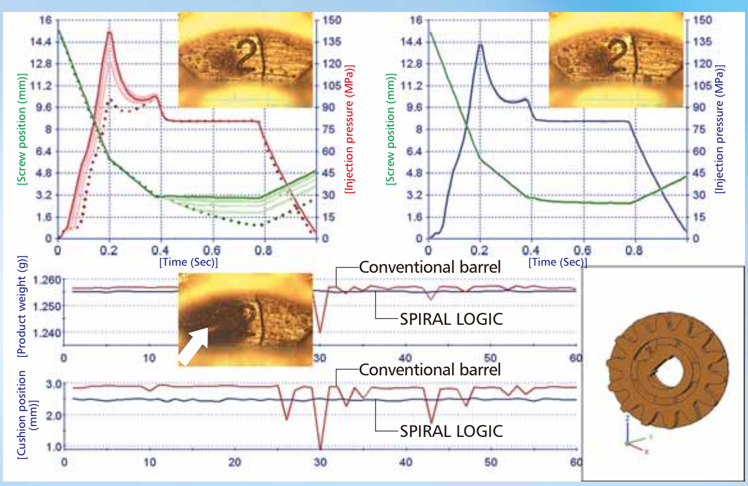


The conventional barrel
Free feeding. A large pressure rises (Red circle).



T-Rex Barrel by SPIRAL LOGIC
GS Loader feeding. Smooth and equal pressure.

Case Study: Injection molding PC gear, 60 consecutive shots
This graph compares the conventional design (left) and the SPIRAL LOGIC design (right) overlaying the cushion position and injection pressure data. The conventional design shows how the melt pressure variation during plasticizing results in significant injection pressure and cushion position variations shot to shot. The lowest curve is the 30th shot and the short shot defect pictured. The SPIRAL LOGIC design provides consistent melt pressure resulting in extremely stable injection pressure and cushion position shot to shot. This is the SPIRAL LOGIC REVOLUTION!



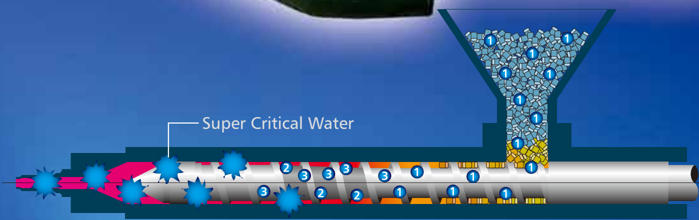
Barrel Wear

The damaged barrel by glass fiber filled material

In conventional barrel design, pellets are free fed without restriction. If the material speed in the feed zone is not matched with the melt zone, high pressures and barrel wear can result in wearing the feed zone out of control. The damaged barrel shown is an example of this wear when using glass fiber filled material.
SPIRAL LOGIC design incorporates the GS Loader to control the material rate entering the feed zone and eliminate this wear problem.

Screw and Barrel Corrosion

One serious problem molding high performance plastics like Nylon can be screw and barrel corrosion. The conventional thinking is this is caused by corrosive gas in the pellets.
SPIRAL LOGIC has found the cause is actually Super Critical Water. Water at a temperature over 374 degree C and pressure over 22.1 MPa becomes Super Critical which has strong acidic characteristics, becomes highly destructive and high density water molecules attack the screw and barrel.
Even after ideal drying, Nylon can still contain 0.02% moisture, which is equal to 200 cc when processing 1,000 kg. RoHS restricts halogen flame retardant and the magnesium hydroxide replacement easily decomposes to magnesium oxide and water. Also, conventional barrel design allows free feeding of material which results in a column of material above the feed zone and restricts the air flow from the screw up through the material hopper.

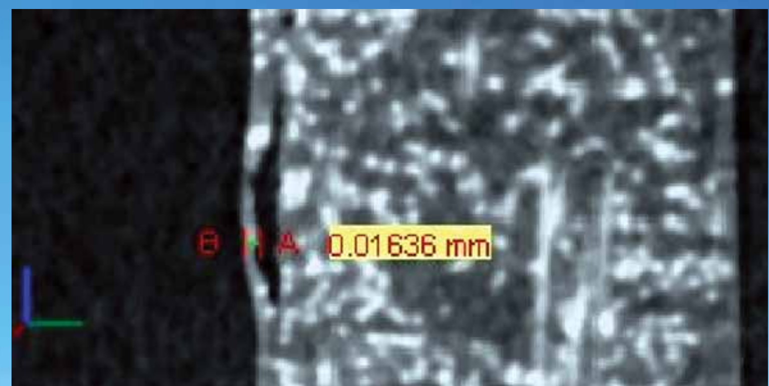


The conventional barrel

Preventing Super Critical Water corrosion by SPIRAL LOGIC
If pellets are not free feed, the hopper can allow free air flow out of the barrel taking out water vapor that would normally be trapped in the barrel with a conventional design and form Super Critical Water. Also the base of the barrel does not require water cooling to prevent premature pellet melting and clogging the feed zone.

T-Rex Barrel by SPIRAL LOGIC

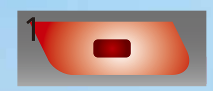
Product Blistering



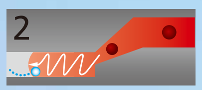
Computer tomography picture capturing the blister of a LCP connector

RoHS certification requires all products use lead-free solder, which has a high melting temperature and results in a requirement for heat resistant plastics in many electronics.
One difficulty molding high temperature plastics is the formation of blisters during soldering which cause alignment problems and failures. The main source of the blister has found to be un-melted plastic solids entering the product, restricting melt flow and causing turbulent flow that entraps air in the molded product.
The SPIRAL LOGIC design solves the blistering problem because all pellets are heated equally by the combination of the GS Loader, T-Rex Screw and compression-free melting model.

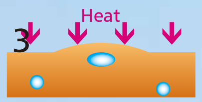
Mechanism of the blister formation



Low viscosity plastics, like LCP, can easily allow un-melted solid material to enter the product because of its low viscosity.



If the melt flow becomes blocked by un-melted material, the flow speed can increase entrapping air in the part and causing voids.

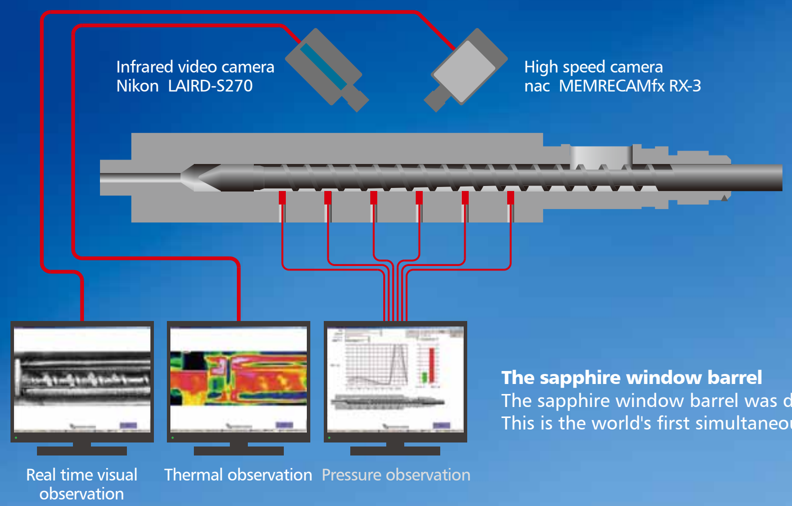


Voids near the product surface become blisters when subjected to the high process temperatures in lead-free soldering.

The Invention of SPIRAL LOGIC

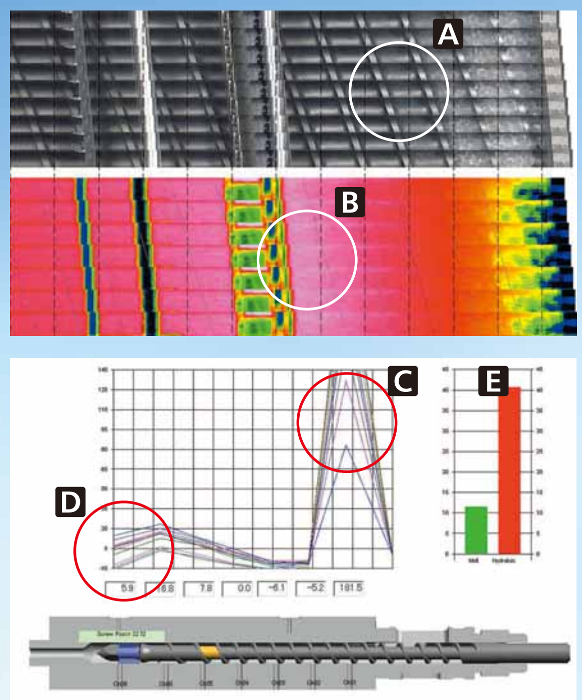
The Sapphire Window Barrel began the revolution of a new melting model

For 50 years the same melting model principle has been used in the design of almost every plastic processing machine made. This conventional feeding, compression and metering design is based on the studies of Dr. Tadmor and Dr. Maddock during the 1950's. Since that time machine designs have gone through dramatic changes from simple hydraulic drives to all-electric servo motors. The controls have changed from simple relay logic to complete PC control. Fully automated production cells are common. But plasticizing, the most critical stage of the process is still based on a 50 year old standard. SPIRAL LOGIC was born from this technology dichotomy.

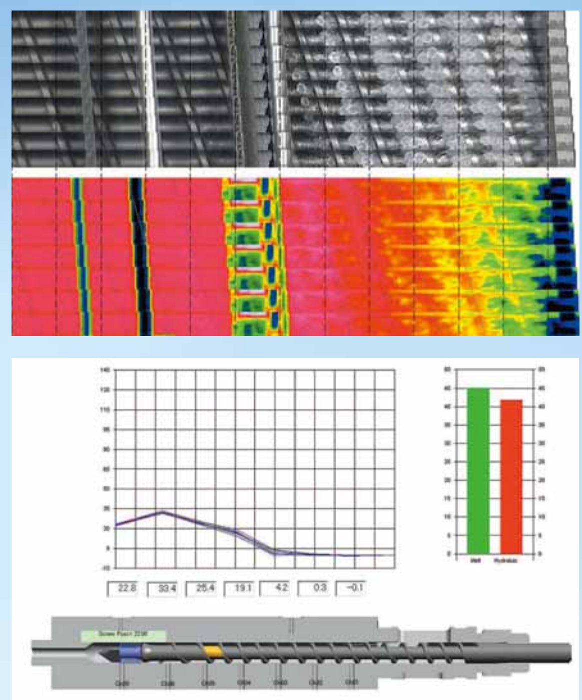


The sapphire window barrel
The sapphire window barrel was developed to observe pellet movement and resin melting in real time. This is the world's first simultaneous, high speed and infrared video of the plastic melting mechanics.

Below is a comparison of a conventional barrel design (left) and the SPIRAL LOGIC design (right).
The traditional theory states the pellets melt in the compression zone. But at point [A] the pellet is already melting in the feeding zone. This is because the melt speed is slower than the incoming solid pellet speed. At point [B] the material is overheating due to excessive shear heating. At point [C] the uncontrolled friction energy compromises the melt pressure control at point [D]. This is confirmed by comparing the melt pressure to the screw back pressure at point [E]. The melt pressure should be higher than the screw back pressure, but it is drastically the opposite and shows the 'un-screwing' effect of the solid material acting like a nut on the screw in the feed zone when free-feeding.



The conventional barrel

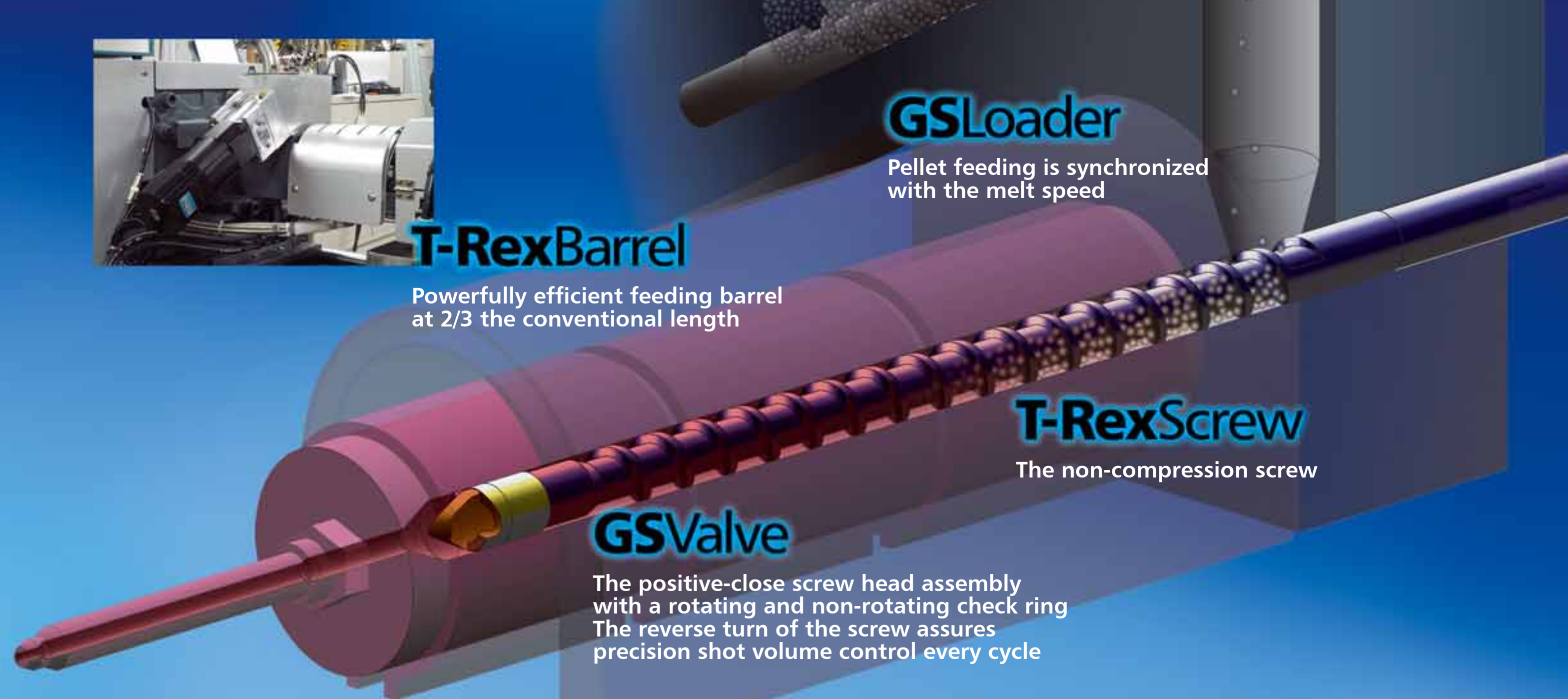


T-Rex Barrel by SPIRAL LOGIC

Since 2002, SPIRAL LOGIC has been studying conventional screw and barrel systems and their effectiveness with various materials and conditions. At IPF2008, SPIRAL LOGIC made its debut being implemented on three Sumitomo Injection Molding Machines. From this research a new plasticizing system has been developed to eliminate the most difficult chronic problems and lead the way to a fully logical plastic processing system.

The SPIRAL LOGIC Design

Four innovations merged to make the perfect system, T-Rex Unit



T-Rex Unit
Non-compression Melting Screw

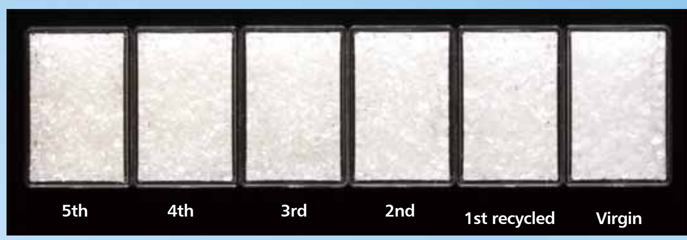
The SPIRAL LOGIC innovations consist of all original hardware designs.

1. GS Valve for precision volume control, shot to shot and minimal wear
2. T-Rex Screw for no compression zone melting
3. T-Rex Barrel for efficient feeding and at 2/3 the conventional length for shorter material residence time
4. GS Loader for precision material feeding rate

Not only for the injection molding machines

Raptor22, the runner recycling system with T-Rex Screw

The T-Rex Screw never creats black spot because there is no compression zone. This feature is succeeded by Raptor22. Raptor22 is recommended for the engineering plastics re-pelletizing.



Recycled pellets COC for lens (APEL5014DP)

Specifications

Main screw diameter	22 mm
Main motor power	1.5 kW
Heater capacity	2.7 kW
Process capacity	5 kg/hr
Cutter blade diameter	29 mm
Strands	2
Dimensions(WxDxH)	1,900 x 500 x 1,400 mm
Weight	200 kg
Power supply	AC200V 3P4L 40A

Trial done by Raptor22

- **Lens**
  COC APEL5014DP
  COP ZEONEX 480R
  COP ZEONEX F52R
  OKP OKP4HT
  PC Panlite SP-1516
- **Light guide plate**
  PC Taflon LC1500
  PC Iupilon HL-4000
- **PA**
  PA46 Stanyl TS200F6
  PA66 Amilan CM3004
  PA9T Genestar N100A
- **Elastomer**
  TPO Milastomer 5030NS
  TPE Vestamid P7283-LD
- **High functional resin**
  PEEK VICTREX 450G
  ULTEM UL-1010
  PPA Amodel A-4422
  LCP OCTA LD-235