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THE HOPSCOTCH MIXER

Over the years, screw design has been a critical issue for the plastics industry. Like a perpetual "mousetrap", screw manufacturers and designers are always attempting to create a higher output screw that will provide an excellent melt as well.

An overview of the more common mixers available includes many of the following: the original "pin" mixing screw, this consists of various rows of equally spaced mixing pins, single or alternated that could be placed as interrupted or non-interrupted to the metering flights. Soon after, the Maddock mixing section (Union Carbide) was introduced, this is a fluted or grooved mixer with undercuts or dams milled to a smaller outside diameter than the actual screw outer diameter. The Egan, Dulmage and Pineapple mixers were also designed utilizing the same principle and idea as the Maddock mixer.

Recently, a new generation of mixing screws have been offered utilizing the "Barrier" principle and wave designs such as those patented by Barr, Willard, HPM, etc. For color dispersion solutions, several mixers have been very successful: this includes the twisted Maddock, Z mixers, Dray mixer and the Pulsar. Many will also increase overall melt and output of the mixing screw. Unfortunately, as an unwanted side effect, many of these mixers produce shear and retention of the process resin, thus eliminating their use in a variety of applications.

ATW has seen the majority of the process problems experienced in the industry. One such existing problem is the increased troubleshooting requirements due to enhanced sophistication of materials and resins. *ATW* is familiar with the considerable change in processing requirements with clients who primarily use regrind or require continuous color changes. Clients attempting to use one screw for multiple resins may find the screw is extremely efficient in one process, while the performance is poor in the remaining processes. The shear factor may also cause material degradation and premature wear at the mixer or barrier ends.

To solve these and many other processing problems, *ATW* designed a new type of mixing screw - *The Hopscotch*. In order to develop a more universal, multi-advantageous design, *ATW* has taken into consideration the successes of some of the present mixers available (i.e., such as pins, Barriers and Maddock mixing sections).

The Hopscotch Mixer consists of various grooves in the metering section of the screw with alternated interruptions capable of orienting the material flow, which in turn eliminates shear. The flow in groove one is the same as the second and third: this allows the same volume of material to pass through. Also, as the grooves are located at equal distances from one another, proper melt and mix is assured. Each groove provides consistent pressure relief. As a result, control and stabilization of accumulating head pressure is secure.

Sequence of the grooves may also be modified depending on the actual process. The overall screw design will include the required compression ratio, feed, transition, and metering sections to work the material and provide a proper melt.

One of the many advantages of *The Hopscotch Mixer* is the ease of use for required color changes. Material is much easier to purge since there are no dead ends where resin can be trapped and retained. On the same principle, processors utilizing contaminated regrind material will no longer experience the typical problems caused by metal particles. Maddock and Barrier screws often encounter these problems. Critical problems such as barrel and screw seize ups, that normally required considerable down time for cleaning and repairs, will virtually be eliminated.

Due to the superior mixing and melt of *The Hopscotch Mixer*, the ability to deepen the metering section exists; this allows an increase in overall output rates. Lbs/hours screw RPM rate will increase considerably in extrusion processes, as quality remains consistent. In injection processes, *The Hopscotch Mixer* will notably shorten traditional recovery times.

The Hopscotch Mixing Screw can be designed to process the following materials:
ABS*POLYSTYRENE*PVC*VINYL*NYLON*PET*LDPE*HDPE*LLDPE*POLYPROPYLENE*

IS YOUR MACHINE ON THE ROCKS?

Pretend for a moment your molding machine is a canoe. The hydraulic/electric system is the river, the injection unit is the rear paddler, and the clamping unit is the front paddler. What is the paddle? It would have to be the screw. The screw provides the push to steer the part in the right direction. It controls how much plastics goes into the mold, how it is mixed, how viscous it is, and how much stress is molded into the part. The screw is the little paddle that controls the show.

Thus, it is quite fitting that we evaluate screws by molding canoe paddles. Anyone who has been canoeing knows that the paddles are always brightly colored and thin. Few have probably stopped to think about the color mixing problems this can pose. Custom molder Mayfair Plastics of Gaylord, Michigan has. This world-class molder of automotive and recreational parts molds mountains of these paddles and knows all about the mixing headaches that can be created. We came into contact with Mayfair and partnered with them to test mixing screws in their new 400 ton molding machine molding a polypropylene canoe paddle. Mayfair was particularly interested in a screw that could mix polypropylene without creating streaking. Meanwhile, we were able to add a series of our own tests to provide a comprehensive overview of

a polypropylene/mixing screw's performance.

Seven different screws were evaluated in this test. We'll provide a quick run through of the participants and then provide you with details on each manufacturer's screw before going on to the test results. The participants are: Advanced Technologies Worldwide, Glycon Corp., Servtek Inc. (A division of Milacron Inc.), New Castle Industries Inc., Spirex Corp., Westland Corp., and Xalby Inc. All of these companies provide parts (specifically injection unit components), for the injection molding industry.

Information Regarding Each Screw In This Evaluation

All screws have a basic goal- to provide the highest possible output while providing an excellent melt. Each manufacturer attempts to solve this puzzle in different ways. This section will detail each manufacturer's design and their reasoning behind these designs.

Advanced Technologies Worldwide- ATW has designed a new type of mixing screw titled The Hopscotch Mixer. The Hopscotch design is intended to provide the overall melt quality and output of the popular "Barrier" principle screws while reducing the shear and retention of the process resin. ATW contends that this can be a problem with many of the "Barrier" style screws currently available on the market. Their design consists of various grooves in the metering section of the screw with alternated interruptions capable of orienting the material flow, which in turn eliminates shear. The flow in groove one, is the

SCREWS



▲ XALOY



▲ SPIREX



▲ NEW
CASTLE



▲ MILACRON



▲ GLYCON



▲ ADVANCED
TECHNOLOGIES



▲ WESTLAND

same as the flow in the second and third; this allows the same volume of material to pass through. The grooves are located at equal distances from one another intentionally to assure proper melt and mix. Each groove provides consistent pressure relief. As a result, control and stabilization of accumulating head pressure is secure.

Glycon Corp.- In our opinion, Glycon has the most unique design of any of the screws in this evaluation. The screw design is a Barr-E.T. with a new, unique mixing device on the end of the screw called the "Infuser". In the E.T. section of the screw, the melt is allowed to pass over the secondary flight along with unmelted material. The undercuts on the secondary flights are quite large compared to the barrier clearance in a barrier screw. This geometry creates random distributive and dispersive mixing of the melt and solid, creating heat transfer. The "Infuser", added to the end of the E.T. section, consists of a series of fixed and floating rings to thoroughly mix and homogenize the melt. The fixed rings (Rotors) are attached to the screw and rotate at the same velocity as the screw. The floating rings (Stators) are positioned between the Rotors and rotate at a much lower velocity than the screw. Material is only allowed to transfer through the mixer when there is a momentary alignment of the axial holes. This axial transfer of material from Rotor to Stator produces a high degree of distributive mixing.

Milacron Inc.- The MELTSTAR screw with Spiral Mixer is another variation on the common barrier screw design. The undercut barrier flight separates solids from the melt. The melt channel cross section is continually increasing in the down channel direction to minimize shear and work input to the melted particles that flow over the barrier flight. The solid channel cross section is continually decreasing in the down channel direction to maintain compression and work input to the unmelted particles. By removing the melted material from the working compression channel, unmelted pellets are continually presented to the barrel surface, maximizing the melting capacity of the screw. The barrier's melting capacity is combined with a spiral mixing head to provide melt homogeneity and color mixing. The multiple spiral channels split the material flow in the vertical plane, and the V-cuts in the outer diameter split the material flow in the horizontal plane. This screw is also available without the spiral mixer for higher output & less stringent mixing applications.

New Castle Industries- The Stratablend mixing screw is designed as a general purpose mixing screw. It achieves this mixing by a continuous series of short grooves and lands in the root, which allow for both extensional and shear mixing as well as a high level of distributive mixing. The grooves in the root are cut into a conventional flighted section with a very shallow depth. In order for the polymer to flow forward, it passes from groove to groove over a series of shallow lands, thereby receiving a series of high and low intensity shear. The length and degree of shear

can be varied to suit the requirement by varying the number and geometry of the grooves and lands quite independent of the output rate. The design tested was a conventional "non-barrier" screw with a mixing section at the discharge end.

Xaloy Corp.- Xaloy's approach in this test was to develop a root geometry that would meet the desired rate required with excellent color mixing. The root geometry is a design utilizing two types of mixing devices. The rate requirements created a deep meter depth. Staggered mixing pins located in the first few flights of the meter zone were used creating a cross-channeling

ALL SCREWS HAVE A BASIC GOAL~ TO PROVIDE THE HIGHEST POSSIBLE OUT~ PUT WHILE PROVIDING AN EXCELLENT MELT.

Spirex Corp.- The MeltPro Barrier Screw by Spirex is a variation on the barrier screw design. The feed section conveys in the same

way as a conventional screw. At the beginning of the transition zone, a second flight is started. This flight is called the barrier, or intermediate, flight and it is undercut below the primary flight OD. The barrier flight separates the solids channel from the melt channel. The barrier flight moves under the melt film and the melt is collected in the melt channel. In this manner, the solid pellets and melted polymer are separated and different functions are performed on each. The melt channel is deep to provide low shear. The solids channel becomes shallower, forcing the unmelted pellets against the barrel for efficient frictional melting. The solids bed continues to get shallower and finally disappears into the back side of the primary flight. Spirex's Z-Mixer was also installed at the end of the screw. The Z-Mixer assists in melting and mixing by re-orientating the material into at least three separate channels. There are also variable flight depth clearances that take place, adding to the shearing ability and, hence, melting capability. This combination of multiple re-orientation, coupled with barrier flights, is designed to produce a low standard deviation in melt quality via the combination of melting and mixing.

Westland Corp.- The Eagle screw by Westland has a mixing section which utilizes wiping lands with large helix angles to rapidly convey the melt either over alternating barrier lands or through mixing notches in the barrier lands. A reduced root diameter in the mixer, as compared with the preceding meter section, allows the mixer to accept substantially all (over 95%) of the melt volume available to it without creating a pressure drop of causing excessive shear. This design is intended to allow the Eagle screw to be run at high speeds (250 RPM or more) without degrading or overheating.

effect. The intent is to deliver a more homogenized melt to the mixer located at the end of the meter zone. The final mixer is a X-201 mixer that allows both distributive and dispersive mixing. The feed zone is 48% of the screw while the metering zone is 32% of the screw. The longer metering zone was used for the rate required, and the quality issues good color mixing posed.

Test Results

Mayfair's Mixing Problem. Mayfair was using a standard, general purpose screw manufactured by the molding machine manufacturer. With this screw they saw a mixing problem with green colorant when running a normal cycle. Therefore, they had to increase the cycle time to fix this problem. The first test we ran was to see if we could reduce the cycle time back down to normal levels with the new screws installed. The colorant level was kept at 4%. All seven screws were able to fix Mayfair's problem and reduce the cycle time down to normal levels.

Note: The mixing tests were run with Mayfair's heat profiles. It could be expected that all screws would perform even better with profiled heats set specifically to fit the screw design.

Mixing. This test was conducted using Mayfair's standard cycle with a green colorant. This colorant is designed to be mixed at a 4% ratio. We started out with a 1% ratio and went up by 1/2% at a time until 4% was reached. At each colorant level we examined three things. First we checked the paddle for streaks. Next we examined a mark on the paddle where