Organizing an Effective Maintenance Program For Plasticating Components

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Several plastics processes—injection molding, extrusion and blow molding—rely on efficient screw-plastication for end-product quality, and for efficiency and profitability of production. The performance of the screw, the barrel and other specialized plasticating components is linked to the operating condition of these components and, ultimately, to how they are monitored and maintained. The plastics processor who takes maintenance seriously will produce better product, more profitably, than the processor who doesn't.

Inevitably, the plasticating unit will wear. This may be due to the materials being processed, different types of additives or operating conditions or a combination of all these factors. Unless this wear is controlled, its effect can be costly, in terms of reduced output, higher energy use, poor product quality and machine downtime.

But even under the worst conditions—usually the use of highly abrasive fillers and reinforcements, or abuse of one form or another—the impact of wear does not manifest itself immediately. It starts slowly, insidiously, and at first the process may not be affected at all. Then, at some point, its effect will begin to accelerate until, eventually, it becomes nearly impossible to make a quality product without excessive waste.

A well-crafted maintenance program, which tracks key process parameters and relates them to screw and barrel wear, will allow the processor to anticipate problems and make the necessary repairs before performance and profitability are affected.

What causes wear?

There are four types of wear that typically occur in plasticating equipment. Often, more than one type of wear may operate simultaneously.

- ***Abrasive wear***—The most common type of wear, abrasive wear occurs when hard particles (usually glass or other abrasive fillers) slide or roll across the surface under pressure. The results can include reduced flight diameter, flight erosion, impaired structural integrity and susceptibility to other forms of wear.
- ***Adhesive wear***—When two metal surfaces (screw and barrel) slide against one another under pressure, minute sections of the surfaces can actually weld together and then be torn apart as the components continue to move. Adhesion can result in screw and barrel galling.
- ***Corrosive wear***—Acids and other aggressive chemicals given off by such plastics as fluoropolymers, vinyls, acetals and flame-retarded compounds, attack the metal surface, leaving it unprotected and susceptible to other forms of wear.
- ***Fatigue***—Repeated or fluctuating stress on the screw can cause minute cracks to grow beneath the surface, leading to delamination of hard-facing materials, accelerated wear and, eventually, component failure.

These types of wear can be triggered or exacerbated by many factors including:

- ***Improper screw design***—If a screw has the wrong compression ratio, improper melting can result in 'solids wedging,' which in turn can cause severe galling. Excessive back pressure can increase component wear, especially when processing reinforced material.
- ***Material***—When processed on an unprotected screw and barrel, highly filled materials will cause accelerated wear.
- ***Incorrect heat profiles***—When excessive shear heating is used instead of electrical heating with heater bands, premature abrasive wear can result.
- ***Misaligned machine components***—Metal-to-metal contact can cause adhesive wear and galling.

■ ***Improper start-up***—If the material is not fully up to temperature before the screw is rotated, stress cracks can form in the screw and in the non-return valve on an injection molding machine.

■ ***Contaminated material***—Any foreign objects entering the barrel can cause severe damage and mechanical failure of the screw, barrel or valve. Magnets, screens or filters can prevent contamination.

■ ***Improper manufacture***—If the wrong process or materials are used in the manufacture of plasticating components, premature wear and component failure can occur. Problems can include: flight cracks, chips, poor plating, warping, uneven hardness and unhomogenized steel microstructure.

Performance vs. wear

As a screw wears, the gap between the screw flight and the barrel wall grows until material no longer is conveyed properly. In injection molding, the processor will notice that shot recovery takes longer. In extrusion, the material output per screw revolution is reduced.

Initially, the wear can be accommodated by allowing a longer shot-recovery time or by increasing the screw rpm. However, as wear becomes more severe, these adjustments can lead to improper melting or poor mixing, which shows up in poor product quality and higher scrap rate.

An increase in melt temperature at the die, resulting from excessive shear heating or extended residence time in the barrel, will be another key indicator and may manifest itself as burning on the finished product. The machine will begin to use more energy to produce the same amount of product. While this is more difficult to determine than other evidence (unless a meter is installed on individual machines), energy waste can have a major impact on plant profitability.

Also in injection molding, a worn non-return valve may allow material to backflow up the screw and short-shots or inconsistent part weight will result. For a while, the molder can compensate by increasing the screw recovery stroke and shot size, but eventually the process becomes intolerably inefficient. Other evidence of screw and non-return valve wear in injection molding includes the inability to hold pressure during packing.

Usually, screw and barrel materials are chosen so as to ensure that the screw (which is easier to repair) wears before the barrel. However, barrels eventually do wear and the results will be the same.

Tracking process changes

Fortunately, as noted above, the process changes that are necessary to compensate for the effects of wear become evident only gradually…over months or years in all but the most difficult situations. And the rate of degradation will accelerate as wear worsens.

So the process changes, themselves, become valuable clues to what is going on in the barrel as the machine runs. An accurate record of processing times, temperatures, pressures, scrap rates—almost any parameter that affects product quality or process efficiency—is critical to anticipating the need for screw and barrel maintenance.

Fig 1 shows a simple chart that can be used for recording

Preparing Your Screw And Barrel For Inspection

A physical inspection of plasticating components in an injection-molding machine or extruder demands that the screw and the barrel be disassembled and cleaned thoroughly so that measurements will be accurate and any damage will be readily visible. Following is a step-by-step procedure for shutdown and disassembly.

Always support the screw as it is being removed from the barrel to avoid bending. If an overhead crane is used, be careful not to over-lift as this can cause severe damage to the screw and barrel.

1. Shut off material at the feed throat.
2. Continuously purge the extruder or injection unit with an approved purging compound or high molecular weight polyethylene, polystyrene, or acrylic material. Purging material should have a higher melting point than the material being purged.
3. Apply maximum backpressure and extrude until there is no material left in the barrel. In injection molding machines, the screw should be in full forward position. Repeat this procedure until all material is out of the barrel.
4. Turn machine power off at the main breaker.
5. Remove the end cap. On injection molding machines, the injection unit may need to be pivoted.
6. Disconnect the screw drive end

information. This information can help you anticipate wear-related problems. If these data are not collected more frequently for other purposes—an SPC/QC program, for instance—they should be logged at least every shift as part of a screw/barrel maintenance program. If a production monitoring system is used to automatically collect process data, create a report that makes it easy to see wear-related changes.

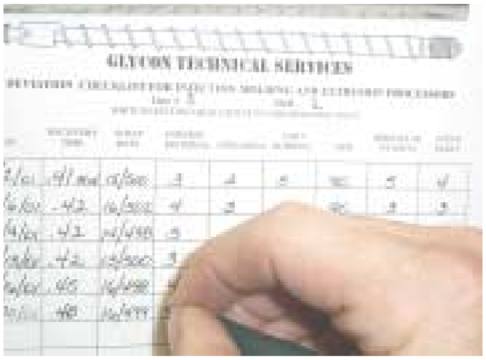

Fig 1. *Processors should create a form like this one to note important process data, as well as significant part-quality anomalies such as burning, streaking or sticking.*

When you can anticipate the need for screw repair or replacement, you can purchase spare parts under more favorable terms, avoid rush-shipping charges and schedule maintenance to minimize disruption of critical production.

Physical inspection

While process changes can indicate what is going on inside the plasticating unit, the only way to be absolutely sure is to take physical measurements.

The first thing to do is to note 'baseline' dimensions. If the screw and barrel are new, the manufacturer's drawing will contain this information. Otherwise, the screw should be pulled and measured and the barrel should be measured with a bore gage. See the sidebar for hints on shutting down and preparing the screw and barrel for inspection.

Once the screw has been removed from the machine, it should be inspected for the following:

- Cracks in the root or outside diameter
- Heavy wear areas or score marks
- Chipped flights
- Worn roots or any surface defect that might cause material hang-ups
- Burrs or chips on the screw drive end
- Dye-check any areas of the screw that appear to be cracked. If any crack on a flight is open and/or runs parallel to the flight, it should be repaired before the screw is reinstalled.

Map these defects on a screw drawing or record the linear location in an inspection report. Then, as shown in Fig 2, use a flight micrometer or gage block to measure the flight diameter at every turn and, again, record the readings. Compare these numbers to the OEM specs, but in general, the screw diameter should equal the barrel i.d. x 0.998, with a tolerance of +0.000/-0.002 in.

Next, check the barrel. Inspect the inside surface for cracks or defects and record their linear location. Then, set a dial bore gage to the original barrel i.d. and measure any variance at 5-in. intervals along the length of the barrel (see Fig 3). Record the variance at each location in the maintenance log. Normal barrel i.d. tolerances are +0.002/-0.000.

Injection molders should also inspect the non-return valve for obvious signs of wear, and measure

and split-ring assembly per manufacturer's specifications.

7. Using soft metal spacer blocks (preferably aluminum or brass) at the feed end of the barrel, push the screw out until it can be pulled from the barrel.
8. Support the screw as it exits the barrel so it does not bend. If an overhead crane is used, be careful not to over-lift as this can cause severe damage to the screw and barrel.
9. After the screw has been removed from the barrel, place it carefully on the floor or bench, supporting it in at least two places.
10. Clean the screw with a soft wire brush or copper gauze while it is still hot. Remove all residual plastic from the flights. Do not use a power wire brush with hardened bristles, which can damage the screw's finish.
11. Wire brush the barrel i.d., removing all plastic from the barrel walls.
12. Clean the end cap seating area to ensure proper seating of the end cap when reassembled.

Before reassembling the plasticating unit, check all electrical and mechanical parts to ensure proper operation. Check the screw drive end for burrs or chips that could cause installation problems.

Then reassemble the unit. The barrel should be hot and the screw at room temperature before assembly. The screw should slide into the barrel with very little effort. If it doesn't, check the screw and barrel for residual plastic or other obstruction. Never force the screw into the barrel. After the screw is assembled into the drive unit, reinstall the end cap, torquing the socket head cap screws to OEM specifications. Never over-torque the bolts as this can damage the seating area. Finally, refer to OEM instructions for start-up.

Fig 2. *Use a flight micrometer or gage block to measure the flight diameter at every turn. Record these readings every six to twelve months to track the progress of wear on the screw.*

sure the check-ring diameter, which should equal the barrel i.d. x 0.999, with a tolerance of +0.000/-0.001 in. Generally, valves will wear faster than the screw or barrel and you may have to replace them several times before the screw needs to be repaired.

Fig 3. *A dial bore gage can be used to measure the barrel i.d. at five-inch intervals along the length of the barrel. Variance from nominal original dimensions indicates wear.*

Compare physical and process data

In general, the amount of screw and barrel wear that can occur before it begins to affect processing will vary depending on the viscosity of the material being processed. A high-viscosity material, with a melt index from fractional to 20 gm/10 min, will be affected less by an increase in clearance than a material with a melt index greater than 20 gm/10 min and higher.

That's why it is important to compare the information gathered in a physical inspection with the process data collected over time. It should be easy to draw a correlation between changes in processing characteristics and the physical condition of the plasticating components, especially after data begins to accumulate over months or years.

Anyone starting a monitoring and maintenance program probably would be well advised to perform a second physical inspection after six months (unless process conditions suggest a problem sooner than that) and then annually thereafter. Of course, if you're running highly abrasive or corrosive materials you might want to inspect more frequently until you are satisfied that you can accurately predict when wear will begin to affect performance.

Do-it-yourself?

There is nothing here that cannot be completed by a trained and competent in-house maintenance staff. So long as procedures are followed carefully and the components are handled correctly, there are few opportunities for error. In fact, the effectiveness of the program is more a matter of diligence than any special training.

However, as processors attempt to run 'lean and mean,' in-house personnel may be overburdened and it may be wise to seek outside assistance. Some screw manufacturers offer service that includes:

- Setting up a program, benchmarking existing components and establishing record-keeping procedures
- Inspecting and measuring components on an appropriate schedule
- Repairing or replacing worn components
- Checking and optimizing performance of new components
- Solving processing problems
- Keeping an inventory of frequently used components
- Special services, as required

The plasticating unit of an injection-molding machine or extruder is really the heart of the system. So it makes sense that profitability should depend on the proper maintenance and operation of these critical components. Whether a processor decides to do the work in-house or contracts with a screw manufacturer, the important thing is to get with a program and stick to it. The costs are minimal and the potential return—more machine up-time, increased efficiency, higher product quality—is well worth the investment.

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