Barrel and Screw Wear

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Extruder wear has been a topic of considerable discussion. Numerous publications have described various types of wear and the metal alloys and surface treatments needed for control. Although an extruder has several parts that wear, the barrel and screw contact surfaces get most of the attention.

Corrosive, abrasive and erosive wear are primarily caused by agents in the process and material. The barrel and screw are made of metals selected for their resistance to the damaging agents.

Wear caused by rubbing contact of the screw flight against the barrel wall, however, is usually due to mechanical conditions which can be prevented or controlled. Also known as adhesive wear, raised points on one surface contact the raised points on the mating surface as they slide past each other. With enough force applied, a protective oxide layer is removed and the contact points plastically yield and form a series of molecular bonds. As the surfaces continue to slide past each other, shearing and tearing occurs but not necessarily at the same location. This leads to particles breaking loose, smearing and galling.

Wear severity is a function of the strength of the momentary bonds formed by the metal to metal contact. Metals have different affinities for each other with like metals forming the strongest bonds. Hardening of the surfaces reduces deformation of contact points under load and therefore lessens the bonding between surfaces.

Various techniques are used by suppliers to reduce wear: heat treating, flame hardening, nitriding, plating, intrinsically hard coatings such as cobalt and nickel alloys that are inlayed to the barrel bore.

Metal-to-metal contact is expected in an extruder, and the construction materials are selected to minimize this and the other forms of wear that the process introduces. This is certainty true at startup when the screw rests on the bottom of the barrel and then rotates up and around the side of the bore until the extruded material acts to center it. While it is difficult to prevent startup contact, steps should be taken to minimize it and to prevent rubbing contact during operation. Doing this requires that the sliding surfaces either are separated with a minimum clearance or have a lubrication film between them.

The very viscous polymer melt being pumped through an extruder should make an excellent lubricant. Sufficient film pressure must be developed between the flight out side diameter and the barrel wall to center the screw and keep the surfaces separated from each other. This pressure can in part be hydrostatic which is developed in the melt at certain points in the extruder by screw geometry. But mostly it is hydrodynamic developed by the surface speed of the screw flight, when eccentric to the barrel wall, and pumping the viscous melt into a converging wedge. This causes a pressure buildup as clearance decreases, and thus forces the screw back toward the center.

Contact occurs if either the melt is not present or inadequate in film strength to prevent contact. Certain conditions exist due to design, construction, installation or operation which overcome the film bearing support. These are:

1) Misalignment: The Screw centerline is not coincident with the barrel bore and, at some point depending on clearance, contact will be made. Design and installation of an extruder includes aligning the barrel assembly to the gearbox which centers the driveshaft and the attached screw.

2) Eccentric or loose fitting couplings: The screw hub is piloted onto the driveshaft. If the method of coupling (key, thread, spline, etc.) causes the screw centerline to be eccentric and orbit the driveshaft, it may rub the barrel wall. Also, the gearbox bearings support and center the screw with enough stiffness to prevent contact until well inside the barrel. A loose coupling defeats this and may cause rubbing at the upstream end where there is no polymer melt.

Screw joint connections must also be rigid and aligned to prevent rubbing contact.

3) Bent screws: Depending on the amount and where they are bowed, the screws will be constrained inside the barrel and form a wavelike series of contacts.

4) Inadequate foundation support: When the barrel assembly is aligned during installation, the foundation (stand or piers) must maintain this position under all operating conditions. If the barrel sags or moves radially during screw rotation, contact is likely.

5) Auxiliary equipment attachment: Bolting hardware to the extruder without provision for flexing can force the barrels out of alignment.

6) Restricted thermal growth: The cumulative thermal expansion of the barrels will cause significant growth in the axial direction. Since the barrels are attached at one end they will expand in the opposite direction. If not, the barrels may bow.

Also, the screw must be free to grow radially outward without loss of clearance if it is hotter than the barrel or made of a more thermally expensive material, such as stain less steel.

7) Screw buckling: High screw end pressure on a large L/D ratio screw can cause compressive load buckling if radial support is lacking.

8) Fluctuating end pressure: If there is axial play in either the thrust bearing or the hub coupling and the load on the end of the screw varies alone or in combination with shear forces, damaging axial vibrations may be set up. This can cause loss of film strength and a wobbling of the screw. Fretting wear is likely. Severe skid damage to the thrust bearing, another form of adhesive wear, is a common occurrence. A constant end pressure is usually beneficial, if it is not excessive, because it helps center the screw.

9) Torsional vibration: The screw is an extension of the drive train which includes the motor. A variation in torque such as that due to changes in feed rate or spiking on the electrical supply line can induce torsional vibrations. If these coincide with drive train resonant frequencies the amplitude may be come large, disrupting film strength and causing fretting wear. The polymer melt can be expected to dampen the vibrations.

10) Transverse forces: Feeding solid pellets or slurries can force the screw to one side. This is a particular problem with twin screw extruders because the screws tend to be forced apart as feed enters the nip. Because polymer melt is not present at this point, metal to metal contact is likely.

Control of these conditions by design, construction and assembly will have a significant affect on barrel and screw wear and provide long term reliability of the extruder.

When rubbing contact does occur during operation, detectable noises are usually emitted and they do provide a means for locating and analyzing the type of wear.

If there are locations where contact can not be avoided, such as at the feed section, and film strength is inadequate, then extruder design modifications should be considered. This may involve screw and hub design.

Development of film bearing support to control screw stiffness and deflection at these points would be part of a design study. Lubrication could be introduced under pressure to provide hydrostatic bearing support. It could be a lubricant compatible with the extruded material or the melt itself conveyed from another location.

In applications where positive pressure or vacuum exists at the upstream end and a hub seal is needed, close bearing support would be required. The bearing can resist any transverse forces that are present as well as eccentric and uneven screw rotation.

Controlling mechanical conditions can have as much significance as metallurgical improvements in limiting or preventing barrel and screw wear.

— Thomas Harrington, P.E.

See also:

- Excessive screw wear
- Extrusion screw wear
- Machinery installation
- Misalignment

- Screw flight wear
- The extruder drive
- Where's the wear?
- Where's the wear? Part II

Return to Consultants' Corner