Where's the Wear?

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Where's the wear? - Some comments on screw wear
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(Note: This discussion will be limited to single-screw machines. In the twin-screw world, there are many special circumstances: compounding of abrasive materials, different pumping mechanisms, interchangeable screw segments, counter-rotating machines which force the screws - outward against the barrel, and conical machines where repair and replacement costs are high. These things are so unique that twin-screw wear would justify a separate article.)

A worn screw is often misunderstood. It isn't always bad news, and it isn't always important, but sometimes it is both. To understand what it really means, we have to ask the question, "where's the wear?" On a single screw, there are four typical places to find wear: the feed zone, the output end of the screw, the "toll gate" (end of the compression zone), and all over.

1. FEEDZONE- When the screw wears just in the feed section, but on all surfaces, not just flight surfaces, an abrasive filler such as glass fiber is being added to the feed. The remedies are to treat the screw surface there to make it very hard, or to avoid adding raw glass fibers there. This can be done either by adding them in a vent further downstream where they are lubricated by the hot plastic, or by using a concentrate if volume isn't too great. If there is wear only on the flights in this zone, and the root isn't especially hardened, there may be a serious mechanical problem (thrust bearing) and immediate attention is needed.

2. OUTPUT END - When the wear is greatest at the output end of the screw and only on the flight surfaces next to the barrel, then there may be a mechanical problem of misalignment. The screw may be bent or warped, or the barrel may not be straight, as might happen if its front support is maladjusted, or if too heavy a die is hung from it without its own support. The real danger of misalignment is not in the barrel, but in the drive, as any lateral force on the screw also produces a matching lateral force in the bearing and gears, which may lead to their early failure. There may be other signals in addition to screw-end wear, such as unusual noise, overheated or vanishing lubricant, or leaks at the seal where the screw shaft emerges from the drive section, often visible in the "inspection space".

3. TOLLGATE - A common place for wear is the end of the compression zone (the "toll gate") where the channel finally stops getting smaller. This happens when the feed zone takes in more than the front (metering) zone wants to put out against the head and die resistance. This is called "blue screw syndrome", and in addition to the bluish appearance of the screw in that region, it can be diagnosed by the overriding of the temperature controller in that zone, an output rate more than might be expected from the die resistance and the basic drag flow of the last zone, as well as wear concentrated in that area. The higher rate results from the push forward given by the pressure peak at the toll gate.

There is a theory that says such wear is caused by actual metal-to-metal contact because the screw is elastically bowed by the high pressure; this is unlikely, as the pressure is the same all around the screw, and it is pressure differential which creates force, not the absolute pressure itself. A more plausible explanation is that high pressure and temperature, at this point, cause some chemical bonding of the screw flight metal to the plastic. What is certain is that wear occurs there, and the pressure peaks have been demonstrated in tests on instrumented barrels (and can be shown by computer simulation, too).

4. ALL OVER - When wear is over all the screw but just on flight surfaces, it is likely that they were originally flame-hardened (the least-hard of common treatments) and have been in service a long time. Some gradual wear is normal for all screws, and is more for certain plastics (e.g., HDPE) that others, but it should be a matter of years rather than months or weeks before a properly specified screw is worn enough to justify attention. Such wear may be greater near the output end of the screw, but it shouldn't be confused with misalignment wear, which is more rapid (and more dangerous).

If all-over wear includes the root and flank surfaces as well, corrosion is the likely cause, and this will happen if certain plastics (PVDC, some fluoroplastics) are extruded in equipment made of the usual steel-based materials. These plastics need special metals in the entire system, usually nickel-based alloys. This was seldom a problem in the pastas users of those plastics knew enough to use the right machinery, but it has now become more of an issue as recyclers wonder what's in their recycle, and are afraid that too much P VDC (or even PVC) will eat up their equipment (a legitimate but seldom significant fear).

WHAT DOES THIS ALL MEAN? Why should we be worried about wear at all? For categories 1 and 4, the answers are fairly obvious. Severe abrasion in the feed zone will sooner or later impair the ability of the screw to convey the feed forward, and corrosion will rapidly change dimensions, and may even degrade the product and make for hazardous working conditions. In these cases, the original materials of construction were inadequate for the job, and new equipment is needed if such materials are to be extruded for years into the future.

For categories 2 and 3, the situation is less clear. In case 2, screw-end wear, this is a call for immediate search for lateral forces responsible: analysis of front-end supports, measurement of the entire screw and barrel, and maybe even inspection of the thrust bearing and gears, to avoid their premature damage. For category 3, toll gate wear, the other symptoms of blue-screw syndrome should be checked out before a firm diagnosis is made.

Even then, the question of what difference it makes must still be asked and answered. It is all too easy to discover wear and then make it responsible for a variety of problems that may not be related to wear at all. The most common of these is a loss in production rate.

Although toll-gate wear may indeed increase production because of the high-pressure peak there, in some cases the higher resulting melt temperature may limit production; also, screw-end wear and gradual abrasion may sometimes reduce the output per rpm, and this may limit production. To be sure that the wear is really limiting rate, we need to be sure that neither material nor extrusion conditions have been changed, and we must eliminate the effects of screen contamination, which will slowly reduce the output per rpm until the screens are changed. In other words, we need to show gradual output/ rpm loss over a long period with the same material to show that output of the screw is indeed falling.

Even if we can show this, its economic significance must be known before appropriate action is taken. Can the loss in output be compensated by increased rpm? Does that lead to a higher output temperature that cannot be otherwise controlled (e.g., cooling) and that has real and measurable money loss? Sometimes running faster just means more idle time, if you can't sell the increased production. Read about solutions to these problems and information about barrel wear in part two in the next newsletter.

— Allan Griff

See also:

- Barrel and screw wear
- Excessive screw wear
- The effect of flight radii size on the performance of single-screw extruders
- Extrusion screw wear
- Thrust bearings
- Where's the wear? Part II

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