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Proper Inspection Catches Screw-Machining Flaws

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A formal method of inspection can detect screw flaws before installation, and thereby reduce process problems.

The purchase of screws to replace those with worn but proven designs is an important process in extrusion plants. Occasionally, new screws do not perform as expected despite meeting design parameters. This may be due to problems with the material of construction or to changes in the frictional coefficients of finishes and coatings. But there may also be hidden manufacturing flaws not discovered in common inspection procedures; an improperly machined taper in the transition section of the screw or in the variable solids-feed depth, for example; or, in a barrier screw, excessive barrier-flight clearance (Fig. 1).

Such flaws can only be discovered with an inspection procedure for screws prior to installation or shipment from the vendor. This paper describes the impact of a machining flaw that escaped detection, and defines an inspection procedure which would have prevented installation of the screw. It also highlights the benefit of on-line monitoring of melt pressure and temperature for defining and minimizing the effects of machining flaws.

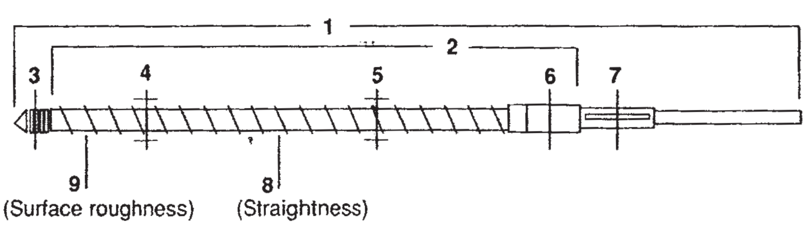
Channel-depth variations in the solids-conveying or melting sections of the screw are machining flaws that can give rise to disturbances in the solid-bed motion, which affect the stability of the extrusion process. (Solidbed refers to resin pellets that, immediately after feeding, are compacted by the screw prior to plastication.) Depending on the magnitude of the error and if it represents a restriction or a pressure relief for the solid bed, several types of disturbances might be expected.

Solid-bed breakup and non-uniform acceleration have long been associated with pressure instability (1-4)[1]. A solid-bed decompression near the feed packet could also lead to air entrapment by the screw. Uniform transition taper has been defined as a critical design parameter by Chung to insure optimum screw-melting performance (5). Depth variations in the melting section can result in poor melting uniformity, rapid bed breakup, low-frequency melt-pressure and temperature changes, and excessive wear. This last problem occurs because of unbalanced forces that push the screw against the barrel, breaking down the lubricating against the barrel, breaking down the lubricating film. The appearance of any of these or other changes in performance after installation of a replacement screw are potential indicators of a machining flaw.

The following study highlights of the effect of a machining flaw in the transmission section.

Screw inspection typically takes place in the shop on a flatness table, where checks are made of feed depth, start and end depths of the transition section, metering depth, diameter, length of each section, and screw straightness, along with the machining of the tail stock. These checks are used to develop a tabular comparison of the design depths with the actual screw dimensions. A complete inspection also consists of a depth measurement at each screw turn as well as measurements of all important clearances.

Data are then plotted to show various parts of the screw profile. Data of this type are easy to take by measuring channel depth relative to the screw-flight tip, using a depth gage and a special V-block holder.



Measuring points	1	2	3	4	5	6	7	8	9
Specified dimension, mm.	8738	6408	274	275	275	275	195	—	—
Actual measurement, mm.	-0.8	-1.0	-0.51	-0.52	-0.52	-0.90	-0.18	0.02	Good

Fig. 1. Close inspection reveals machining variations in screw.

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A more complete description of the screw can be obtained by measuring the profile at several angular positions around the screw to insure that no bumps exist over a turn.

The discipline of the inspection process is to perform the plotting of the inspection data and to develop a set of criteria against which to judge the quality of the machining. The criteria permit relatively inexperienced personnel to make meaningful decisions results and whether to accept or reject a screw.

Our company has been established a screw-inspection procedure which is generally the responsibility of one or two individuals. One time, however, an engineer unfamiliar with extrusion technology conducted the inspection; in the absence of criteria for acceptance, he was unable to make a meaningful determination as to the quality of the machining. All data were collected and tabulated, and the screw was shipped and installed.

The screw design chosen was a remake of a screw with a documented performance record. After several months of production the line showed symptoms of substandard performance in capacity and film quality when compared to a sister line. At startup of the line, motor-current fluctuations were noted on a once-per revolution basis and were thought to be associated with a mechanical binding. Power consumption of the suspect screw was higher than comparable screws, and was at the torque limit of the drive (Fig. 2). Otherwise, all aspects of the screw's performance matched expectations, and pressure and temperature uniformity appeared good when monitoring digital readouts for short intervals (5 min.).

During film manufacture, however, periodic disturbances were seen in film-gaging readouts and in visual uniformity of sheet, which rose to unacceptable levels as screw rpm increased above 70% of the sister screw's output. During a review of the line's performance, a transient rise in melt temperatures was observed and chart recorders were attached to the extrusion systems. While short-term temperature stability was better than 1° C and short-term pressure stability showed less than 1% variation, a transient upset was recorded every 7-10 min. in melt temperature and pressure. This upset is typical of an imbalance between melting and conveying functions. Upon a review and plotting of the screw inspection data, there was found a machining flaw in the taper of the melting channel that accounted for the poor long-term stability of melt temperature and pressure.

The hump in the transition section caused a restriction to the forward flow of solids in the solids channel.

SCREW FLAWS NECESSITATE MODIFYING TEMPERATURE PROFILE

Temperature, °C

Zone	Specified Profile	Actual Profile
1	210	210
2	220	220
3	245	265
4	245	265
5	245	245

This required that pressure build behind the solid plug to push the solids past the hump. The resulting high-pressure point restricted melt and solids flow, causing a localized increase in temperature. As the pressure reached a point where the plug was pushed past the hump, there was a surge in pressure and output melt lasting about 1 minute.

The motor current also showed the effect of the increased pressure as an increased motor load during the transient. This indicated that the restricted solid flow was forcing the screw against the barrel, with the potential for higher wear. The problem was corrected by installing a new screw built to exact specifications and properly inspected prior to the installation. This required 16 weeks. In the meantime, the on-line recording was used to modify process conditions in order to minimize the problem and maximize productivity. The table compares the temperature profiles used to minimize the pressure build-up by increasing the melting rate in the area of the defect.

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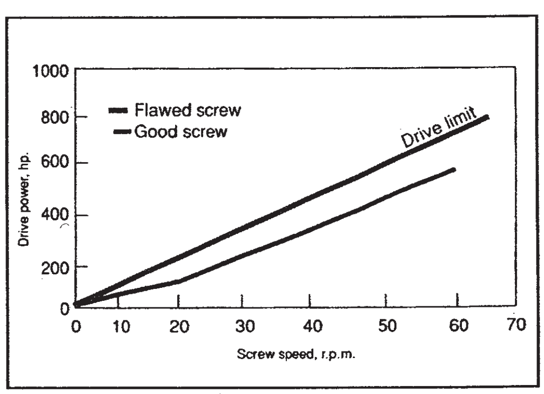

Fig. 2. Screw flaws increase energy use.