

Extruder Barrel Alignment

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Extruder barrel alignment is one of the most important aspects of a properly and efficiently operating plastics extrusion process. Whether it's a blown film line, injection molding, extruded sheet process, pelletizing or recycling, the relationship between the rotational center of the thrust shaft in the gearbox and the rotational center of the screw are vital.



Misalignment is known to cause excessive screw wear and barrel wear. If the misalignment is severe enough, the screw can fail prematurely as a result of the fatigue caused by the cyclic bending of the screw as it rotates in the barrel. In some cases, the clearance that is opened up between the flights of the screw and the barrel will allow significant losses of system efficiency as well as the through put of the system. Misalignment is also known for creating enough excessive pressure and temperature between the screw and the barrel that the screw becomes “welded” to the barrel.

The real value of a plastics extruding line does not rest in any single component of the extrusion process. Rather, the *operation and production* of the system is the value of the extrusion process. If the process isn't operational, for a day, a shift, or even an hour; you are going to lose production value.

These days, facilities are demanding more and more production from existing equipment. If a poorly aligned extruder system was operated for 5,000 hours prior to failure, it would run and be productive for 625 work days (8 hr/day - 5 days/week) or about 2.4 years prior to a component failure. Honestly, there aren't many production facilities operating at those production rates. So, with that same 5000 hour Mean Time between Failure (MTBF), for a plant running 2 shifts/day – 6 days/week, that same system will only operate 1 year prior to a failure that shuts down the process and halts production. Not only are the production revenues lost for the period of time it takes to repair the system, the cost of a new screw and barrel can be \$30,000 or more (depending on size and application) with thousands more spent on labor. Should a failure occur in the feed section of the extruder, an even greater expense can be incurred by having to replace the feed throat. Catastrophic failures can even cause failures and expense in the drive components of the gearbox.

Laser Alignment of an extruder system can be completed in less than 8 hours and typically in less than 4 hours. That 4 to 8 hour "investment" will; in all likelihood, result in extending the life of the extruder barrel and screw and help in keeping your facility doing what it is supposed to do:

Making product and moving it out the door.

Definition of Extruder Barrel Alignment: Positioning the extruder barrel at the supports and the feed throat in such a manner that the barrel mechanical center is collinear with the gearbox thrust shaft rotational center (within a set of tolerances) under normal operating conditions.

That's a pretty big statement and it's not always easy to accomplish.

Alignment Methods

Historically, there have been three methods utilized to align the extruder barrel to the gearbox thrust shaft.

A Level

The first is to measure everything with a level. The idea being that if the machine is level, everything should be aligned. This is a serious misconception and will almost certainly result in a misaligned process and certain failure. This method of extruder barrel alignment does not take into consideration the horizontal position of the barrel. Misalignment in the horizontal plane is just as problematic as misalignment in the vertical plane.

Other problems arise when the level used is not a precision measurement machinist level. The resolution and accuracy of a carpenters level or torpedo level is far inferior and will not give the desired results in any orientation.

Even if a machinist level were utilized, level is not necessarily the reference for measuring, the rotational center of the output shaft of the gearbox is the reference that mates to and drives the screw.

A Borescope

Another alignment method for extruder barrels was to use an optical Borescope. A precision bore mounted telescope is installed in the gearbox thrust shaft and “bucked-in” to the mechanical center of the through hole. The eyepiece of the bore scope has a precision cross hair that is focused to infinity. The operator can then sight down the barrel and measure the displacement of the optical target at multiple points along the barrel ID, provided the section is accessible and clean.

The accuracy of the optical measurement is dependent upon the accuracy of the thrust shaft bore. The borescope measurement also relies on human patience in establishing a reference as this process can take hours to complete. The ADVANCED Team’s laser measurement system utilizes the rotational center for reference, therefore accuracy of the bore of the trust shaft is incidental and the reference is typically established in just a few minutes.



Typical Optical Borescope

A Laser-based Extruder Barrel Alignment System

A laser based extruder barrel alignment system is both faster and more accurate. Rather than ambient light traveling up the barrel to the operator's eye looking through the Borescope eye piece; a laser system utilizes a columnated beam of laser light directed from a transmitter that is mounted on the thrust shaft. The laser transmitter can be quickly qualified to project the true rotational center of the thrust shaft at any point along the barrel (or even beyond the end of the barrel if mold position, rollers, casting cans or other downstream production component measurements are needed). The qualified laser beam strikes the surface of a Position Sensitive Detector (PSD) mounted in the barrel. Rather than a cross hair and scale to measure displacement, the PSD very accurately measures the center of the laser beam to less than half a micron and displays the measurement value on a display unit.

Depending on the machine configuration, laser based barrel alignment measurements can be completed in about an hour. Corrections are made using live values that are updated in real time in both the horizontal and vertical plane, cutting the correction time significantly.

There are several laser alignment manufacturing companies that sell laser alignment systems that could be utilized for extruder barrel alignment. A laser system improves accuracy, speed of measurement and reporting on the alignment of the barrel to the thrust shaft rotational center. The typical accuracy of the laser system is 0.001". While the laser system is going to improve the accuracy of the alignment, the money spent on the laser alignment system and the time involved in learning how to properly utilize the technology can sometimes be daunting for a manufacturing plant.

Simply purchasing a laser system does not qualify someone to perform precision alignment; any more than buying a stethoscope makes someone a medical doctor.

Tolerances

Alignment tolerances are a point of contention as they apply to extruder barrels and screws. A typical screw/barrel clearance rule of thumb is as follows:

$$\text{Diametrical Clearance} = \text{Nominal Diameter} \times 0.002''$$

| Nominal Diameter | Specified Barrel I.D. Size | Specified Screw O.D. Size | Barrel/ Screw Diametrical Clearance |
|------------------|----------------------------|---------------------------|-------------------------------------|
| 2" | 2.000 +.001/-0.000 | 1.996/1.995 | .004/.005 |
| 2-1/4" | 2.250 +.001/-0.000 | 2.246/2.245 | .004/.005 |
| 2-1/2" | 2.500 +.001/-0.000 | 2.495/2.494 | .005/.007 |
| 2-3/4" | 2.750 +.001/-0.000 | 2.745/2.744 | .005/.007 |
| 3" | 3.000 +.001/-0.000 | 2.994/2.993 | .006/.008 |
| 3-1/4" | 3.250 +.002/-0.000 | 3.2435/3.2425 | .0065/.0095 |
| 3-1/2" | 3.500 +.002/-0.000 | 3.493/3.492 | .007/.010 |
| 3-3/4" | 3.750 +.002/-0.000 | 3.743/3.742 | .007/.010 |
| 4" | 4.000 +.002/-0.000 | 3.992/3.991 | .008/.011 |
| 4-1/4" | 4.250 +.002/-0.000 | 4.242/4.241 | .008/.011 |
| 4-1/2" | 4.500 +.002/-0.000 | 4.491/4.490 | .009/.012 |
| 4-3/4" | 4.750 +.002/-0.000 | 4.741/4.740 | .009/.012 |
| 5-1/4" | 5.250 +.002/-0.000 | 5.240/5.238 | .010/.014 |
| 6" | 6.000 +.002/-0.000 | 5.988/5.986 | .012/.016 |
| 8" | 8.000 +.002/-0.000 | 7.984/7.982 | .016/.021 |

The right column (in red) indicates the clearance between a new barrel and a new screw. A typical 4" diameter barrel has only 0.008" of diametrical clearance or 0.004" of radial clearance. Misalignment greater than this will cause unwanted barrel and screw interaction.

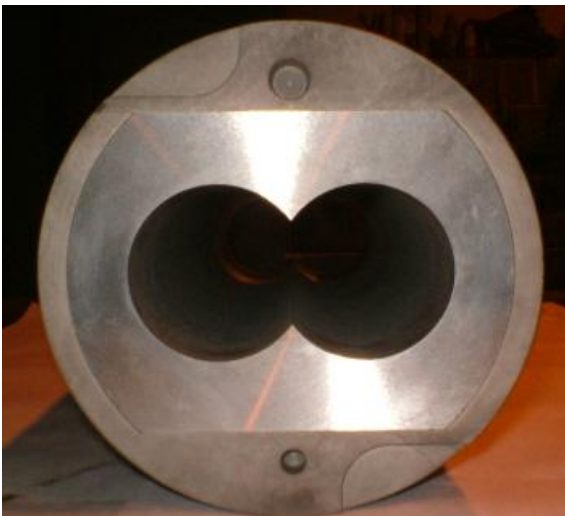
Twin Screw Extruders

A twin screw extruder barrel has the same alignment tolerances as a single screw barrel. Although the measurement procedure is slightly different from a single screw application, the overall measurement goal is exactly the same; to eliminate the unnecessary wear and fatigue failures due to barrel misalignment.

The laser measurement procedure is much better suited to complete this type of barrel alignment. Typically, there is not a thrust shaft with a line of sight hole to allow a Borescope to be mounted. A laser transmitter can be mounted on the gearbox output shaft quite easily and the alignment of the barrel or barrel sections can then be measured in the same manner as a single screw extruder.

For example, years ago The ADVANCED Team performed an alignment on a 35mm twin screw extruder. This extruder had a history of failing screws in less than 30 days. Typically, the screw would shear at the coupling end between the barrel and the gearbox. This is the thinnest section of the screw.

We found the barrel to be out of position at the die end by 0.065" in the horizontal plane and 0.019" too high, relative to the rotational center of the gearbox output shaft. Adjustments were made to the die end of the barrel in both the horizontal and vertical planes. This Extruder has not suffered a broken screw since the Laser Alignment was completed.



Barrel/Screw Diameter vs. The Need for Precision Alignment

Referring to the clearance chart above, and the preceding twin screw case history on 1.4" diameter screws, one should realize that the need for precision alignment is just as important on smaller diameter barrels as it is on large diameter barrels.

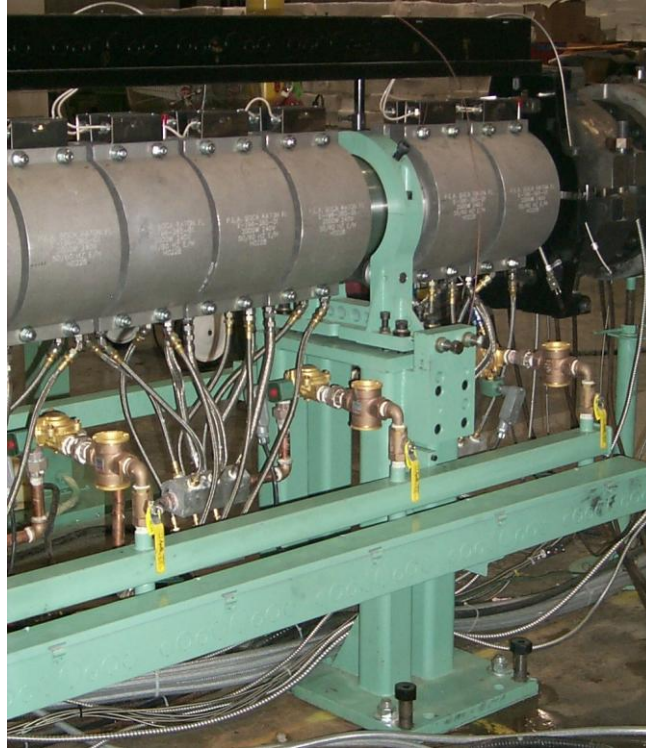
Misalignment, and therefore cyclic fatigue stresses on a 1" diameter screw will cause a failure exactly as it would on a 4" screw. The technology is available and readily adaptable for the measurement of just about any extruder system in use.

Extruder Barrel Supports

The support structure under the extruder barrel is of critical importance to the life of the extruder barrel/screw system and the quality of the alignment as the machine reaches normal operating temperatures. Most extruders have one or more mechanical supports under the barrel. They have 3 basic functions:

- Support the barrel to prevent it from sagging due to its weight.
- Act as an axial guide to allow the barrel to expand and grow in length as the system is heated up.
- Most important...to provide a structurally sound method of making precise vertical and horizontal adjustments to properly align the barrel with the thrust shaft rotational center.

All too often, extruder barrel supports do not have mechanism(s) for alignment. This leads to more time and dollars in making the alignment possible. The lack of jacking bolts and/or shims should not be justification for believing that the alignment process is unnecessary.



This is an example of a properly supported and adjustable barrel.

As you can see in the picture above, the barrel is adequately supported, has plenty of clearance to insert shims to perfect the vertical alignment and has horizontal jacking bolts to allow for precision positioning of the barrel in the horizontal plane.

Moving an Extruder? Beware of Inducing Misalignment

If you plan to move an Extruder within your facility, or if you are installing an extruder that has been shipped to your facility, be aware that it is probably misaligned. Even if it was Laser Aligned at some other location! That's right. Just because it was Laser Aligned before it was moved or shipped, does not indicate that it will be in the proper position when it is re-installed.

This is not a theory, it is factual. Time and time again on-site measurements at the "new" location have proven that a previously "properly aligned"

extruder barrel is not properly aligned after moving, rigging, trucking, ocean voyages, etc. Misalignment as much as .232" (5.8mm) has been measured in the "new" location after the barrel was laser aligned in a previous location. OEM's are acknowledging this and several are now calling for Laser Alignment to be performed on-site, even though they aligned the barrel in their manufacturing plant.

Thermal Growth of the Extruder Barrel

After the alignment, the extruder screw will be inserted in the barrel, the screen changer, mold or other downstream components will be placed back in the system and the production line will be re-started. As the extruder barrel heats up it is going to expand.

If the barrel is supported from below, it will rise in elevation as the barrel temperature reaches a stable operating point. These elevation changes will have an impact on the alignment of the barrel. The thermal growth at the die end of the machine, as well as at any other supports should be measured and accounted for as part of the alignment process.

Measurements have confirmed a 0.0125" change in the elevation on a 3" diameter barrel when heated up to approximately 600°F. That is a diametrical change. The centerline change in the vertical plane will be exactly half of that value; or 0.00625".

What does this mean? It means that a barrel, aligned to "zero" in the horizontal and vertical planes cold will be misaligned slightly when the process is heated up. Every effort should be made to account for these changes when aligning the barrel in its cold state.

With today's measurement equipment, obtaining the changes in barrel elevation and horizontal position from Off Line and Cold to operational conditions is relatively easy.

Conclusion:

Today's manufacturing environment demands maximum production at minimal cost. Eliminating losses in process streams will help ensure that a manufacturing facility maintains its competitive edge and stays profitable for the long term. There aren't many areas in a facility that will exhibit the return on investment faster than properly installing and maintaining production process equipment. ROI is extremely important in the plastics industry, where the "other guy" is always knocking on your customers door.

Modern methodologies and measurement tools streamline installation and maintenance jobs saving time, money and frustration. One of the most expensive phrases in manufacturing and in maintenance is, "That's the way we've always done it."



Don't let this happen to you!

For more information please contact:

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