

Uniloy is proud to introduce this month's web posting which features information about **extruder barrel and screw wear**, its effects, how to evaluate your extruder performance, and how to decide if it's time for a new barrel and screw. The information in this posting will focus on the 250R, the 350R and the 400R series machines.

The moral of the story is you should replace your barrel and screw when either:

1. Your extruder output has fallen to the point where desired output levels cannot be achieved.
- Or
2. Using the calculations in this posting, you can cost justify replacement based on loss of productivity and higher cost of energy.

[CLICK HERE](#) for a spreadsheet that is provided to make these calculations easier to compute. The assumptions used below are loaded into the yellow cells of the spreadsheet to get you started.



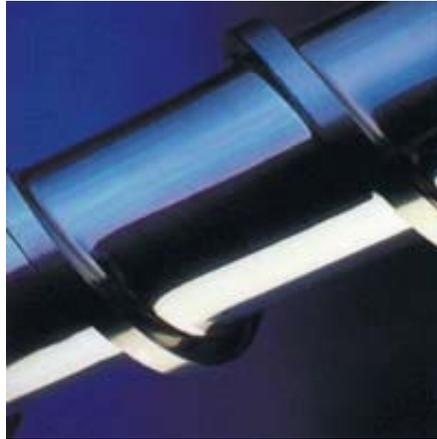
One of the most common causes of poor extruder function is excessive barrel and screw wear which leads to:

- Decreased plastic throughput
- Increased energy consumption
- Increased shear heat and melt temperature

Barrel and screw wear occurs between the top of the screw flight and the inside diameter of the barrel. As the amount of wear increases, the screw O.D. gets smaller and the barrel I.D. gets larger creating more clearance between the screw flights and the barrel. While operating the extruder in this condition, the increased clearance allows plastic to pass over the flights of the screw instead of continuing forward. This slippage is the cause of decreased plastic throughput, increased shear heat, and increased melt temperature. Increasing extruder drive speed to compensate and regain desired throughput is possible to a point, however, this is limited to the maximum screw speed for a given drive size. Increasing the extruder drive speed also results in increased energy consumption for a decreased throughput.

How Do You Evaluate the Condition of Your Extruder Barrel and Screw?

The quickest way to evaluate your existing barrel and screw is to perform a throughput test. This test can be performed with minimal interruption to your production schedule and without any disassembly of the machine.



The proper procedure for measuring throughput is:

1. Set the extruder drive speed so that the screw is turning at maximum speed (rpm).
2. Press the charge button.
3. Start your stopwatch.
4. Clear all the plastic below the head.
5. Release the charge button.
6. Allow the extruder to produce plastic for 60 seconds. (timed with stopwatch)
7. At the 60 second mark, press the charge button.
8. Stop the extruder.
9. Collect the plastic extruded during the timed 60 seconds.
10. Weigh this plastic (lbs/min) and multiply the weight by 60 (min/hr).

* This will give you the total throughput of the machine in lbs./hr

* Use the appropriate values from Table 1 below to evaluate your results

Please note: If the results from the throughput test show a capacity reduction of 15% or more, your barrel and screw have significant wear and should be considered candidates for replacement.

Table 1: Maximum Throughputs

Screw Size (Dia.)	Drive Size (HP)	Screw Speed (rpm)	Screw Type		
			General Purpose (lbs/hr)	Generation 1 High Output (lbs/hr)	UR Series High Output (lbs/hr)
2.5	50	150	275	320	325
3.5	75	100	480	550	625
3.5	100	135	600	680	780
3.5	125	150	650	725	845
4.0	125	115	750	800	875

Example:

We are evaluating a 350R2 with a 100 Hp drive and a General Purpose Screw. During the throughput test, the drive motor was turned up so that the screw speed was 135 rpm. Running the extruder at this speed for 60 seconds produced 8.5 lbs of plastic.

$8.5 \text{ lbs/min of plastic} \times 60 \text{ min/hr} = 510 \text{ lbs/hr of plastic}$

From Table 1, the maximum lbs/hr for a GP screw at 135 rpm is 600 lbs/hr.

This means the extruder has a reduced capacity of $600 - 510 = 90 \text{ lbs/hr}$.

This represents a $(90 \text{ lbs/hr}) / (600 \text{ lbs/hr}) = 15\%$ reduction in throughput capacity.



Increased Cost of Production by Running with Reduced Extruder Capacity

The machine in the example above has a badly worn barrel and screw. This is evident by the reduced capacity measured in the throughput test at maximum screw speed. What does this mean in terms of capability to run production?

Let's say the machine is a 6 head running a 90 gram bottle with flash, and a desired cycle time of 8 seconds.

The required lbs/hr would be:

$(6 \text{ heads/cycle}) \times (90 \text{ grams/head}) \times (60 \text{ sec/min}) / (8 \text{ sec/cycle}) \times (60 \text{ min/hr}) / (454 \text{ grams/lb})$

$= 536 \text{ lbs/hr}$

This would normally require a screw speed of 121 rpm and a motor speed of 1563 rpm. Because of the wear on the barrel and screw, and the decreased throughput, the worn screw speed would need

to be 142 rpm. Unfortunately, as shown in Table 1, the maximum screw speed using a 100 hp motor is 135 rpm and based on the throughput test, we know the machine is only capable of 510 lbs/hr. As a result, we can calculate the minimum cycle time with the worn screw as:

$$(6 \text{ heads/cycle}) \times (90 \text{ grams/head}) \times (60 \text{ min/hr}) / (454 \text{ grams/lb}) \times (60 \text{ sec/min}) / 510 \text{ lbs/hr} \\ = 8.4 \text{ sec/cycle}$$

Running in this condition means lost production. The machine is now limited to producing 2571 bottles/hr (6 heads at 8.4 sec/cycle) compared to the production of 2700 bottles/hr (6 heads at 8.0 sec/cycle) which would be possible with a new barrel and screw.

Calculating the cost of lost production

As an example, assuming a 3 shift operation and a selling price per bottle of \$.15=

2700 bottles/hr – 2571 bottles/hr = 129 bottles/hr of lost production

129 bottle/hr x 6000 hr/year = 774,000 bottle/year of lost production

774,000 bottle/year x \$.15/bottle = **\$116,100** per year of lost revenue

Increased Cost of Energy by Running with Reduced Extruder Capacity

Table 2 below contains the drive energy cost to produce plastic with 50, 75, 100, and 125 hp drives and new extruder screws and barrels. These values assume 6000 hours of operation per year and \$.08 per Kwh energy cost.

Table 2: Annual Energy Consumption Costs with New Barrels and Screws

THRUPUT LBS/HR	GP SCREW				UR SERIES HIGH OUTPUT SCREW			
	50 HP	75 HP	100 HP	125 HP	50 HP	75 HP	100 HP	125 HP
225	\$14,371				\$12,189			
275	\$17,581				\$14,875			
300		\$15,474			\$16,257			
325		\$16,717			\$17,565			
350		\$18,038						
400		\$20,615				\$15,836		
480		\$24,746	\$23,386	\$27,270		\$19,010		
500			\$24,339	\$28,382		\$19,784		
550			\$26,771	\$31,218		\$21,762	\$20,626	
600			\$29,207	\$34,058		\$23,741	\$22,502	\$26,198
625				\$35,487		\$24,737	\$23,446	\$27,297
650				\$36,886			\$24,370	\$28,374
780							\$29,240	\$34,044
845								\$36,896

Note: The energy costs shown here for the 75, 100, and 125HP VFD drives are calculated based on 350R extruders. The 50HP drive is utilized exclusively on the 250R1.

Table 2 can be summarized as the following energy cost per 100 lbs:

Cost per 100 lbs	GP SCREW				UR SERIES HIGH OUTPUT SCREW			
	50 HP	75 HP	100 HP	125 HP	50 HP	75 HP	100 HP	125 HP
	\$1.06	\$.859	\$.811	\$.946	\$.901	\$.660	\$.625	\$.727

Continuing our previous example, you can see from the information above, the drive cost to produce plastic using a new GP screw and a 100 hp drive can be expressed as \$.811 per 100 lbs. Given this rate we can calculate the cost to produce 536 lbs/hr for that year at:

$$\text{Drive Cost} = (.811 \text{ dollars}/100 \text{ lbs}) \times (536 \text{ lbs/hr}) \times (6000 \text{ hrs}) = \$26,082$$

In the example, the extruder became limited to 510 lbs/hr which **should** cost:

$$\text{Drive Cost} = (.811 \text{ dollars}/100 \text{ lbs}) \times (510 \text{ lbs/hr}) \times (6000 \text{ hrs}) = \$24,817$$

Since the extruder is consuming energy at a rate 15% higher than normal, the elevated rate can be calculated at:

$$\text{Inflated drive cost} = 1.15 \times .811 = .933 \text{ dollars}/100 \text{ lbs}$$

This means producing 510 lbs/hr for a year will now cost:

$$\text{Drive Cost} = (.933 \text{ dollars}/100 \text{ lbs}) \times (510 \text{ lbs/hr}) \times (6000 \text{ hrs}) = \$28,550$$

This is an extra **\$3,733** a year at the increased cycle time of 8.4 seconds.

The obvious answer to the problem presented in the example is to replace the barrel and extruder screw with a new GP screw. There is another solution that could not only restore the extruder to its original level of productivity, but improve to an even better level.

The UR Series High Output Screw offers a drive cost of \$.625 per 100 lbs. This means that a year's production at 536 lbs/hr would only cost:

$$\text{Drive Cost} = (.625 \text{ dollars}/100 \text{ lbs}) \times (536 \text{ lbs/hr}) \times (6000 \text{ hrs}) = \$20,100$$

This is a savings of **\$5,982** over a new GP screw and **\$8,450** over the worn GP screw and a restored **8.0** second cycle time.

Bottle Quality is Affected Too

Losses of productivity combined with wasted drive energy are not the only downsides of running a worn barrel and screw. Wasted drive energy being consumed produces unwanted heat in the extruder. This extra heat increases melt temperature of the plastic, which causes reduced bottle quality and increased load on barrel and mold cooling systems.

Do I Replace the Screw, the Barrel, or Both?

Table 3 contains the dimensions of new barrels and screws and the nominal clearance between them when the parts are new.

Table 3 Screw to Barrel Clearance

Extruder Size	Barrel I.D.	Screw O.D.	Clearance	Nominal Clearance
2.5	2.500/2.501	2.496/2.494	.004/.007	.006
3.5	3.500/3.502	3.494/3.492	.006/.010	.008
4.0	4.000/4.002	3.994/3.992	.006/.010	.008

Note: All dimensions are in inches.

As a rule of thumb, when the clearance between the barrel and screw doubles from the nominal clearance it is time to replace one or both of these components.

For example, from the table above we see that the outside diameter of the 3.5" extruder screw is 3.492" to 3.494" while the inside diameter of the barrel is 3.500" to 3.502". This means that when both components are new, there is an .008" nominal diameter difference. If an additional .008" wear occurs so that the diameter difference grows to .016", then the barrel and/or screw should be replaced.

To check the physical dimensions of the existing barrel and screw, the screw must be removed from the barrel. Use Bakelite Natural 7 Purging Compound in the extruder before disassembling. Remove the head assembly and then the extruder screw from the barrel.

Checking the Inside Diameter of the Existing Barrel

Clean, polish, and inspect the I.D. bore of the barrel to ensure that it is completely clean of any remaining plastic or purging compound. Measure the bore of the barrel with a bore gage (with extensions). Pay special attention to the front third of the barrels' bore, this is normally where the barrel wears during normal use.

Checking the Outside Diameter of the Existing Screw Flights

Clean and polish the screw flights so that they are free of any remaining plastic or purging compound. Using a micrometer and a parallel bar, measure each flight diameter, making sure to always span three flights with the parallel bar. The parallel bar should always be located as close to the screw centerline as possible to obtain the most accurate measurements. The measurement of each flight will be calculated by subtracting bar thickness from the micrometer reading.

Example

The barrel and screw from a 350R2 are removed from a machine and measured. The barrel I.D. is found to measure 3.505" and the screw flights measure as small as 3.489". These readings show wear in the barrel of:

$$\text{Barrel wear} = 3.505 - 3.501 = .004''$$

The readings show wear on the screw flights of:

$$\text{Screw wear} = 3.493 - 3.489 = .004''$$

$$\text{Total wear} = .008''$$

By adding the total screw wear to the normal screw flight to barrel clearance, we get a total clearance of:

$$\text{Total clearance} = \text{total wear of } .008 + \text{nominal clearance } .008 = .016''$$

Based on this amount of combined barrel and screw wear, the barrel **and** screw should be replaced to regain full production capacity and optimum energy efficiency. Replacing either the barrel **or** screw in this case would only regain half the lost production and efficiency.

Sales and Service

For more information new barrels and screws, please contact your local Uniloy Parts Sales Representative. Trained Uniloy Service Representatives are available to assist in the installation of these packages at your facility.