TSB GEN 0001

TECHNICAL SERVICE BULLETIN

EXTRUSION EFFICIENCY

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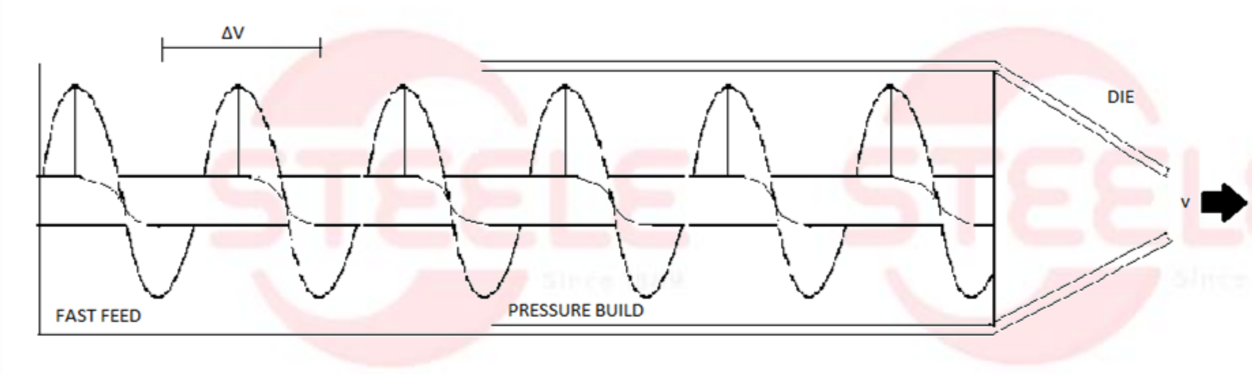
THEORY

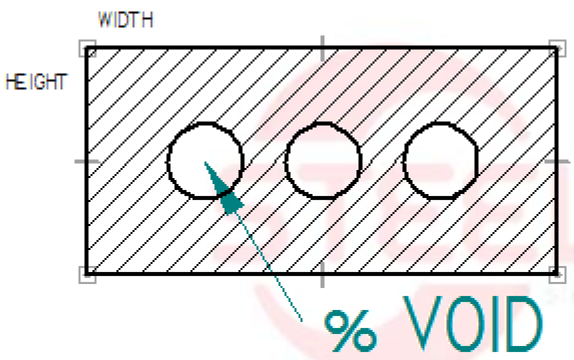
Extrusion efficiency, η_{eff}, is a ratio of the actual volume displaced by 1 auger revolution, ΔV_{actual}, to the theoretical volume displaced by one auger revolution, ΔV_{theo}. ΔV_{theo} represents a no-slip condition, where the distance a particle is displaced with 1 auger revolution is equal to the length of 1 auger. In reality, multiple types of slip can occur, causing the actual volume displaced to be less than the theoretical value. The theoretical volume can be calculated by multiplying the pitch by the cross-sectional area, then subtracting the area of the auger wings. The limitations of this measurement include that the model ignores power consumption and assumes a uniform drag coefficient. The standard practice is to define ΔV_{theo} at the entry into the point auger.



CALCULATION

The extrusion efficiency, η_{eff}, as mentioned previously, is the ratio of actual volume displaced to theoretical volume displaced: $\frac{\Delta V_{actual}}{\Delta V_{theo}}$. ΔV_{actual} is difficult to directly measure, but can be calculated using the area of the front face of the brick, the velocity of the brick as it leaves the die, and the rotational speed of the augers.

For a clay product:



% void represents the area percentage of the holes with respect to the entire brick. The total brick area can be calculated as shown below:

$$A_x = (1 - \%\, void) \cdot h \cdot w$$

This area is used in the extrusion efficiency calculation:

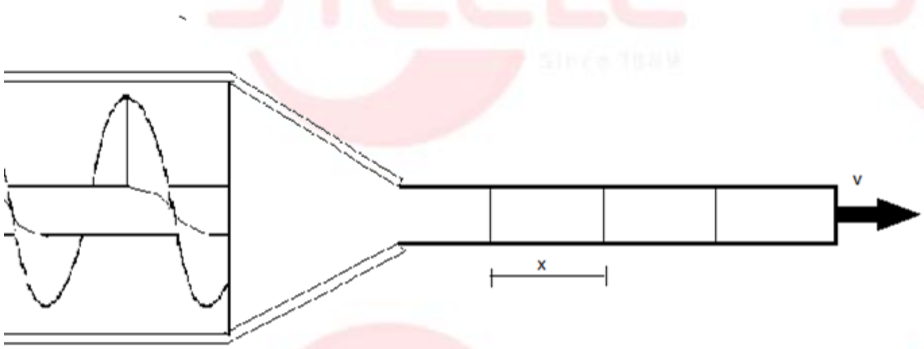
$$\eta_{eff} = \frac{A_x \cdot v}{\Delta V_{theo} \cdot \omega}$$

where ω is the RPM of the augers.

Now the only unknown variable in the calculation is the velocity, v.

The velocity can be measured 2 different ways. The first is by using a handheld RPM gauge. Due to the non-constant velocity of the brick as it exits the die, this method is prone to error.

The second method uses the cutting frequency of the slug cutter:



f = slug cutter frequency (cuts per minute)

x = length per cut

$v = f \cdot x$ (length/time)

It is important that "x" be the entire slug length and not just usable brick length when calculating extrusion efficiency. To not include slug returns is a measure of process efficiency instead. Likewise, any die trimmings should be included when calculating A_x. If you are not using a slug cutter (i.e. pelletizing), consult TSB GEN 0002 for velocity measuring methods.

MACHINE	THEORETICAL VOLUME DISPLACEMENT (IN^3)	THEORETICAL VOLUME DISPLACEMENT (M^3)
HD10 HCV	229	0.00375
HD10 HTR	229	0.00375
25BEX SCV	560	0.00918
25BEX CAR	560	0.00918
45ATX, "C" SET	1790	0.02933
45ATX, PR-16 SET	1050	0.01721
75ADEX CV	1622	0.02658
75ADEX BR-16	1390	0.02278
90ADEX, HCV	2060	0.03376
90ADEX, HTR	1750	0.02868
120ADEX HCV	2990	0.04900
120ADEX HTR	2990	0.04900

CONVERSIONS

STANDARD	METRIC
1 inch	25.4 mm
1 foot	0.3048 m
1 lb	0.4536 kg
1 in/min	0.000423 m/s

USE

The extrusion efficiency calculation was developed as a means to compare machines against each other. It can also be used to compare the efficiency of different processes using the same machine (i.e. different materials) or compare machines of different sizes. Comparing measured efficiency to an expected value can help determine when wear parts need to be replaced.

FACTORS

Here are some factors that may affect extrusion efficiency:

- Moisture content of material
- Backflow due to gap between augers and liner
- Slickness of augers
- The capacity at which the augers are run (how much material is in the fast feed area, i.e. starving vs full augers)
- Wear state of the auger and liner (affecting distance between auger and liner)
- Material Characteristics (i.e. coefficient of friction, temperature, plasticity)