Extrusion screw speed and fit affecting pasta quality

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Pasta makers must maintain proper extrusion screw speed and screw to barrel fit to optimize pasta quality. These factors assist in keeping the extrusion process slow and warm. A slow and warm extrusion process achieves the best results by preserving the mechanical properties of the glutens that form good pasta. Glutens act as the binder for the pasta giving it strength and texture, desirable aspects for cooking quality and taste.

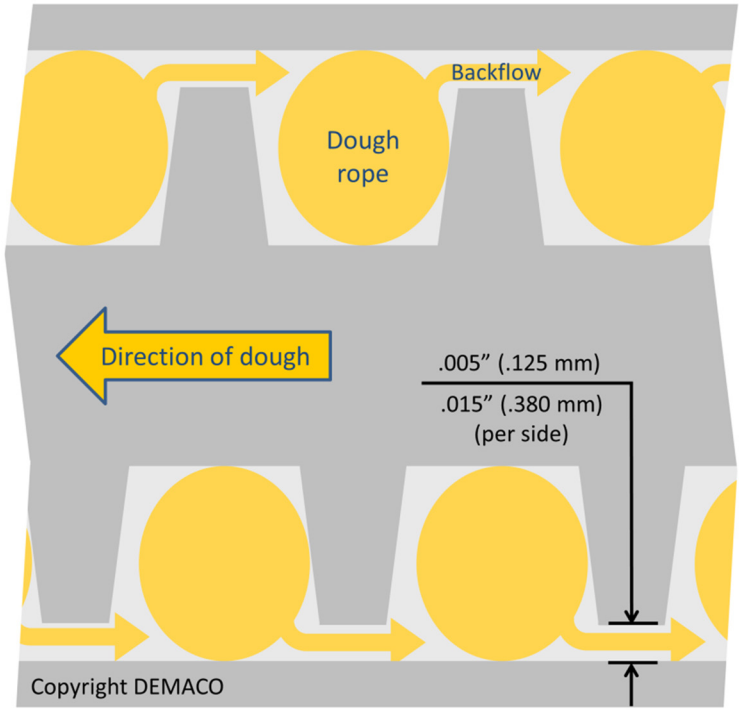
Screw speed

Operators should run the extruder at a target screw speed of 22-24 rotations per minute (RPM). Artisan pasta makers usually drop the speed to 18 RPM or less. The extruder must knead the dough with the screw and build enough pressure inside the cylinder to push the dough through the die. This process creates heat and heat can transfer to the dough. Dough needs some heat to become malleable enough to squeeze through the die. However, too much heat destroys the gluten structure. Thus, pasta makers must carefully maintain the correct temperature of the dough, a temperature that balances dough malleability with preserving gluten structure. The speed of the screw significantly impacts the heat generation in the process and temperature of the dough.

Screw fit

Proper screw to barrel fit enhances pasta quality by preserving gluten structure. A good fit is when the screw rotates inside the cylinder freely, but tight enough to push the most amount of dough forward to the die with minimal loss from backflow.

Backflow occurs when dough slips over the flight of the screw and does not advance forward or even travels backward. This slippage damages the gluten structure of the dough by subjecting it to both excessive shear at pinch points between the screw and cylinder and unnecessary heat caused by friction. In turn, this overworks the dough, which degrades pasta quality.



Backflow of dough over flight of extrusion screw inside cylinder barrel. The dough rope is in the cavity created between the screw flights, the screw root and the inside of the barrel. Tolerance for good screw to barrel fit is shown.

A well-made, properly functioning extruder has a .010-.030 inch (.250-.760 mm) gap between the screw flight and the inside wall of the barrel. As this gap widens, the screw becomes less efficient at pushing the dough rope forward resulting in more backflow.

Basics of pasta dough rheology

In a well-functioning extruder, the screw and cylinder barrel achieve good dough flow in the form of a dough rope. When the dough balls or "crumbles" enter the cylinder from the mixer, they compact to form a viscous rope. As the screw rotates, it transports the dough rope in the space or "cavity" created between the screw flights and the inside wall of the cylinder barrel. The dough rope winds around the screw root and the screw flight pushes the dough rope forward towards the die. As the rope hits the die, the dough becomes compressed as its flow becomes obstructed. Essentially, the free flowing dough rope hits a wall (die) with tiny holes (die inserts). The viscous dough resists flow through the die inserts and becomes compressed against the die. As the screw continues to push the dough rope forward, the compression increases and creates pressure. As the pressure mounts, the screw eventually presses the dough through the die.

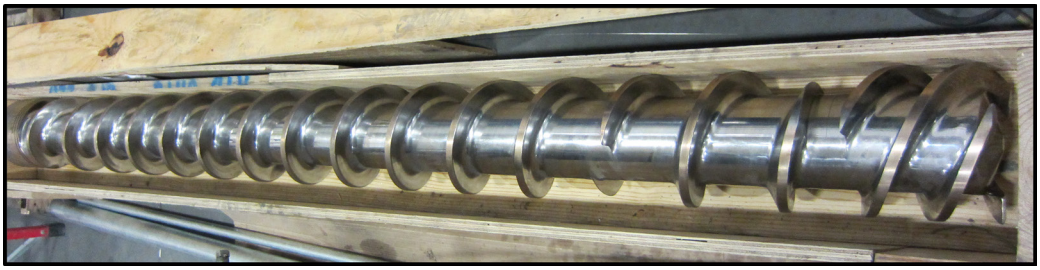
Screw and cylinder wear

Pasta dough is abrasive and wears the extrusion screw and cylinder, increasing the gap between them. The rate of wear depends on several factors, including type of dough, construction of the screw and cylinder, maintenance interval, and sanitation procedures.[1] For example, some additives such as ground black pepper are extra abrasive. However, hardened flights and barrels can significantly resist wear. Daily wash-down sanitation procedures using caustic cleaning agents can significantly increase corrosion and wear.

To account for wear, some equipment manufacturers design screws and barrels for easy refurbishment to original factory specification. Typically a pasta maker can refurbish a screw several times before refurbishing a cylinder. In particular, screws with bronze coated flights facilitate rebuilding by reapplying the bronze. This makes it easier for pasta makers to keep the screw and cylinder to within factory specification.

Impact of wear and screw speed

As the screw and cylinder wear, the extruder pushes less dough through the machine under the same RPM and dough temperature. Thus, pasta makers produce less pasta at the target RPM of the screw. To account for this, some pasta makers increase the RPM trying to maintain the same level of extrusion output. However, increasing the RPM in an attempt to maintain the rated capacity increases backflow and reduces pasta quality. As a rule of thumb, a drop of 10-15% in production while running the extruder at the target RPM or increasing screw



7.5 inch (190mm) diameter extrusion screw with bronze coated flights from DEMACO.

speed to 30 RPM or higher indicates the screw and cylinder require replacement or refurbishment.

Quality extruder manufacturers rate capacity of the machine based on a target screw speed of 22-24 RPM. A pasta maker can easily raise the RPM to increase production, but doing so increases the risk of damaging the gluten structure. Higher RPM usually means increased temperature of dough and higher pressure. Higher pressure results in more backflow, further compounding the problem of damaging dough and reducing the quality of pasta.

Conclusion

Extrusion screw speed and screw to barrel fit impact backflow and dough temperature, two important elements related to pasta quality. Maintaining proper screw to barrel fit helps pasta makers utilize ideal screw speeds without incurring excessive backflow.[2] When it comes to pasta quality, screw speed and backflow are interrelated. With all other factors equal, increasing the RPM of the screw also increases dough heat and backflow, which impact the gluten structure of the dough and ultimately the quality of the finished product. The master pasta maker must carefully manage all of these factors to make the best possible pasta.

Leonard J. DeFrancisci works at DEMACO. All pictures & diagrams compliments of DEMACO.

[1] Interview between John Eureka, Nestlé Research & Development Engineering – Solon, Ohio and the author in January 2012.
[2] Interview between Jay Vermylen, President of A. Zerega's Sons, Inc. and the author in January 2012.