Highlights 10 years of Feed Tech

Extruders: cook, form,

A bewildering variety of extrusion devices are used in today's technology. A feed extruder is a device that expedites the shaping and restructuring process for feed ingredients. Extrusion is a highly versatile unit operation that can be applied to a variety of feed processes. The devices are constructed in many different ways and are given many different names. Extruders can be used to cook, form, mix, texturise and shape feed products under conditions that favour quality retention, high productivity and low cost.

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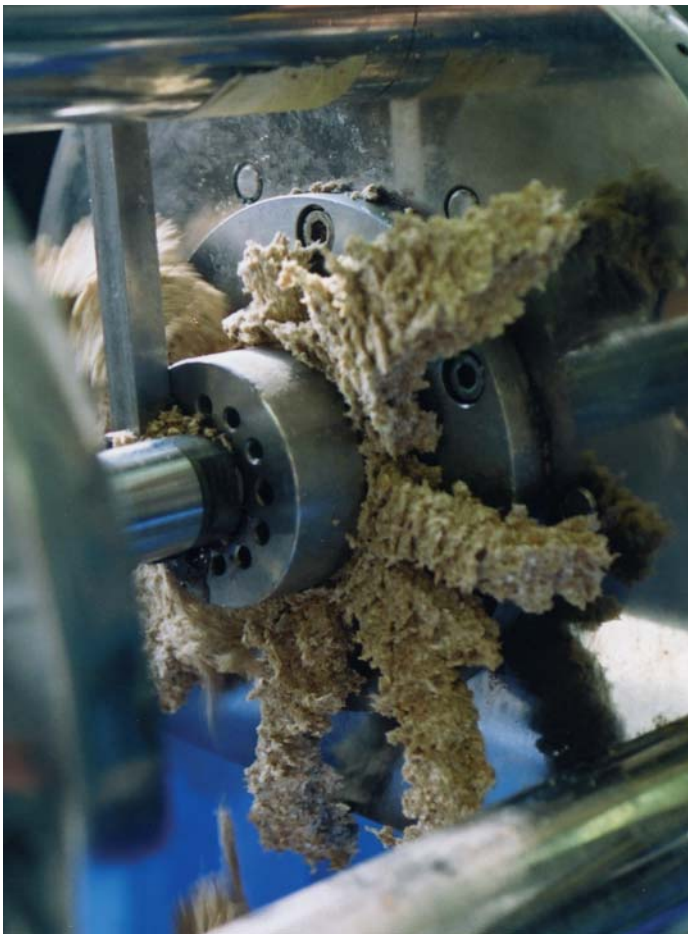

Extruders have become very versatile processing machines that allow feed manufacturers to use ingredients that are otherwise difficult to process. (Photo: Dick Ziggers)

Extruders and expanders have general similarities in terms of design and function. They are, however, not the same. Even within the extruder family, there are many not-so-subtle differences that have a major impact on the characteristics of the end product. Extruders can be broadly classified as dry or moist, and as single or twin screw. Dry extrusion usually implies process moistures of 18% or less, while moist extrusion generally processes recipes at a higher moisture level.

There is less functional difference between the expander and the single-shaft extruder. Both systems work according to the common high-temperature short-time (HTST) principle and use approximately the same treatment parameters, such as temperature, pressure, kneading and shearing forces, product moisture, and shaping.

In general, the expander produces an unshaped pellet while the extruder creates a shaped pellet. It is possible to produce a shaped pellet with the expander without the use of a pellet mill; the only real difference in the process is the final product moisture content. The expander works with product moisture of max 22% and a subsequent drying of the product is usually not required.

For extrusion of special feed by a single-shaft extruder, product moisture of 25-30% is required, as well as subsequent drying of the product. Another feature of the expander, including the Anderson machine, is the fact that the kneading and shearing forces are generated via special paddle configurations using stop bolts. The Andritz Sprout expander, however, works with a worm configuration instead of paddle/stop bolts.

More flexible with cone

In the oilseed crushing industry, the raw materials to be processed with the expander have a high fat content. In the feed industry, how ever, raw materials normally have a low fat content and are more difficult to process. For increasing the flexibility of the

mix, texturise and shape

Die configuration have become very flexible. (Photo: Extru-Tech)

Some extruders heat the material as it extrudes and causes the material to "expand" upon extrusion. These special kinds of extruders are used in the feed industries to make "expanded" products. Since these heating extruders "expand" the products, they are often called "expanders." The word "expander" has become a generic name in the oilseeds milling industry for a type of cooking extruder first built by the Anderson International Corporation known as the Anderson International Grain Expander. In the mid-eighties Amandus Kahl recognised the advantages resulting from the use of such a machine for the production of compound feed, especially with regard to improving the nutritive value and pellet quality.

Kahl machine in the feed industry, it has been equipped with an annular gap system instead of a stationary die, so that various individual feedstuffs, and mixtures, can be treated in an optimum way. A special feature of the Kahl annular gap expander is the use of a cone instead of a die at the product outlet, which is hydraulically adjustable in order to ensure a specific control of the energy input into the product.

Several expander manufacturers, such as Almex, Bühler, Kahl and Andritz Sprout, have advanced the expander to be equipped with various outlet accessories and its use has been extended to a variety of situations.

Uses of expander

The expander is often used as a pressure conditioner before the pellet mill for improving the pelleting properties and nutritive effects. It can also be used as a standalone machine for producing a crumbled, but not pelleted, product which is fed to the animals directly. The field of application is not limited to the hydrothermal pressure treatment for improving the nutritive value, but the expansion also helps to reduce pathogen germs, inactivate anti-nutritive factors, modify starch, and increase the content of rumen undegraded protein.

The first expanders, produced in the sixties by Anderson International (*Figure 1*), were used mainly in the oil milling industry. The outlet of this expander was equipped with a firmly mounted die, a separate conditioner before the expander for water, and steam addition, which had not yet been provided. Water and steam were added in the expander. Experimentation with the interrupted expander showed that, unlike the screw press, the expander operated well without any preconditioning of the feed material other than grinding.

The interrupted flight design mixes and thoroughly blends injected water and steam into the feed material. This allows the expander to accept a dry, free-flowing material, therefore simplifying the preparation equipment.

Through the years, interrupted flight expanders have manufactured human foods, animal feeds and adhesives made from cereal grains. Interrupted flight expanders impart cooks that destroy undesired enzymes, such as urease, lipase and myroxinase. These expanders transform oilseeds, such as cottonseed and soybean and screw pressed oilseeds, into porous collets that dissolve extract very efficiently. Interrupted flight expanders also dry synthetic rubber by mechanical friction.

Varying levels of temperature and moisture inside the barrel have an influence on the grade of cook. Moisture can vary from 0-15%. Temperature can vary from 120°F to 320°F (49°C to 160°C). Direct-injected water and steam influence moisture. Temperature is influenced by the amount of final moisture injected as steam as well as the friction generated per kg of material. Horsepower consumption is influenced by the number and size of dies through which the material is forced to flow, as well as the level of moisture.

Gelatinisation and puffing

Cooking gelatini.ses starch into an elastic adhesive that glues the solid particles into an inflatable mass. When this inflatable mass leaves the expander's high-pressure interior and passes into an atmospheric pressure environment, some moisture will vaporise. This inflates and stretches the mass with many small internal holes, giving the mass a porous interior composition. Conditions within the expander can easily control the degree of puffing. Puffing requires that the material contains some ingredients that can

Table 1 - Specific qualities of some expanders

Make	Special features
Anderson	Extruder head with fixed die
	Extruder head with adjustable jaws
Kahl Annular Gap Expander	6 sizes with capacity ranging from 100 kg/h to 80 t/h
	Barrel in different lengths, depending on the requested treatment intensity, equipped with paddles and stop bolts
	Additional direct steam addition via purpose-made stop bolts
	Annular gap outlet, hydraulically actuated, controlled via the kWh/t energy input
	Separate crusher of structuriser with beaters and screen basket following the expander
Special applications	*Extruder head with hydraulically movable die and knife head*
	Slide outlet, 3 slides hydraulically controlled + structuriser
Almex Contivar™ Expander	Five sizes from 1 to 80 t/h
	Barrel in different lengths, depending on the requested treatment intensity, equipped with paddles and stop bolts
	Additional direct steam addition via special steam nozzles
	AD head: Active disc system (hydraulic slide), hydraulically actuated, controlled via the kWh/t energy input,
	Separate crusher following the expander
Special applications	*Cone outlet, motor controlled + separate crusher*
	D head: Extruder head with fixed die and knife head
	DAD head: Combination of AD and D head
Bühler Expander Condex	2 sizes ranging from 6 to 24 t/h
DFEB -315 and DFEA -220	Barrel equipped with paddles and stop bolts
	Additional direct steam addition via purpose-made stop bolts
	Annular gap outlet, hydraulically actuated, controlled via the kWh/t energy input, with integrated cutter head for crushing the product
Andritz Sprout Feed	Three sizes ranging from 6 to 80 t/h
Expander, Fex	Barrel with continuous worm thread in standard length and one outlet paddle
	Additional direct steam addition is possible
	Annular gap outlet, hydraulically actuated via 3 hydraulic cylinders, with nozzle adjustment
	Separate crusher following the expander

become sticky and inflatable, usually starch.

In the 1970's and 80's, other companies developed an expander for the production of expanded animal feed. This expander replaced the stationary die with an outlet cross-section which can be adjusted during operation. Conditioning with steam and water took place in a separate short-term conditioner. The paddle designs were adapted to the feed products and the treatment intensity. The expander, therefore, became a more versatile machine and was given preference for the production of poultry, pig, and cattle feed.

A typical expander consists of a barrel which is equipped with stop bolts. Paddles of different geometry and effect are mounted on the expander shaft. The product is sheared and kneaded when passing through the machine by means of these paddles and stop bolts. This effect can be increased by adding direct steam into the expander.

Contrary to the traditional extruder, the outlet is not formed by a fixed die, but by a hydraulically actuated cone, making way for an annular gap similar to a valve. Depending on the product to be treated, the internal pressure in the expander can be changed by the hydraulic pressure on the cone and the corresponding change of the cross-section in the annular gap.

Slotted-wall expanders

Oilseeds containing more than 30-33% oil cannot be extruded through a closed-wall expander because the oil accumulates within the expander and stops steady state operation. In an effort to reduce the oil level, extracted meal is sometimes mixed with the fresh oilseed. This reduces the oil level, however, the reprocessing of extracted solids increase the load on the expander, the solvent extractor, and the desolventiser. This may force the plant to run at reduced capacity. Williams developed a slotted-wall expander that can make collets from high oil materials by allowing the liberated oil to escape through the slotted-wall drainage cage.

Expanders are also used in preparing oilseeds for mechanical crushing. Soybean can be passed through a high shear interrupted-flight extruder equipped with a rotating cone point at the end of the shaft to shear and force the bean to flow between adjustable jaws. This converts the unbroken beans into a frothy

The UP/C allows the processor to utilise many raw materials that do not process well in a conventional pellet mill such as those which contain high fibre or high levels of sugar. (Photo: Wenger)

meal of fluid-like consistency.

The main features of the expander variants of the different manufacturers are described in *Table 1.*

Universal pellet cooker

Another extrusion-based system is the (Wenger) patented Universal Pellet/Cooker (UP/C), cooking system and process. It was designed specifically for the production of livestock feeds, however, due to its design it can also be used to make other extruded products such as aquatic feeds and some pet food. The UP/C allows the processor to utilise many raw materials that do not process well in a conventional pellet mill such those which contain high fibre or high levels of sugar.

The UP/C needs to be considered as an alternative to the conventional pelleting process. From an economic standpoint it is likely that the UP/C may never directly compete in the production of large volume, low margin pelleted feeds. Its unique design gives special processing advantages to producers who use raw materials that vary significantly, diets that contain high levels of internal oil, or high lactose diets. The UP/C should also be considered in cases where the animal performance is enhanced by this high temperature short time process.

Opportunities and applications

Low moisture or dry extrusion has been utilised in the feed industry for many years. Although applications have usually been limited to extrusion of dietary ingredients such as full fat soy, extrusions of complete diets without a pellet press have been employed. Extrusion has been used to process:

- full fat soybeans and other high oil ingredients
- piglet feed and calf starters
- hygienic feeds for poultry
- protein by-pass feeds for ruminants
- aquatic feeds
- pet foods
- feeds containing high levels of wet by-products
- enzyme active ingredients

Flight (or paddle) configuration of an extruder screw which determine the kneading and shearing properties of the extruder. (Photo: Feed Tech)

Conclusion

The equipment in feed-processing plants is required to perform the following functions: receiving, storage, grinding, mixing, conveying, extrusion cooking, drying/cooling, pumping, coating, and packaging.

The objective in the formulated feed industry today is to manufacture a diet that:

- satisfies target animals' nutritional requirements
- meets or exceeds the customers' expectations
- satisfies environmental concerns
- provides favourable economics

Although the focus in the past has often been strictly on economics, shifting trends in today's society underlies the importance of environmental issues. Feeds that are "environmentally friendly" are not only popular, but are being demanded by the public. Today's issues include processing a feed in a manner that will maximise animal efficiency by freeing feedstuffs for human consumption, reducing animal waste outputs, and eliminating food-borne illness in the food supply chain. As formulated feeds become more sophisticated to meet the specific physiological needs of the animal and the environmental expectations of the public, processing technologies such as extrusion will become a factor in this industry. ●

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