The KAHL Crown Expander -
a Way out of the Feed Structure Dilemma

By: Dr. Heinrich Graf von Reichenbach, Amandus Kahl GmbH & Co. KG, Reinbek

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Introduction:

For some time now, more and more have turned away world-wide, particularly in Germany, from the hitherto customary fine grinding of pig and poultry feed. For a time, fine grinding was seen as key to achieve high feed conversion rates and good pellet quality with low fines. But today, it is recognised more and more that the vulnerability of our livestock is growing with the genetic progress and that finely ground feed can cause major health problems and reductions in performance. Recent research on pigs has proven that too many fine particles in the feed necessarily cause stomach ulcers, so that the majority of the animals for slaughter is already severely damaged (Nielsen 1998; Kamphues 2007; Große Liesner 2008). In addition, Kamphues et al. (2007) underline the importance of coarse grinding for the suppression of salmonella in pigs. Betscher et al. (2010) refer to the pH-grading of coarse feed structures in the stomach of pigs and poultry, which is not only immunologically important, but also a prerequisite for a high activity of the protein digestive enzyme pepsin.

Today's high-performance broilers respond to very fine feed structures with changed development of the gastro-intestinal tract: Glandular stomach and pancreas are enlarged and the gizzard is underdeveloped, resulting in health problems and in a reduced performance. Especially under extreme climatic conditions at higher altitudes, which promote the development of abdominal dropsy (ascites), the coarsely ground structure is of particular importance for a good health and high performance of the animals (Taylor and Jones 2004). Various studies have shown that higher contents of coarsely crushed cereals exercise a healthy effect on broilers and that feed conversion and weight gain were not reduced by coarse feed components, but in fact increased (Trevidy 2005). In the latest feeding tests, both structurally ground and expanded broiler feed showed a better protein utilization and a higher lysine effectiveness than finely ground or not expanded feed (Wecke et al. 2011).

Structural grinding:

In the meantime, many feed manufacturers have responded to this by changing to structural grinding with the crushing roller mill. With this machine uniformly coarse particle structures can be produced at high throughputs, low energy input and without expensive explosion protection measures.

Practice has shown, however, that a large segregation problem is associated with the use of uniformly coarsely crushed cereals in the rations: Compound feed does not only contain cereals, but also numerous components which are naturally finely ground or at least have a high content of fines. The protein carriers soybean and rape extraction meal as well as some concentrates and additives are particularly worthy of mention. While finely ground feed components are largely stable to segregation, mixtures of coarse and fine particles considerably tend to segregate. During transport the fine particles fall through the coarse particle matrix producing a layering from coarse to fine. – Fig. 1 shows the heterogeneous grain size distribution of a compound feed with a coarsely ground cereal content. The fine and medium fractions mainly consist of soybean meal, premix and minerals, and the coarse fraction of cereal particles with a high starch content.ting process is accompanied by a strong post-crushing of the coarse feed structures. The pelleting press acts like a pan grinder mill, the significant post-crushing effect of which has been proven by different sides (Große-Liesner 2008; Graf von Reichenbach 2011). So, the positive effect of structural grinding with the crushing roller mill is largely annulled by traditional pelleting and the fines content in the feed is increased significantly.

Fig. 1: Feed mixture with coarsely crushed cereals - above classified into three fractions, below crown-pelleted.

Preservation of coarse particles during expansion:

In recent years, the annular gap expander has acquired a solid position in the compound feed industry world-wide. In the Netherlands alone, more than 80 KAHL annular gap expanders are in operation. A large part of the North American turkey feed is expanded before pelleting, and also in South America the expander experiences a boom.

Leading feed producers point out that the expansion of coarsely ground feed mixtures does not (significantly) cause post-crushing of the coarse particles. Embedded in the matrix of the surrounding fine particles, the pressure and shear forces are distributed on the total volume of the coarse particles, which are thus treated with care mechanically, despite all hydrothermal effect. Fig. 2 shows the strong, well-preserved primary particle coarse structure of a barley-containing pig feed after grinding with the crushing roller mill and conventional annular-gap expansion.

Contrary to the pelleting press, the annular gap expander does not produce regularly shaped and cut pellets, but a so-called "Expandat" of irregular flaky shape and surface. – This is why the compound feed industry demands:

"Optimise the annular gap expander to the effect that the expanded product will be shaped and cut to regular pellets.

The coarse particles in these pellets must not be post-crushed significantly. The pellets should be dried by cooling alone, energy consumption and throughput of the expander are to correspond to that of a pelleting press, and the energy inputs or process intensity should be very easy to control."

Methods and procedures:

An approach was to provide the proven KAHL annular gap expander with a die and a cutting device. The die was designed as a ring-shaped extension of the tubular case of the expander. This ring can either be provided with longitudinal slots or holes. An important prerequisite for a high throughput of the machine

Fig. 2: Expanded pig feed with a high percentage of intact coarse particles

Fig. 4 Poultry feed before and after crown pelleting

was that a large number of slots or holes can be placed on the annular circumference. A rotating cutter was designed, the knives of which cut the product strands leaving the die to uniform granulate or pellet lengths.

So the Crown Expander was born. The machine owes its name to the crown form of the first test dies which were provided with slots instead of holes.

One important component of the KAHL annular gap expander remains unchanged in the crown expander: The hydraulically moveable cone, which is moved into the crown die end like a piston closing it backward. With retracted cone, the product only remains the way through the die holes (see fig. 3 and 4).

In addition, the cone is used as a control element: The deeper it is pressed into the crown, the less slot or bore cross-section of the crown die is open for product discharge. With decreasing passage cross-section, however, the energy required for pressing the product through it increases. The higher the energy input, the more the product temperature and hence the modification and expansion degree rise. – By varying the cone position in the crown, important process parameters can be influenced and so the process controlled rather simply. Even specific energy inputs into the feed can be preset in the control system; these will be adjusted by the hydraulic system of the cone after start.

In conventional extruders, the number of die holes cannot be varied during the extrusion process, nor can it be varied during the pelleting process with pelleting presses. Here, the "open perforated surfaces" are constant, and these determine, in conjunction with the effective bore length and geometry, the energy input during extrusion.

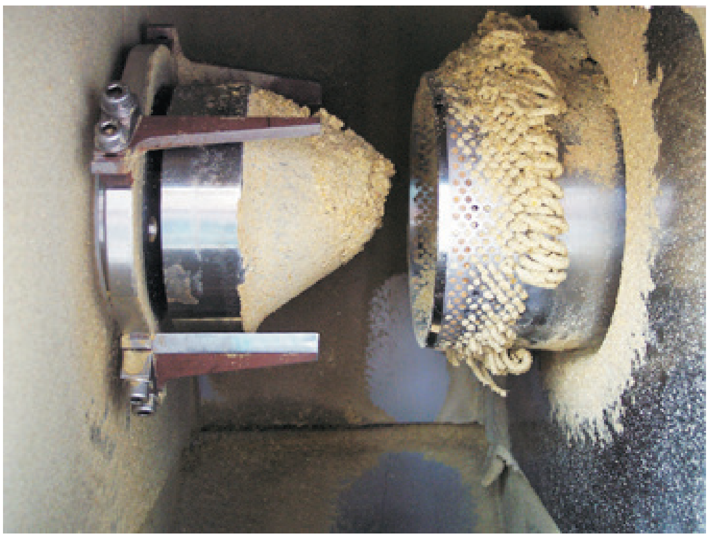

Fig. 3: Expander crown after shutdown

Throughput and energy consumption:

The throughput of the crown expander is essentially determined by the mechanical energy input into the feed desired or required for shaping. The diameter of the crown holes plays a role, too; and of course the formula components, their grinding and in particular the fat content in the formula have an influence on the mechanical energy consumption.

For the production of stable pellet structures with a low fines content, a certain adhesiveness of the feed mixture is required which is mainly achieved by starch modification as well as by influencing the protein folding structures. This requires that certain minimum temperatures are reached. An intensive pre-conditioning with steam raises the temperature level of the raw materials in advance and minimises the necessary mechanical energy input by the crown expander. This is not higher than in case of pelleting with a pelleting press. If a particularly high modification is to be reached or extra hard pellets are to be produced, the mechanical energy input can also be increased.

It is also important that "crown" pellets do not have to be dried separately, but that the product, just like simply pelleted pellets, are dried simultaneously to storage stability in a conventional cooling process.

Success and proof in practice:

With high throughput and low energy consumption, the crown expander produces pellets or regularly shaped product aggregates. Coarse particles remain unchanged; fine particles are agglomerated. (See fig. 5.) The expander treatment also serves for excellent hygienisation of the feed. Then there are the positive nutritional effects that have long been known from expanded feed – an advantage which cannot be achieved by conventional pelleting.

As the coarse particles are embedded in the aggregated matrix of the fine particles, any segregation tendency of the feed is suppressed. In contrast to meal feed, the poultry can no longer select individual particles, but must peck the feed in the desired composition. In case of liquid feeding of pigs, the crown pellets show the known advantages of Expandat, i.e. a good solubility in water and the formation of a homogeneous and stable liquid feed mixture.

The surprisingly high absorption capacity of the crown pellets turned out to be an additional advantage: How difficult was it so far to add larger amounts of fat or oil to the pellets post-pelleting. The micro-capillaries of the crown pellets, however, soak up oil, fat and other liquids like a sponge.
Even large amounts of fat and oil are absorbed completely, without any costly vacuum technology. The crown pellets remain free-flowing and do not stick together (see fig. 6). – These features predestine the crown pellets for use in supplementary feed with a high protein and fat content.

Fig. 5: Two types of pig feed, crown-pelleted

The first crown expanders have already demonstrated their impressive efficiency for more than one year in several compound feed factories both in Germany and abroad. They prove to be good for modification of feed components, production of pig feed crumbs and pellets, and pelleting of broiler feed – the machines are multi-taskers. The acceptance of the feed by the animals is excellent and the nutritive effects are convincing.

Fig. 6: Poultry-feed crown pellets, on the right post-coated with 12 % oil

Summary:

The realisation that dawns with the increasing distribution of crushing roller mills for structural grinding of compound feed corresponding to the animals' needs is that the desirable coarse feed structures are post-crushed in the downstream pelleting process and that unpelleted meal feed of coarse and fine particles is significantly susceptible to segregation.
A modified KAHL expander can pellet or aggregate feed mixtures, however, without causing a significant post-crushing of the coarse particles. In addition to their coarse primary particle structure, the resulting pellets show the well-known nutritional benefits of expanded feed. Thanks to their micro-pore content, they are highly absorptive and absorb high oil or fat quantities of more than 10 % by weight without requiring a costly vacuum treatment. This recommends the "Crown Expander" for the production of supplementary feed. The energy demand corresponds to that of a conventional pelleting press. Unlike extruded feed, the cooling process in the pellet cooler is sufficient to dry "crown" pellets to storage stability. In addition, high-temperature processes are possible in the crown expander, for example for the modification of grain starch or the elimination of antinutritive substances.

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