Knife condition and its influence on the pellet quality

Figure 1: Worn knife

The cutter at the outside of the pellet press die is yet another derminant of the physical quality of feed pellets. Research at FôrTek in Norway affirms this assumption.

By Dejan Miladinovic, research engineer at Centre for Feed Technology (FôrTek), Norwegian University of Life Sciences (UMB)

During the feed pelleting process conditioned feed mash passes through the pellet press die where animal feed pellets are formed by the rheological properties of the mash and various mechanical forces applied to the mash.

Different sized animals eat different sized feed, therefore cutting to ensure uniformity of feed pellets is an essential procedure for feed producers. In the final stage of the pelleting process pellet press knives are used to cut the feed pellets **(Figure 4).** Bearing in mind that worn knives usually have a randomised cutting area, feed pellets are more randomly stressed. This creates new abrasions and therefore causes the formation of more dust in the end product. This furthermore leads to reduced physical quality of feed pellets and dissatisfied customers.

Research based on the assumption that the condition of pellet press knives influences the physical properties of feed pellets has been accomplished at FôrTek - Centre for Feed Technology, Norwegian University of Life Science. Insufficient information regarding a standardised feed uniformity procedure gave rise to this research. The research showed that the condition of knives (worn or sharp) can affect the physical quality of feed pellets.

Research set-up

Research was based on two types of ingredient composition **(Table 1)**, hypothetically, superior and poor for physical properties of feed pellets. Feed mash conditioning was performed in a pellet press conditioning chamber with 75 °C preset temperature in both, and tested and replicated for both ingredient compositions. Samples taken after the conditionering were analysed for moisture levels. Moisture was found to be similar in both tests and diets (±1%). Finished feed samples were taken immediately at the pellet press outlet to avoid any stress (breakage) due to transport to the packaging line. Cooling was performed for six hours at an ambient temperature of 26 °C and relative humidity of 50% to avoid any forced moisture removal, or more likely, larger crack formation.

Two different knife conditions **(Figure 1 & 2)** were used as well as the new technique of pushing pellets by a pellet pusher, thus breaking them where the sheer stress is most likely to be lowest **(Figure 3)**.

In order to obtain a better overview of this research, two different pellet lengths were extruded (10 and 20mm respectively), meaning that different distances were set between knives and pellet press die surface. The durability test was performed by a Holmen Pellet Durability tester for both the test and its replica, according to UMB-PQP procedures*.

Results and discussion

Abrasion formation, i.e. the percentage of fines or physical property of feed pellets defined as PDI (%) was shown to be dependent on pellet press knife condition **(Figure 5)**.

When the pellet length is shorter or when knives are adjusted closer to the pellet press die, in this case 10mm, wheat-based pellets demonstrate a slight decline in the physical properties when cut with worn knives. The opposite was observed in maize-based feed pellets, where the worn knives have even induced a better PDI (%) values ($p < 0,01$). >

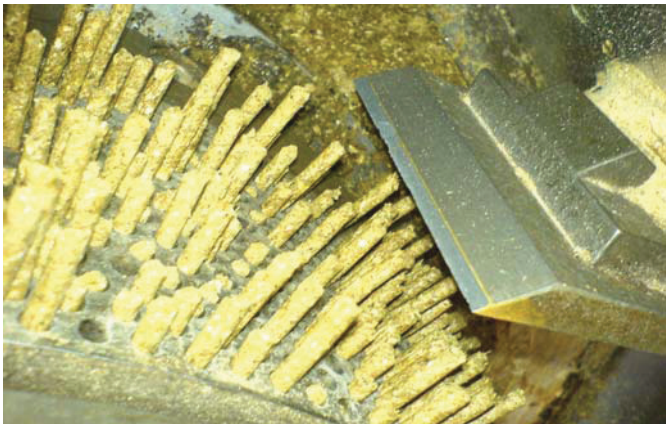


Figure 2: Sharp knife

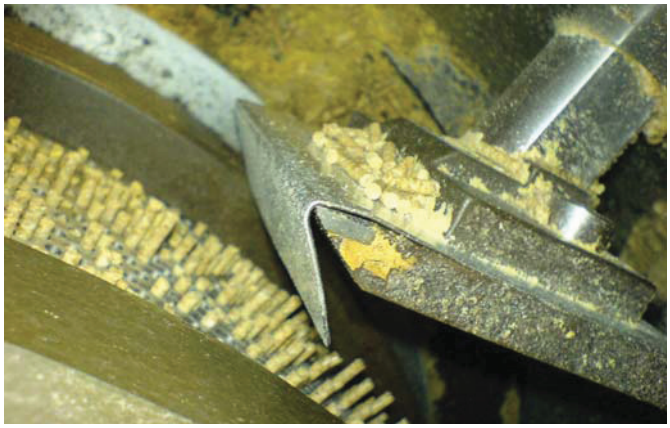


Figure 3: Pellet pusher

Figure 4: Conventional cutting technique of the feed pellet

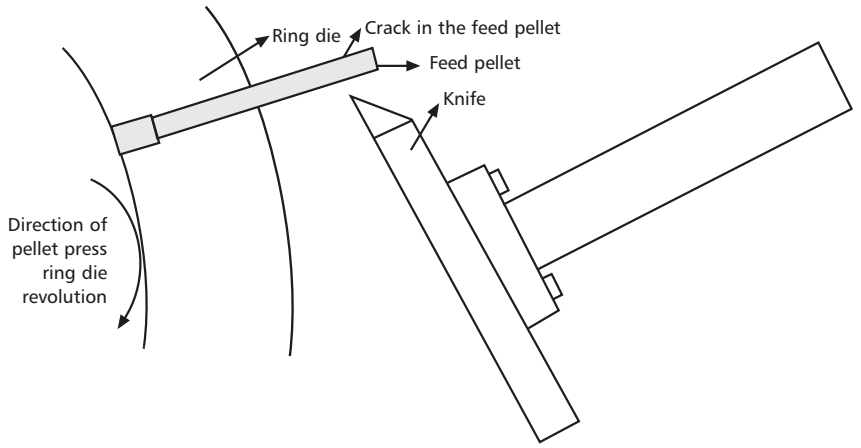


Figure 5: PDI (%), Worn knife vs. sharp knife

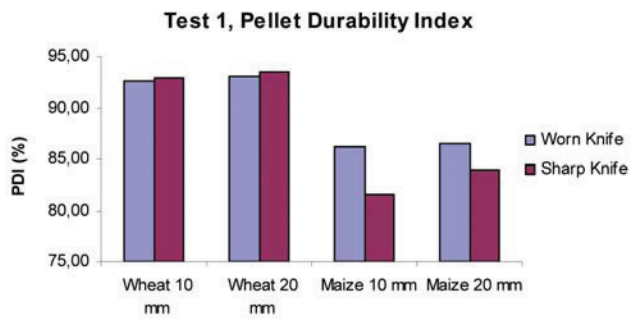
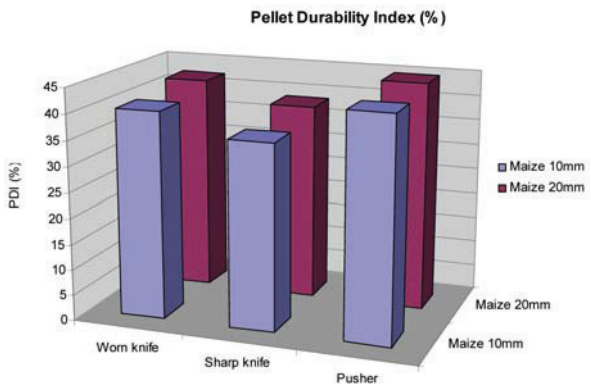


Figure 6: PDI (%) means, Sharp vs Worn knife vs Pusher



With increasing the pellet length to 20mm and cutting with a worn knife, the physical properties of wheat-based feed pellets have not changed significantly compared to a sharp knife. In the case of cutting maize-based pellets, however, the opposite effect was observed.

Feed pellets, compressed and formed in the pellet press die at the die outlet are experiencing sheer stress formed by the knife. Wheat-based pellets did not appear to be influenced by different knife conditions, whether sharp or worn.

When the knife is worn, theoretical impact of revolved pellets is led by chance, thus additional abrasions on pellets are likely to form. The opposite to the theoretical hypothesis was observed on maize-based feed pellets, where worn knife or wider cutting area led to improved physical properties **(Figure 5)**.

Changing the cutting technique, i.e. pushing the maize-based pellets by angled and widened flat surface as illustrated in **Figure 3** enhanced the physical properties (durability) of maize-based pellets, as compared to cutting similar pellets with sharp knives **(Figure 6)**. The explanation for these demonstrated results is that a "pusher" is simply pressing on feed pellets which are occurring behind the pellet die holes, consequently forcing the pellet to break in places where a natural crack already exists, without additional sheer stress onto the other cracks present in the feed pellet. When pellets are extruded through the pellet die holes, some abrasions are likely to form due to different compression and adhesive >

The deadly danger of dust particles

If you google on the Internet the words "feed mill" and "fire" it gives you over 100,000 results. This suggests that a feed mill is a definite fire hazard. In most cases, dust is the accelerating cause for mills to completely burn down or in the worst case to explode. Enough reason to pay attention to explosion prevention.

By Dick Ziggers

Recently a grinder motor at a Purina Mills plant in Hagerstown, Maryland, USA overheated causing some of the grain inside the plant to burn. The fire crew arrived quickly and prevented the smouldering kernels escalating into a real fire. The deputy chief with the Maryland State Fire Marshal said, "One of the hazards that we had is dust. There's a lot of dust that travels throughout the building when the grain's moving. Also when grain like that catches on fire or burns, it falls down inside and continues to smoulder until you have a fire inside." Globally, the amount of devastation incurred by factory explosion is staggering. The US Chemical Safety Board (2006) reported that they have "identified 281 combustible dust incidents between 1980 and 2005 that killed 119 workers and injured 718, and extensively damaged industrial facilities. Injuries or fatalities occurred in 71% of the incidents." FM Global reported recently that over a 10 year period the loss per incident due to explosions was $398,000. Current statistics estimate that approximately 2-3 dust explosions occur daily in various facilities in the US, with a major dust explosion happening every 20 years per facility. Plants that handle powders and bulk solids are even more susceptible. Susceptible equipment includes: bucket elevators, silos, bins, dust collectors, high-speed mills, grinders, blenders, and mixers. There are five essentials needed for a dust explosion to occur:

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properties of neighbouring particles. Longer pellets would be pushed by the pusher and the weakest abrasion is likely to crack, while this likelihood is reduced when pellets are set to be shorter. The differences ($p<0,01$) obtained when using the "pushing technique" for maize based feed pellets with different lengths is illustrated in **Figure 6**.

Table 1: Experimental ingredient composition

	Wheat based	Maize based
Wheat	70,3	-
Maize	-	70,3
Fish Meal	6	6
Soyabean Meal	15	15
Soyabean oil	4,3	4,3
MCP	1,7	1,7
Limestone	2,7	2,7

Conclusion

Depending on a feedmill's specific requirements and the estimation of binding properties of feed formulation, the cutting technique has to be chosen carefully. Results from this research shows that feed pellets made of raw materials expected to have good physical properties (in this case, wheat-based) can be cut with sharp and maintained knives, but if the knives are worn, additional maintenance investment is not necessary. However, pellets manufactured of raw materials assumed to have bad physical properties for pelleting (in this case, maize based) should be pushed. Hence the pellet is forced to break where its natural weakest crack exists with an obvious increase of PDI and reduction of additional cracks formed by knife shear stress.

** UMB-PQP pellet durability test procedure – Before the durability test, all samples are weighed out as 120g representative samples and cleaned from any dust with the Retch, AS 200 sieving machine. After sieving 3mm diameter pellets through 2,6mm sieve, each sample was weighed as a 100g sample. The Holmen pellet durability tester was run for 60 seconds and then 30 additional seconds to collect remaining feed pellets. Considered durability test results - PDI % (Pellet Durability Index) are presented from the weight that remained from pellets in the 2,6mm sieve, sieved for 30 seconds by Retch, AS 200 sieving machine on 1,5 mm shaking amplitude to avoid any human error.*

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