Factors that Affect Pellet Quality

IAOM MEA
Feed Milling Technology &
Trends Seminar
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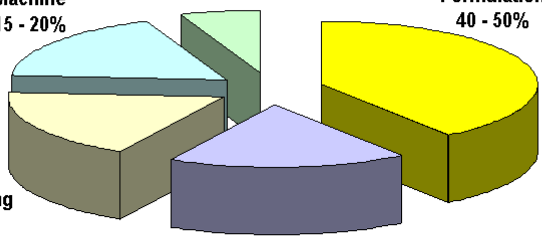
Pelleting Technology

Main influences to the pelleting process.



Source: Kansas State University

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Pelleting Technology

Main influences to the pelleting process.

Influencing parameters >>>>>> **Aimed target**

Raw material / mash

- Physical characteristics
- Chemical characteristics
- Preparation of mash
- Pelleting aids

Process control

- Steam conditioning
- Throughput regulation
- Fine returns
- Liquid addition

Machine

- Die circumferential speed
- Die configuration
- Roll configuration
- Roll gap

→ **Behaviour in pelleting** → **Pellet quality / Stability / Durability / Energy consumption**

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Influence of raw material.

Chemical characteristics

- Crude protein
- Crude fibre
- Crude fat
- Crude ash
- Nitrogen free extract

Physical characteristics

- Bulk density
- Angle of repose
- Product moisture
- Particle size
- Particle shape

Preparation of mash

- Size reduction
- Drying / toasting
- Cleaning / storage
- Age / origin

Pelleting aids / additives

- Lignin sulphonate
- Cellulose ethers
- Aluminium oxide / Bentonit
- Preservatives / Emulsifiers

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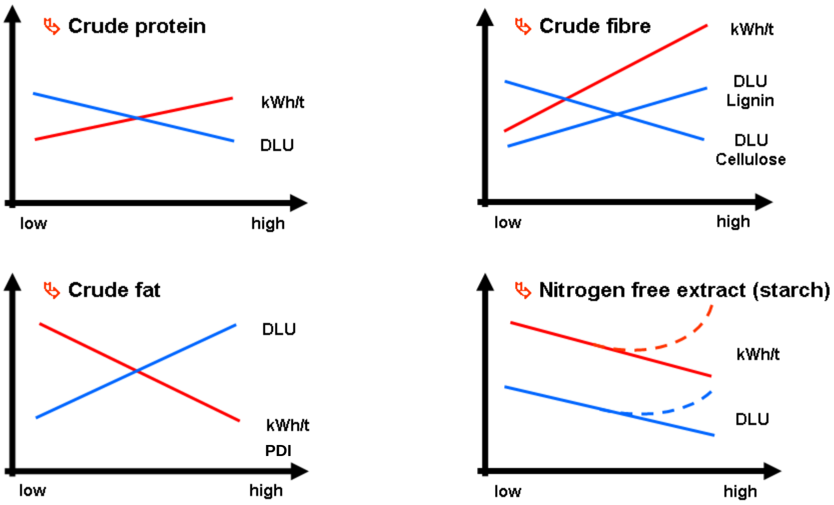
Influence of raw material - chemical properties.



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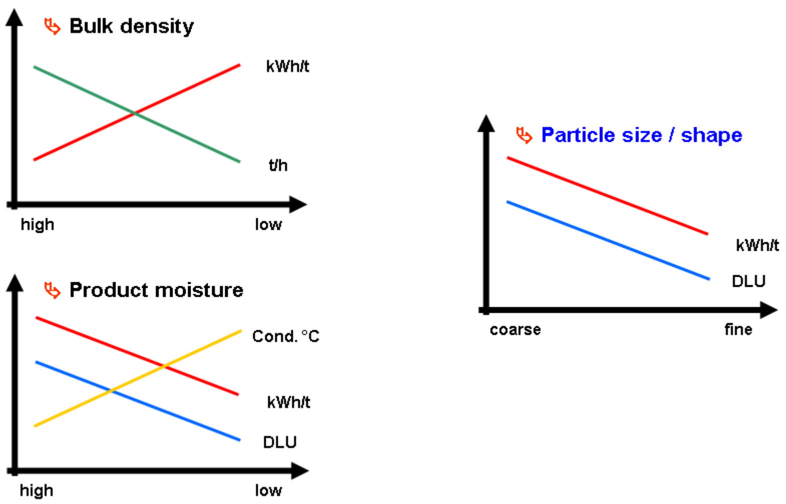
Influence of raw material – physical properties.



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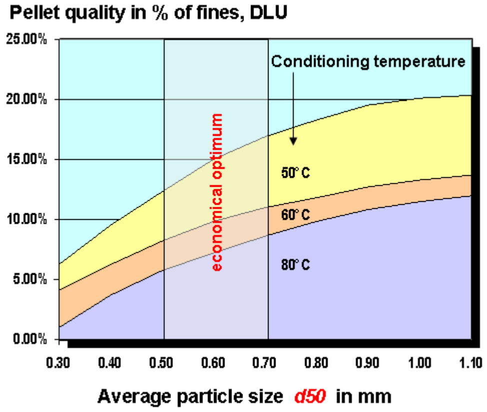
Influence of raw material - Particle size and pellet quality.



Maximum and minimum particle size

Overs	**1.5 mm**	**none, max.**	**5 %**
Overs	**1.0 mm**	**up to**	**10 %**
Overs	**0.5 mm**	**up to**	**40 %**
Overs	**0.3 mm**	**up to**	**25 %**
Throughs	**0.3 mm**	**not less then**	**20 %**

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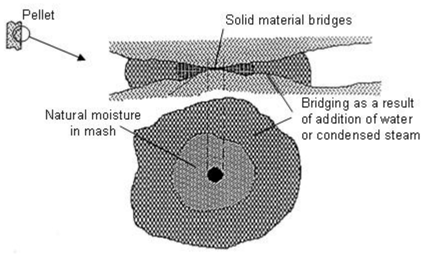
Process parameters – Main reasons for steam conditioning.

Binding bridges between two mash particles



- **Reduction of harmful bacteria**
  = *thermal treatment / Hygienizing*
- **Plasticizing of the individual solid particles**
- **Creation of liquid bridges**
- **Higher throughput rates**
- **Reduction of the energy requirement**
- **Longer service life of dies and rolls**
- **Partial gelatinisation of the starch**
- **Improvement of the moisture balance**
- **Reduction of production costs**

After cooling, the pellet should have a moisture content of ***12 – 14 % H_2O.***

- **For commercial reasons** > **higher bulk density possible.**
- **For quality considerations** > **as close as possible to the shelf life limit.**

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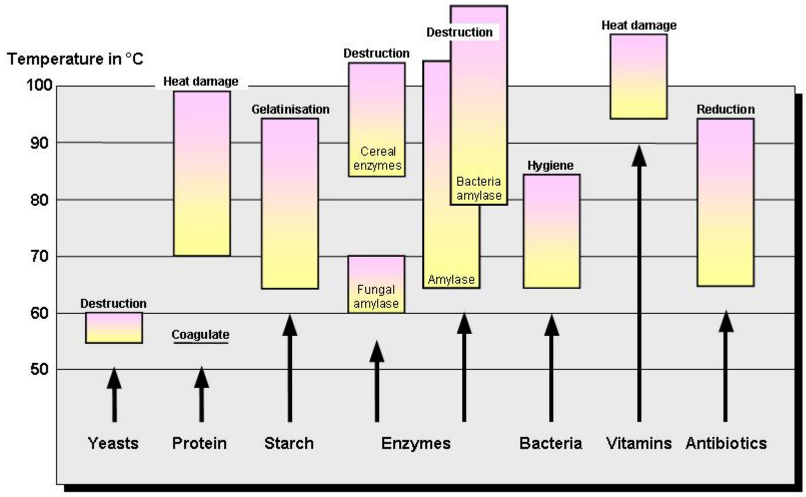
Process parameter - Conditioning and its effect on nutrients and micro organism.



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Process parameter - Conditioning with water or saturated steam.

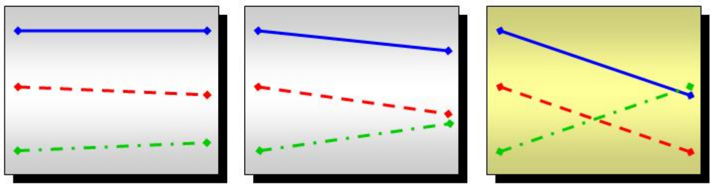
Addition of: Cold water | Hot water | Saturated steam

Influence on:

Pellet quality (fines)

Energy consumption

Pellet mill throughput



An increase in the product temperature by 10°C through the addition of saturated steam translates into an increase in the product moisture by 0.6 – 0.7 % H_2O.

Conditioning is limited above all on the moisture content and by the influence it can have on the nutrients, vitamins and micro-organism contained in the mash.

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Pellet mill and its influencing parameters - Sequence and zones in the pelleting process

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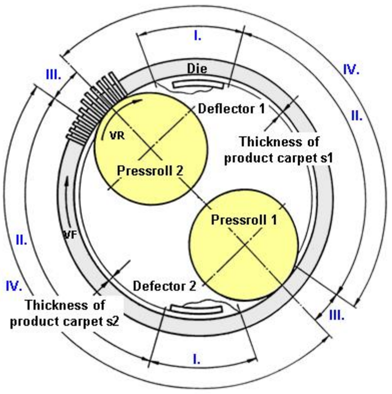

Zone I = Product intake

After the mash has been fed into the die cover it will be fed in zone I to the area of the rotating die.

Zone II = Product distribution

Zone II serves for the uniform spreading of the mash across the die width.

Zone III = Compression and output

Zone III often called the nip, is the phase where the pelleting process takes place.

The carpet of mash reaches the roll and is drawn into the nip formed between the roll and the die, is compressed and is forced through the die holes.

Zone IV = Dwell time / no advance in die hole

In zone IV the pellet will be carried without further external influences to the next pressroll.

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Pellet mill and its influencing parameters - Sequence and zones in the pelleting process

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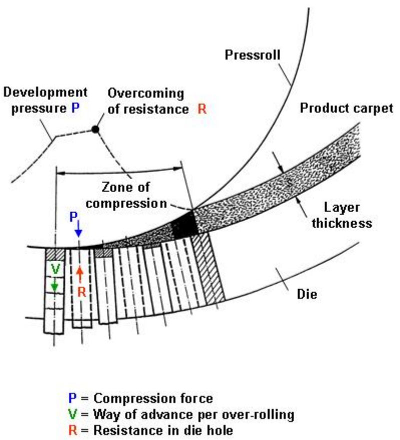

The mash is subjected to rapid compression / compaction as a result of the narrowing of the gap.

- **The pressure "P" is increasing in direction of the die hole, until resistance "R" in the die hole has been overcome.**
- **The pellet will be advanced by the product layer thickness "V" forced into the die holes.**

The pressure in the compression zone depends on:

- **Friction coefficient of the mash.**
- **Die hole design.**
- **Die hole condition.**

By increasing the product feed rate, the thickness of the product carpet will increase.

Maximum product layer thickness depends on:

- **Resistance in the die hole.**
- **Configuration of the press rolls.**
- **Escape of mash at the sides.**
- **Pellet quality.**

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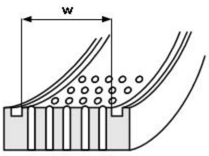
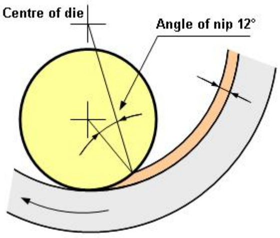
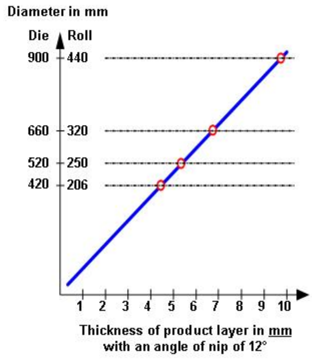
Pellet mill and its influencing parameters – Diameter of die and press rolls.

- **The relation between the size of the rolls and the diameter of the die, is of enormous importance to the resulting angle of nip and consequently to the intake capability of a pellet mill.**
- **The physical intake capability, or maximum product layer, will be limited by an angle of nip of 12°.**







Q = Throughput [t/h]
ρ = Bulk density of mash [t/m³]
s = Thickness of product layer [mm]
w = Active die width [m]
vF = Die speed [m/sec]
n = Number of pressrolls

$$s = \frac{Q \bullet 1000}{\rho \bullet w \bullet 3600 \bullet vF \bullet n}$$

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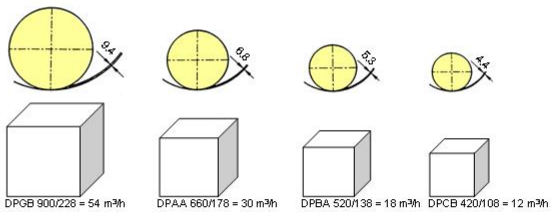
Pellet mill and its influencing parameters – Diameter of die and press rolls.



Intake capability of pellet mills

At an angle of nip of 12° and a die circumferential speed of 7 m/sec

Values related to one pressroll only.

Pelleting die and pressrolls are the most important elements of a pellet mill.
Their diameter has a direct influence on:

- **Relative movement of the rolls.**
- **Spec. energy consumption.**
- **Maximum intake capability.**
- **Conditioning temperature.**
- **Pellet quality.**

A uniform as possible distribution of the mash over the entire width of the die and the number of pressrolls is of enormous importance.

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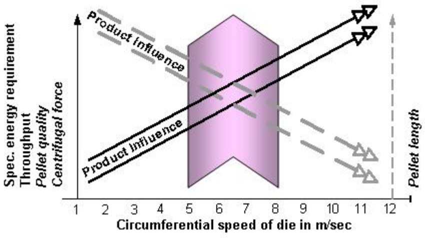
Pellet mill and its influencing parameters - Circumferential speed of the die



Increase in circumferential speed of die by *1 m/sec*

= Increase in spec. energy requirement *0.6 – 0.8 kWh/t.*

An excessive circumferential speed of the die will lead to excessive energy costs and may affect the pellet quality.

An insufficient circumferential speed of the die will limit the throughput and will often lead to choking of the pellet mill.

Values commonly encountered in practice: *5 - 8 m/sec.*

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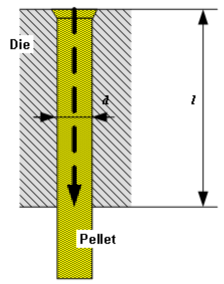
Pellet mill and its influencing parameters – Die configuration / retention time in die hole.



ft = Retention time [sec]
d = Die hole diameter [mm]
l = Active hole length [mm]
π = Circle number [3.14]
n = Number of die holes
ρ = Density of pellets [1.3 kg/dm³ for common feed]
Q = Pellet mill throughput [kg/h]

The die configuration is simultaneously related to the retention time of the product in the die hole.

Rule of thumb: **the longer the retention time the better the pellet quality.**

The dwell time will be influenced by following parameters:

- **Volume of die hole [mm³]**
- **Number of die holes [-]**
- **Pellet mill throughput [kg/h]**
- **Density of pellets [kg/dm³]**

$$ft = \frac{d^2 \bullet \pi \bullet l \bullet n \bullet \rho \bullet 3600}{4'000'000 \bullet Q}$$

Values commonly encountered in practice: *3 - 6 sec.*

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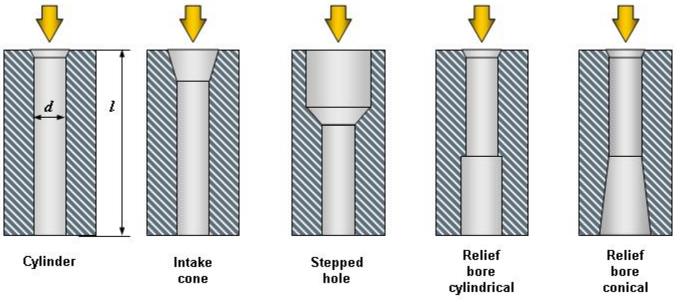
Pellet mill and its influencing parameters – Die configuration / die hole design.



- **The die hole design as an influencing factor that does not offer very much space and can only be applied to a limited extent >> mainly related to type of feed and animal species.**
- **Cylindrical holes are the most applied - reasonable price, optimal service area.**
- **Intake cone and stepped hole result in a much stronger compression - specific application.**
- **Relief bores result in a lower compression – mainly applied for small holes in large dies.**

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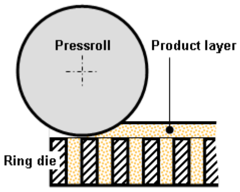
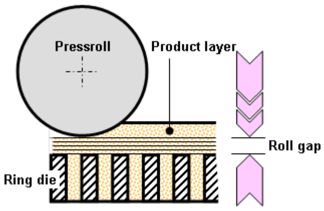
Pellet mill and its influencing parameters – Principle without and with roll gap adjustment.



Without roll gap the mash, which is fed in form of a product carpet to the pressroll, will be compacted and finally pressed into the die hole.



A roll gap between the roll and the die means that the product particles before being forced into the die hole passes several times under the rolls.

The herewith occurring shearing and kneading forces leading to an intensive pre-compaction of the mash.

Larger particle will be reduced and natural binding properties in the mash will be activated which results in a more abrasion resistant pellet but also in a higher specific energy consumption.

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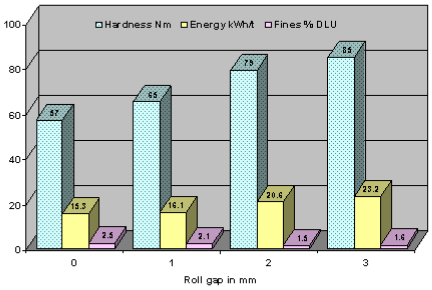
Pellet mill and its influencing parameters – Effect of the roll gap adjustment.

Example: cattle feed – die size 6 x 80 mm



The roll gap has a direct influence on:

- **Pellet quality (hardness, durability)**
- **Specific energy consumption (kWh/t)**
- **Intake capability (due to roll slippage)**

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Objectives and benefit of hygienizing and compacting animal feeds.

Animal nutrition / feeding

Feed manufacturer
Storage and logistics

- **Reduction of pathogenic germs in feed / salmonellas.**
- **Better utilisation of nutrients / improved digestibility.**
- **Higher feed intake possible / selection not possible.**
- **Improved feed conversion rate / slower digestion.**
- **Improvement in palatability / toasting effect.**
- **Modified structure of feed / physical and chemical.**
- **Less labour involved for feeding / automation.**

- **Less storage volume / smaller transport elements.**
- **Better flow properties / easier to discharge from bins.**
- **Reduced risk of bridging in the bins.**
- **Improved storability and longer shelf life.**
- **Lower risk of segregation and contamination.**
- **Utilisation of cheaper raw material / production cost.**
- **Less feed losses and dust formation.**

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