Department of Mathematical Sciences and Technology (IMT)

Facilities to Research in Feed Technology, an engineering approach

Norwegian University of Life Sciences

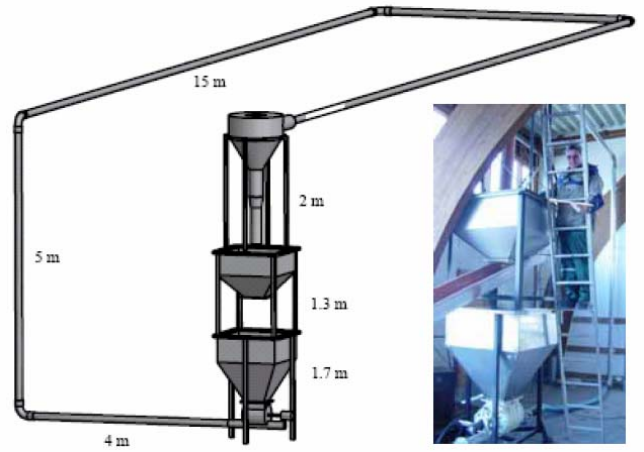
The research activities in Feed Technology at the Department of Mathematical Sciences and Technology at UMB, are taken with an engineering approach. This is a summary of our activities.

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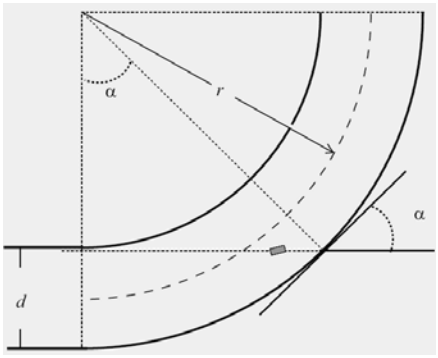
Pneumatic conveying system for pellet durability tests.

This facility is used to study and to improve the pellet durability during the pneumatic conveying.



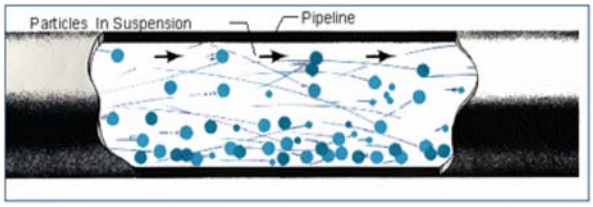
Designed by Tore Ensby in the CAD program Inventor.

The Pneumatic conveying system for research use an hydraulic blower, the air velocities in the system can be regulated from 0 – 50 m/s.



Sketch showing the maximum impact angle in a pipe bend (Aarseth, 2004).

The picture bellow shows the transporting travesty of the feed pellets during pneumatic conveying.

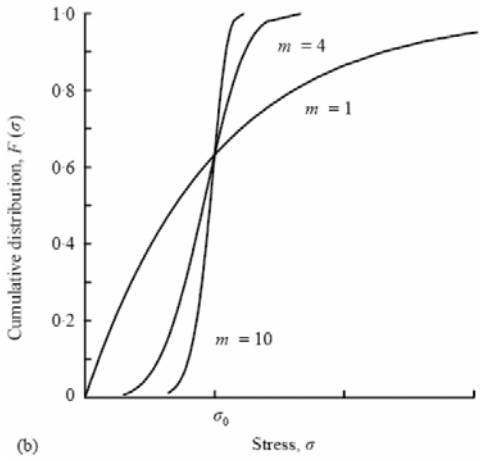


Material science, mathematics and statistics in Pellet Quality

The physical properties of feed pellets can be investigated in the context of fracture mechanics of brittle materials. These materials exhibit high scatter in strength due to variation in flaw sizes in the material, known as Griffith cracks. Weibull analysis assumes a relation between the size distribution of Griffith cracks and the scatter in fracture strength. In this way, Weibull analysis (Weibull, 1939) integrates fracture mechanics and statistics in order to describe the strength of brittle materials (Aarseth, 2003).

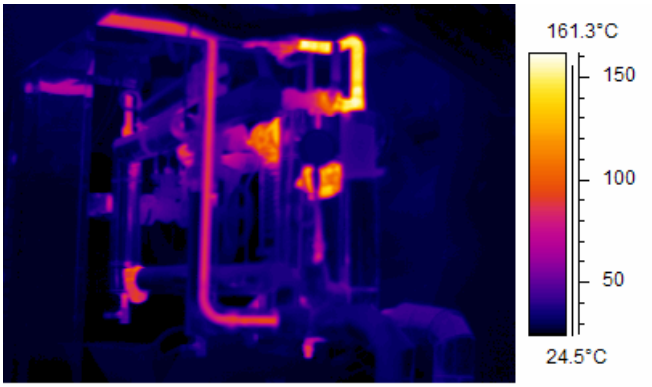
$$f(\sigma) = \left(\frac{m}{\sigma_0}\right)\left(\frac{\sigma}{\sigma_0}\right)^{m-1} \exp\left[-\left(\frac{\sigma}{\sigma_0}\right)^{m}\right]$$

Weibull analysis provides information that complements the Holmen durability and the Kahl-hardness tests. The Weibull parameters represent a gain of information from this analysis.



Weibull analysis is potentially relevant for both the optimization of feed pellet processing and to predict product losses when the product is handled and transported.

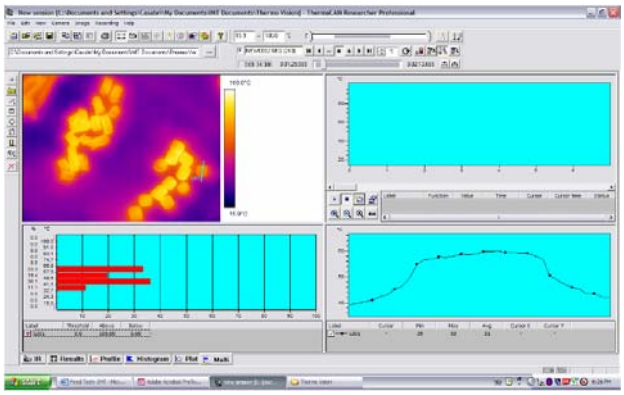
Thermo vision & image analysis



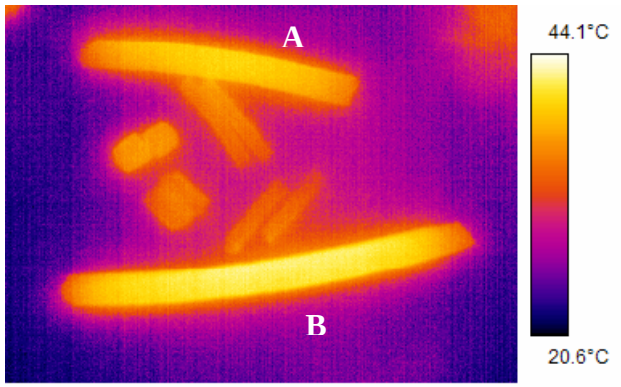
The picture shows the heat distribution of a piping in the pelleting line at the Centre for Feed Technology (Fôrtek) located in the University campus.

The lighter colors indicate the areas with higher emission of heat (higher temperature) and the darker colors the colder areas (see temperature scale on the right). Some of the advantages of using thermo vision is that every pixel represent a different temperature measurement, therefore is like a single thermometer per pixel.

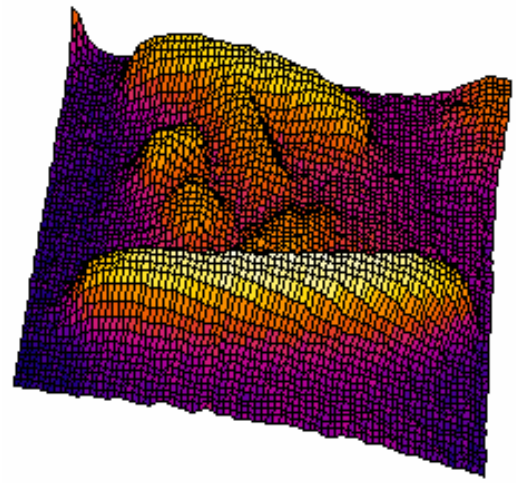
The camera is able to capture a sequence of events as a movie film, and the sequence can also be analyzed as a series of pictures, thus allowing studies of changes according with time. On the other hand, a special software makes able the use of this information as an output signal for a control process, in this way the user is able to utilize part of the image to command some event, like for example to decrease the addition of steam through a computer connected to LabView.



The above picture shows the software for research analyzing data. On the bottom left a Histogram analysis and on the right the temperature profile of the cross section of a single pellet.



E.g. The picture above shows the heat retention of different pellets. The long pellets "A" and "B" were produced with the same diameter and recipe, but the pellet "A" was made with lower viscosity than the bottom pellet "B", thus making influence in the heat retention. The pellet were produced using a new device created at IMT to study the rheological properties of the feed products.



3D analysis of the heat intensity and distribution of the above picture.

Holman tester for pellet durability

This device is used for determination of pellet durability. The pellets are subjected to a shearing and abrasive action, in this way the amount of fines returned from the batch is measured. These circumstances occur during pneumatic transportation.



Pellet hardness test

The hardness test is base in a statical pressure to simulate the forces on the pellets, the statical pressure is caused for example by the weight of the pellets on top of the lower ones. In wide silos where a part of the pressure cannot be relieved to the walls of the silo, breakage of the pellets on the bin bottom may occur (Thomas et al., 1996). Also the availability of nitrogenous components for intestinal absorption has been reported to be affected by hardness (Čuperlović, 1973; Čuperlović et al., 1973).



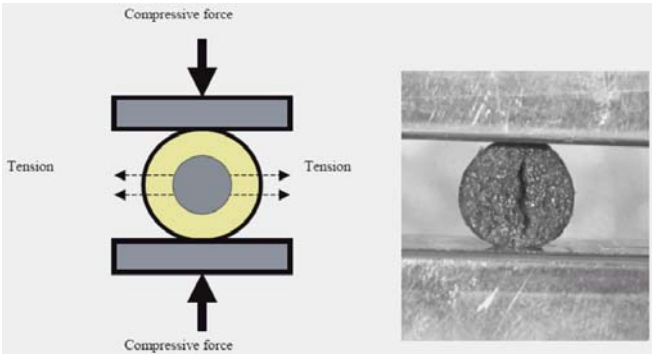


Diagram and picture of forces during the hardness test (Aarseth, 2004).

Bulk laboratory for feed and raw materials

These facilities allow the analysis of the bulk properties of feed pellets and feed ingredients. These properties are related with the storage and handling characteristics.



Study of the angle of repose and segregation (left) and dry sieving for analysis of particle size distribution (right).





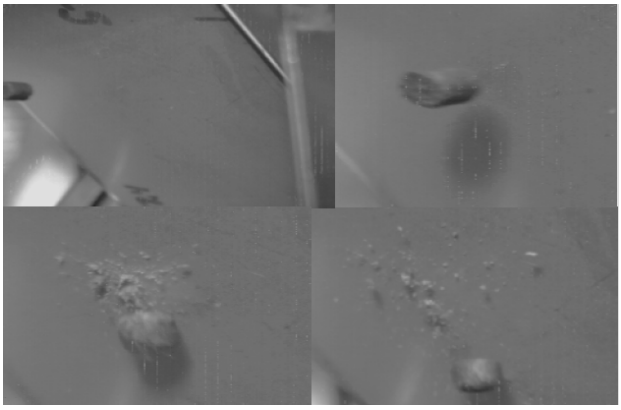
The devices on the pictures (above: left and center) are used to measure the bulk density of a sample, the devices showed up-right and down-left, are used to separate one sample in more keeping similar segregation levels (samples splitter).

The aquatic feeds can be differentiated according to their floating characteristics; they can float, sink or have a slow sink. The bulk density of feeds will influence the sinking velocity, this is primarily important for fish farms due to different species prefer different sinking profiles and generally speaking a fish feed with a slow sinking will allow the fish to have more time to consume the feed before falls through the cage bottom.
The variables to produce these differences are the density of the feed pellet, the salinity of the water, water temperature, pellet shape and the water currents. The tester for sinking allows the study of these parameters to improve the different requirements of the fish feed.



Impact tester for pellet fracture

The impact tester is an experimental device that use air pressure; the air push a single pellet (e.g. an air rifle) that hit an inclined surface. This surface can be adjusted in different angles to simulate the effect of the angles of impact (e.g. a pipe bend) over the pellet structure. The pellet brittleness is studied using this system. This tester together with the use of a high-speed camera provides a help to analyze the effect of the impact over the feed pellets.



Picture showing the impact of a single pellet in the impact tester, the figure shows the sequence of a pellet hit over an inclined surface. The pictures were taken in a high-speed camera (courtesy of Saven Hitech, Norway).



Controlled drying and cooling system

The department has available a drying and cooling system for experimentation, this is a cycling air system that can dry a sample by the use of a pre-established air moisture content, at the same time is possible to set different air temperatures from –20 to 40 °C. The system can dry and cool down small samples up to 50 Kg, the flow rate can vary from 0–400 m_3/h.





The changeable area of the bed (down) also allows the change of the air speed. The options are a fixed bed (the pellets lay in the bed) or fluidised bed (the pellets are suspended due to the air current) in the drier chamber. The picture on the left shows the panel to set the working parameters.

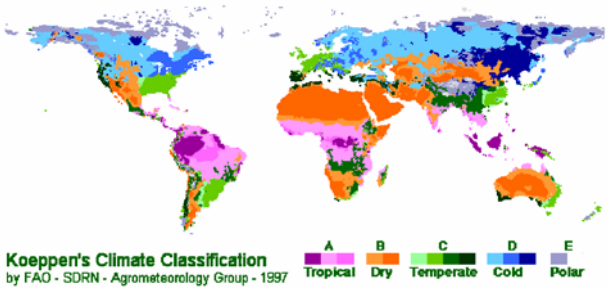


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Cabinet for climatic simulations



The climatic cabinet has a potential to study the effect of different climatic conditions over the Raw Materials and pellets, in this way is possible to have a simultaneous control of temperature, humidity and light. A microprocessor-based controller allows an easy control of the climatic parameter and periodical changes.



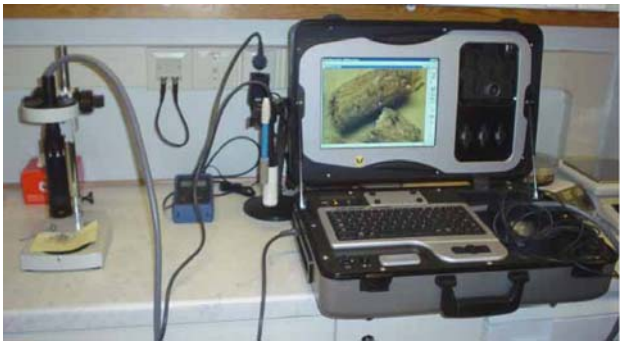
The climatic cabinet allows the controlling of the following parameters:

- 4 Temperature settings
- 4 humidity settings
- 4 Light intensity settings
- Alarm
- Safety thermostats
- Digital calibration
- Ultrasonic humidifier

Portable video microscope & image analysis

Microviper is a portable video microscope and their specifications are the followings:

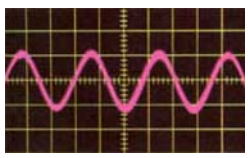
- Up to 1000x magnification
- Portable and compact
- Archiving and storage of images in a PC Windows base
- High contrast & high resolution display
- Image capture and processing
- Used for laboratory and field work





Visualization of a feed pellet with its fibers and a crack (photo; Carlos Salas).

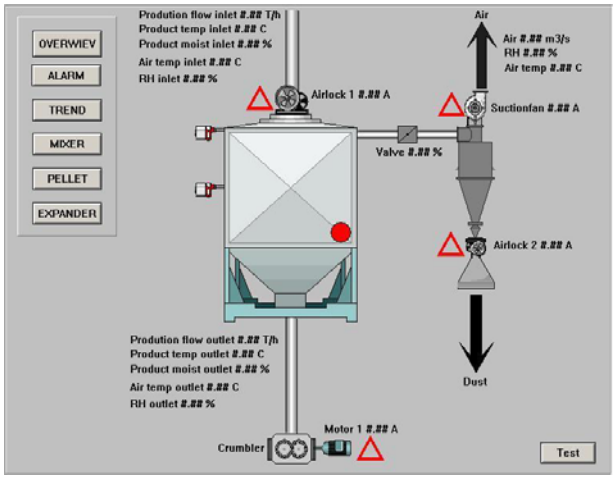
Electrical laboratory for controlling and monitoring systems

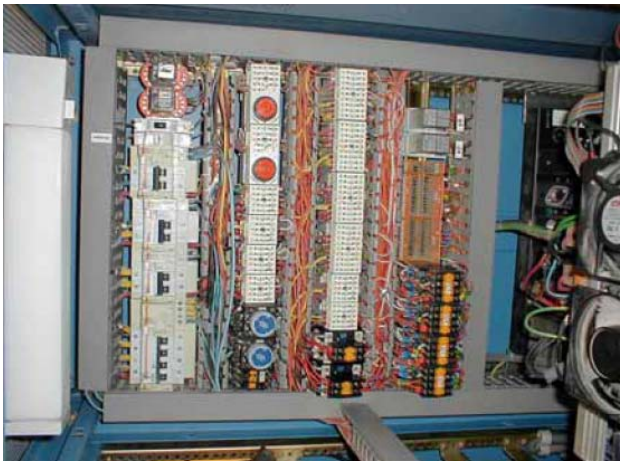


The electrical laboratories account with a considerable amount of instruments and high skilled professionals. Many controlling and monitoring systems for different measurements are being developed at these facilities for diverse industries and academic purposes during many years.

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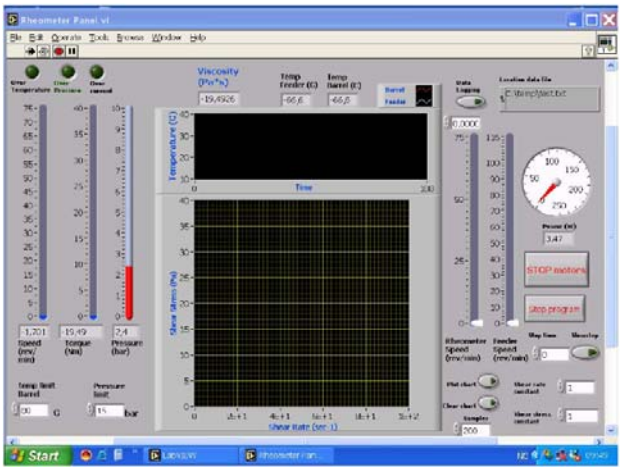




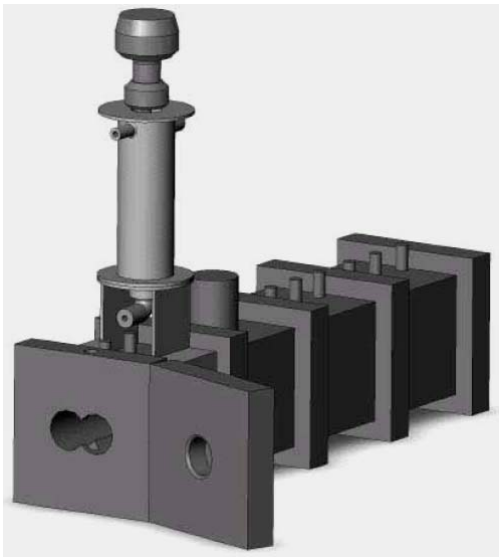
Education and On-line quality control: As a University, UMB is concern about the current problems in the feed industry, as well as the transfer of knowledge to their students. This is an example of a panel made for a dryer for the feed technology using the Software INTOUCH by the ending student Tom Joransen.

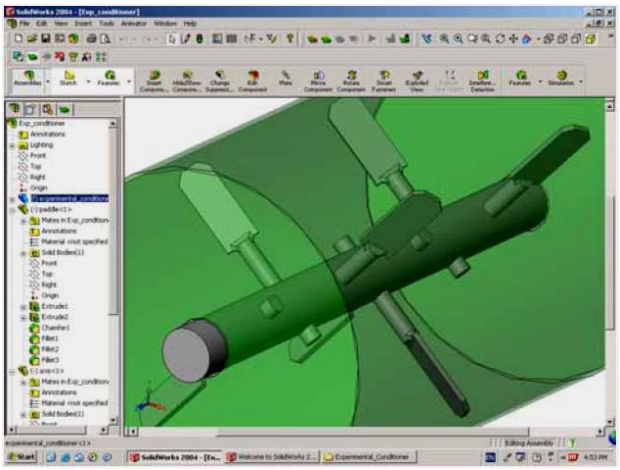
Machineries prototyping and WorkShop

The department for engineering has installations to develop machineries; the use of virtual prototypes (3D) is an essential tool to increase the quality as well as reducing the time for prototyping. The department also has a Workshop and installations with skilled personnel to develop new equipments. The picture shows a virtual prototyping for an installation of a product quality control device in an extruder, designed by Carlos Salas in the CAD program SolidWorks.

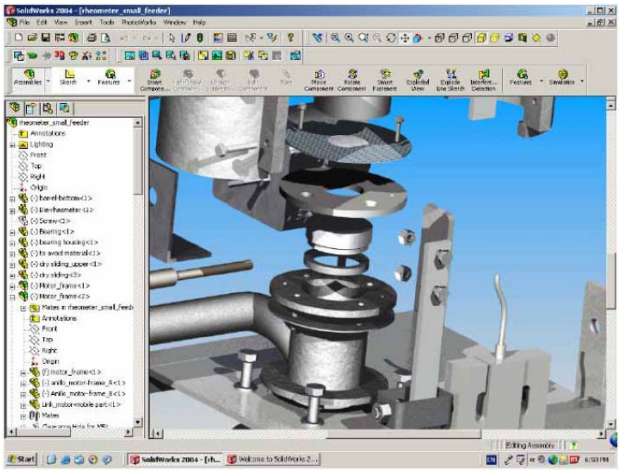


The picture above shows the control panel of an on-line control quality device (rheometer) to be used in the feed industry. The software used is LabView and its development is being made including the participation of ending students (Pål Martin), all assisted closely by professionals from the IMT department (Andreas Flø and Carlos Salas).

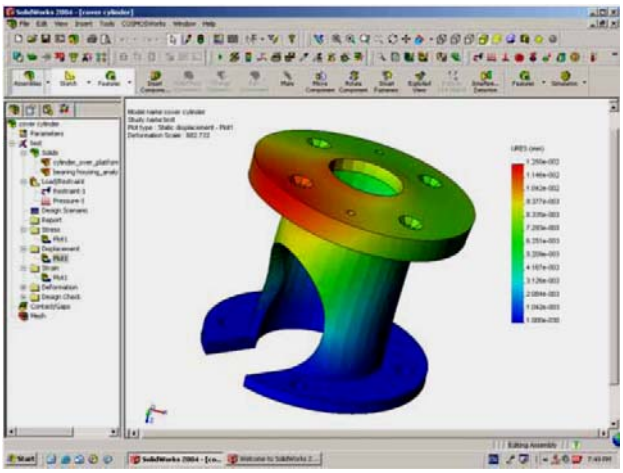




Virtual prototyping process of a shaft for feed technology experimentation using SolidWorks. (Design; Carlos Salas).



Virtual prototyping of a rheometer for pellet quality control (Design; Carlos Salas).



Every part must be tested to simulate the effect of the loads, pressures and temperatures over the materials; this process is assisted with a software for engineering simulations (CosmosWorks), also the department account with facilities for real tests of the structures.

The following picture shows some of the equipments to build devices.



The WorkShop has machineries especially made to build small parts (using fractions of millimeters) and another to build larger parts.



The GVC 1000 (above) is able to read a virtual prototype, building by itself the part made by the designer.



Some of the researches available for companies and institutions

The following is a list with some of the possible researches than can be performed at our facilities:

• Pneumatic Conveying systems

- Determination of durability for a batch of pellet. Known parameters: air velocity and use of sensors for pellet velocity.

- Determination of the air speed influence over the pellet durability.

- Determination of the bend radius influence over the pellet durability for a batch of pellets in a pneumatic conveying system.

- Use of Weibull analysis to determine the mechanical properties of a batch of pellets and its distribution in a pneumatic conveying system.

• Holmen Tester for Pellet Durability

- Determination of pellet durability for a batch of pellets.

- Use of Weibull analysis to determinate the mechanical properties of a batch of pellets and its distribution.

• Pellet Hardness Test

- Determination of the representative pellet hardness of a batch of pellets.

- Use of Weibull analysis to determinate the mechanical properties of a batch of pellets and its distribution.

• Bulk laboratory for feed and raw materials

- Determination of the angle of repose for a batch of pellets or raw materials.

- Determination of the bulk density of raw materials or feed pellets.

- Determination of the particle size distribution of a grinded raw material.

- Determination of dust content in a bag of feed pellets.

- Determination of the sinking velocities of pellets in a water tank.

• Impact Test for Pellet Fracture

- Studies of the pellet brittleness due to impacts over a surface with different inclination angles. Known parameters: pellet velocity, angle of the surface and force of the impact. Additional tools: high-speed camera.

• Controlled drying and cooling system

- Effects of different air temperatures, moistures and velocities over the physical characteristics of feed pellets.

• Cabinet for climatic simulations

- Determination of the effect of different climatic conditions and storage time over the quality of raw materials and feed pellets. The potentials aspect to study are the physical consequences over the feed pellets, and with an internal cooperation within NLH is possible to investigate the nutritional and chemical effects as well.

• Portable Video Microscope

- Examination of the pellet or meal structure.

- Video recording of a pellet breaking during a statical load.

• Electrical Laboratory for monitoring and controlling systems

- Development of systems to monitor in-line a process (steam pressure, temperature, power consumption, specific mechanical energy, etc.).

- Prototyping systems for a process control using on-line and/or in-line measurements.

- Software preparation for monitoring or a process control.

• Thermo vision & image analysis

- Use of thermo vision to detect efficiencies in the drying and cooling process for a single pellet (temperature differences between the core and the outer layer) or for a batch of pellets.

- Efficiency analysis for coolers, dryers, conditioners, pellet press, extruders, etc. according to their heat distribution.

- Use of thermo vision to improve the insulation in pipelines, buildings and for all the thermo processes.

• Machineries Design and WorkShop

- Design and prototyping of new machineries for the feed industry.

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