Centre for Smart Energy Solutions,
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Mechanical durability and relaxation times of dried extruded fish feed

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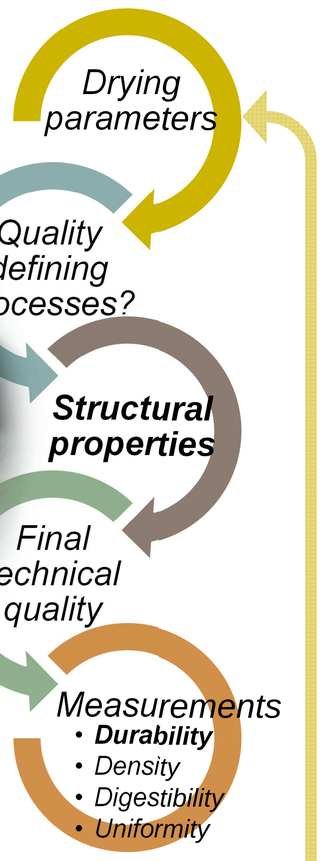
Introduction

Scope

Establish relation between structural properties and mechanical durability

Poor mechanical durability increases costs of fish farming and pollutes aquatic environments



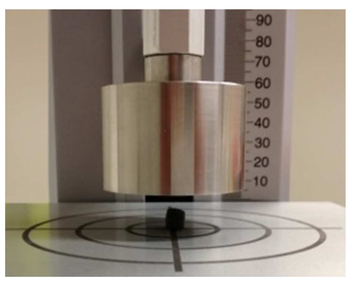
Outcome

Optimize drying parameters to improve technical quality

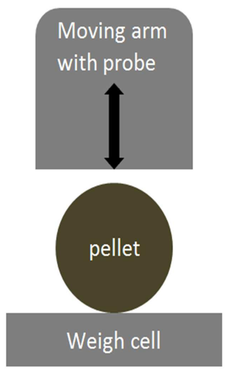
Experimental study

STRUCTURAL PROPERTIES FROM TEXTURAL ANALYSIS

Textural analysis are conducted to elucidate on rheological details in fish feed pellets.



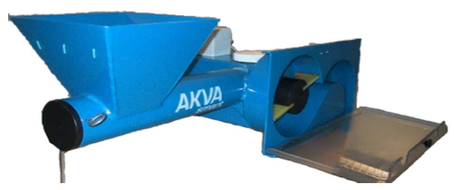
Force exerted against the weigh cell is recorded over time and can be used for graphical analysis.



From graphical analysis different structural properties of the pellets can be quantified and correlated against measurements of mechanical durability.

DURABILITY ASSESMENT

When subjected to an amount of mechanical stress, a portion of pellets will break into fines



'DORIS' tester. Pellets are subjected to an amount of stress and subjected to a sieve analysis.

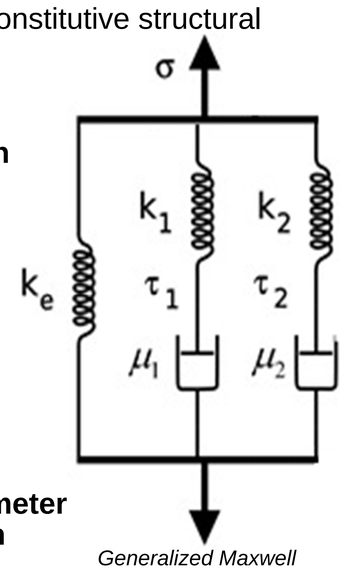
Theoretical study

STRUCTURAL BEHAVIOR FIT TO MECHANICAL MODELS

Assessment of properties in terms of material mechanics is done by fitting the recorded behavior of the pellet to different constitutive structural mechanics models

Model reconstruction of structural behavior

Record structural behavior



Generalized Maxwell Model with 2 Maxwell arms

Multiparameter regression analysis

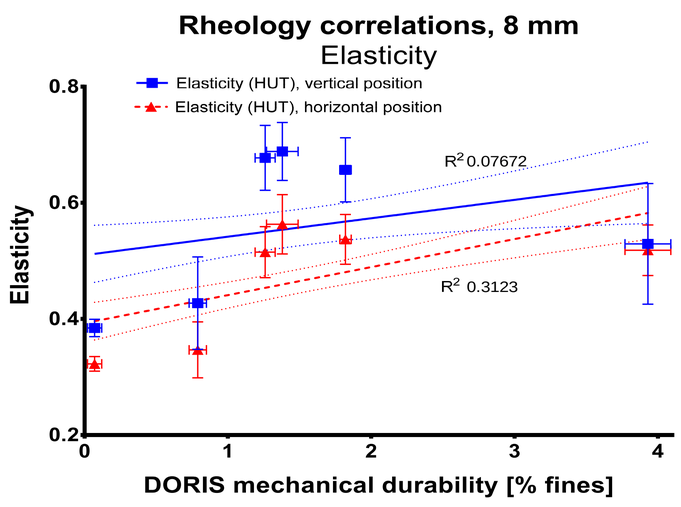
Model parameters!

k_e	33100 N/m
k_1	94400 N/m
τ_1	0.32 s
k_2	14500 N/m
τ_2	6.90 s

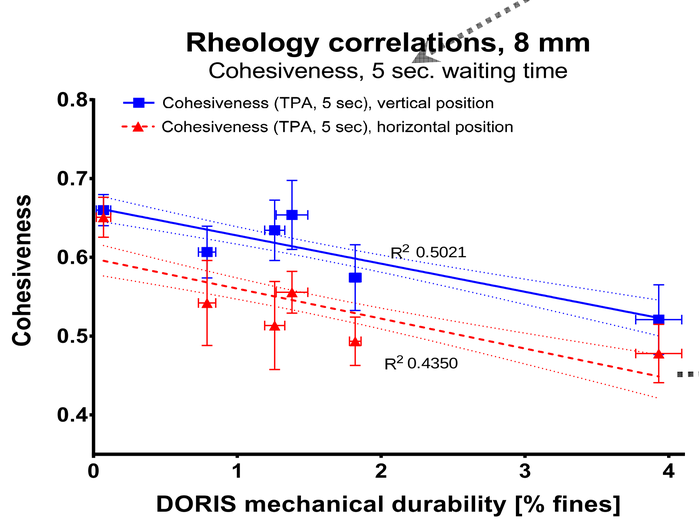
Largest relaxation time is 7 seconds!

Results

IDENTIFICATION OF STRUCTURAL BEHAVIOR

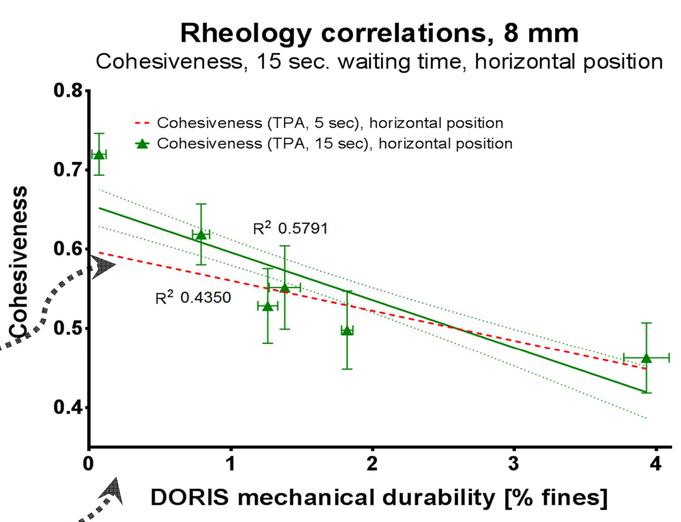


The 'elasticity' of a pellet is found to have some importance. Pellets will have a high durability when able to relax the force applied at the surface as deformations in non-elastic type behavior.



'Cohesiveness' is an important structural property on the durability. Cohesiveness describes a products ability to return to its original state shortly after a deformation.

JUSTIFICATION OF RELAXATION TIMES

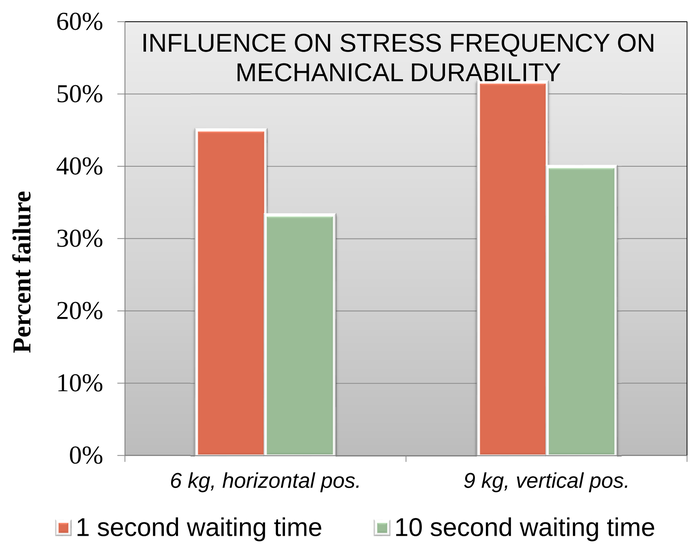


After the waiting time was changed from 5 to 15 seconds, a better response was obtained in the cohesiveness-durability correlation. This:
(i) Demonstrates that durable pellets possess viscoelastic behavior
(ii) Justifies a relaxation time longer than 5 seconds.

From above observation on elasticity and cohesiveness, and from fitting data to theoretical mechanical models, it is suggested that the structural behavior that promote durable feed pellets:

- is **viscoelastic,** and possess a **relaxation time**, which will allow the pellet to return to its equilibrium state.
- have a total relaxation time of around **7 seconds.**

5 seconds waiting time was initially used in the practical assessment of cohesiveness. If durable feed pellets truly is characterized by exhibiting viscoelastic behavior, the response of the cohesiveness-durability correlation should improve when increasing the waiting time in TPA.



The proposed relaxation time was justified in a separate stress frequency experiment. 9 consecutive impacts were made on similar pellets, using 1 and 10 seconds in between the impacts (60 repetitions).

There is a profound tendency that extruded fish feed pellets should be allowed to relax for the duration of the largest time constant to maximize its mechanical durability potential.

Conclusion

- **Durable extruded fish feed pellets possess viscoelastic structural behavior, promoting stress relaxation and apt reversible deformation.**
- **A relaxation time of ca 7 seconds exists in the viscoelastic feed pellets.**
- **Structural behavior and the existence of a relaxation time in the feed is justified:**
  - ✓ The response and regression of the cohesiveness-durability correlation was significantly improved, by increasing the waiting time in the TPA test.
  - ✓ Pellets exposed to a repetitive mechanical stress pattern could be more prone to fail when the applied frequency is below the relaxation time.
- ***All of above should be accounted for in the selection of drying parameters, once the connection between drying parameters and viscoelasticity is established!***

Acknowledgement

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