

# Mechanical properties of granular biomass determined in Vane Torque Tester

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## INTRODUCTION

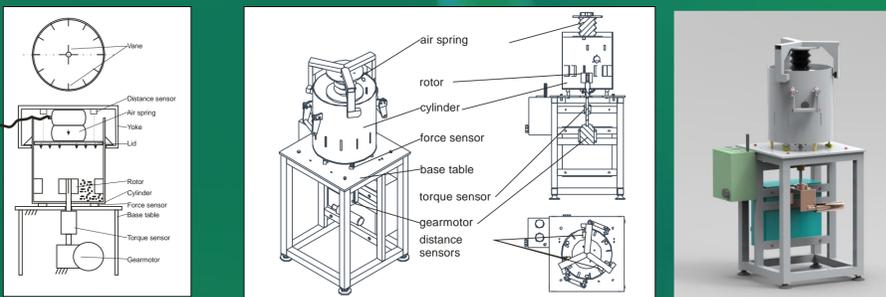
Rheological behavior is one of the classical characteristics of fluids and powders. The rotating vane method is a tool used widely in various branches of technology. The objective of performed project was examination of samples of forest woodchips consolidated under pressure corresponding to the one existing in storage silos used in power and heat plants. The measurements deliver information about the load during emptying of the silos with screw feeder. The values of the measured maximum torque allow for estimation of the shear strength of the material under load that may be used for design of equipment and control of technological operations.

## MATERIAL AND METHOD

Experiments were performed on forest woodchips which is a granular biomass widely used in firing and co-firing in power and heat plants in Poland. After the delivery the material was dried in thin layer in laboratory conditions. Then, proper amount of distilled water was added and the samples were tumbled for 15 min of each hour through 24h in laboratory mixer to obtain desired levels of moisture contents of: 10, 20, 30, 40 and 50%.

The experiments were performed in a new designed vane shear tester. Tests were conducted for four rotation rates 3, 6, 9 and 13 rpm, under four levels of consolidation pressure of: 5, 10, 20 and 30 kPa. The required consolidation pressure was generated by air compressor and measured by analogue and digital manometers. The influence of 4 h consolidation time on torque vs. time characteristics was also determined. In this case, the sample remained under consolidation pressure of 5 kPa or 30 kPa for the duration of 4 h and then it was sheared with speed of 3 rpm or 13 rpm. The torque vs. time characteristics and other measured parameters were recorded by data acquisition system.

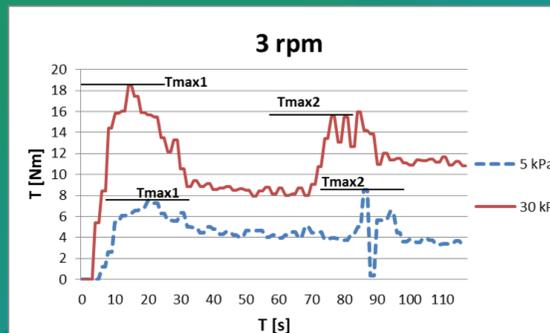
## VANE TESTER



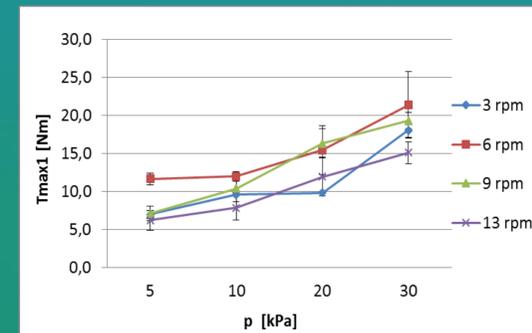
## FOREST WOODCHIPS



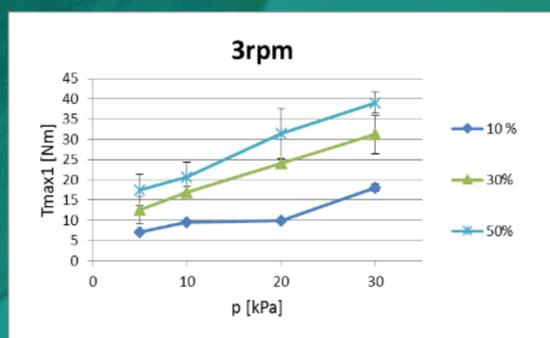
## RESULTS



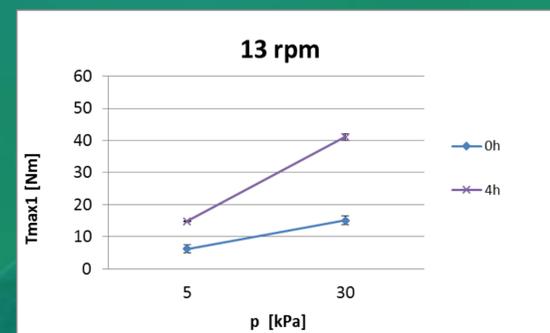
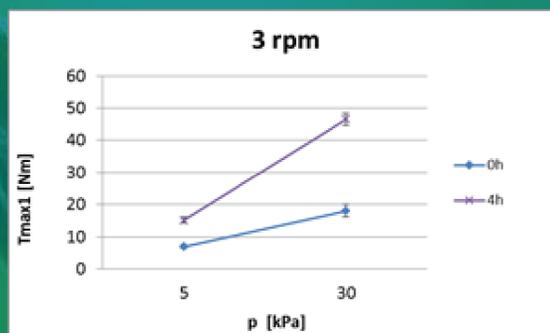
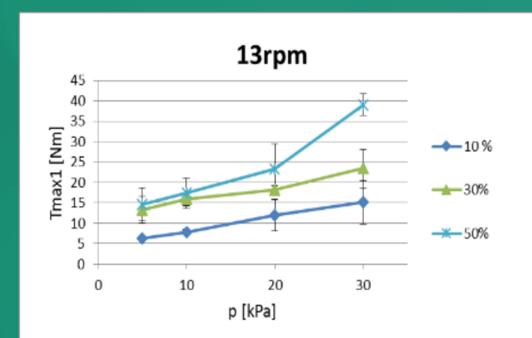
Typical torque vs. time curves measured for forest woodchips



Torque vs. compaction pressure relationships for 4 rotation speeds



Torque vs. pressure relationships for 3 levels of moisture content



Maximum values of torque as dependent on pressure, obtained for consolidation times of 0 and 4h for rotational speeds of 3 and 13 rpm.

- The measured maximum values of torque  $T$  increased with compaction pressure  $p$ .
- An increase in compaction pressure resulted in steeper increase of slope of  $T(t)$  curves.
- The time (i.e. the deformation) to reach rupture point decreased as compaction pressure increased.
- No significant differences between values of maximum torque for different rotational speeds were observed.
- A significant increase in  $T_{max}$  with increasing time of consolidation was observed.
- The  $T_{max}$  values measured for consolidated material were higher than the those obtained without time consolidation. Difference between values of  $T_{max}$  determined for consolidated and nonconsolidated material increased with an increase in consolidation pressure.
- An effect of moisture content of the material on the  $T_{max}$  was examined at different rotational speeds for the m.c. ranging from 10% to 50%. Regardless on the rotational speed, an increase in moisture content resulted in an increase in  $T_{max}$ .