Densification concepts for torrefied biomass

Torrefaction workshop

European Biomass Conference, Milano 2012

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Danish Technological Institute

Presentation overview

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- Danish Technological Institute and its role in SECTOR
- Advantages to combine torrefaction and densification
- Difficulties and challenges
- Possible Solutions
- Conclusions

Danish Technological Institute (DTI)

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STATUS

An independent, non-profit institution

Approved as a technological service institute by the Danish Ministry of Science, Technology and Innovation.

OBJECTIVE

Address the needs of the industrial sector and society as a whole through the development and dissemination of technological innovation.

Danish Technological Institute (DTI)

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LOCATIONS

Role of DTI in SECTOR project

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- Several years of experience with torrefaction and pelletization processes
- Heavily involved in national and international R&D projects
- Wide network with industry and academia
- Torrefaction and pelletization from laboratory to production scale

→ **Major activities within SECTOR project will be in WP4**

Densification of torrefied biomass

Why combining torrefaction and densification ?

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- **Torrefied biomass is difficult to handle**
  - Porous and brittle structure
  - Low density
  - Dust and dirt formation (health & explosion risk)

  → **Poor handling properties**

- **Densification**
  - Pelletizing & briquetting
  - Increase density
  - Homogeneous shape and size (automatization, standardization)
  - Less dust and fine formation

Densification of torrefied biomass

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- **Benchmark**

	Wood Chips	Wood Pellets	Torrefied Pellets	Charcoal	Coal
Moisture (wt%)	30-55	7-10	1-5	1-5	10-15
Calorific value LHV (MJ/kg)	7-12	15-17	18-24	30-32	23-28
Volatile matter wt% db	75-84	75-84	55-65	10-12	15-30
Fixed carbon wt% db	16-25	16-25	22-35	85-87	50-55
Bulk density (kg/m^3)	200-300	550-650	650-800	180-240	800-850
Vol. Energy density (GJ/m^3)	1.4 – 3.6	8-11	12-19	5.4-7.7	18-24
Hygroscopic properties	Hydrophilic	Hydrophilic	(Hydrophobic)	Hydrophobic	Hydrophobic
Biological degradation	Fast	Moderate	None	None	None
Milling requirements	Special	Special	Standard	Standard	Standard
Transport cost	High	Medium	Low	Medium	Low

Data from ECN

Densification of torrefied biomass

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- Pelletization and Briquetting
- Both established processes for many decades
- Torrefied biomass: Focus is set on pelletization, but briquetting is considered as well
- Experience with many different raw materials (wood, agro, waste)

→ So how difficult can it be to pelletize torrefied biomass?

→ Unfortunately its not as straight forward

Challenges when pelletizing torrefied biomass

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- High friction in press channel
  - High energy uptake of pellet mill 150 kWh/t (50-60 kWh/t for wood)
  - Heat generation in pellet mill (risk of fire / dust explosion)
  - Lower capacity
  - More wear on the pellet mill parts
- Pellet quality
  - Durability
  - Density
  - Hydrophobicity
  - Storage of torrefied pellets

Issues are closely linked to

- Biomass feedstock
- Torrefaction parameters
- Pelletization parameters
- Can be different case by case

Requires knowledge and further studies

Challenges when pelletizing torrefied biomass

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- Process development is time consuming and expensive
  - Lack of knowledge
  - Process development via pilot trials
  - “trial and error” & experience → learning by doing

→ **Aim of the SECTOR project is to provide solutions**

- Method development for fast and simple testing of pelletizing properties
- Create knowledge about combinig torrefaction & pelletiziation
- Improve process and product
- Cost competetitive solutions

Challenges to pelletize torrefied biomass

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- We have a laboratory method to screen the pelletizing properties of (torrefied) biomass
  - Fast and simple
  - Just a few grams are needed
  - Adjustment of different pelletizing parameters
- Pelletizing tests and optimization on laboratory scale
- Results give indication what equipment and parameters should be used for pelletization
- Correlation between lab trials and production size pellet mill has been shown

Pelletizing process

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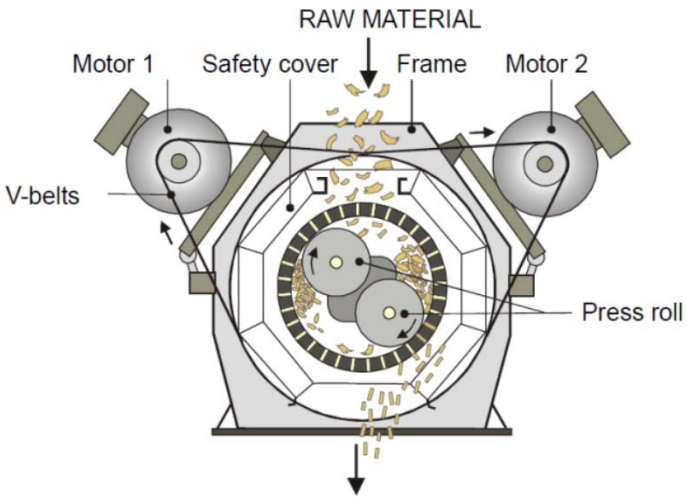
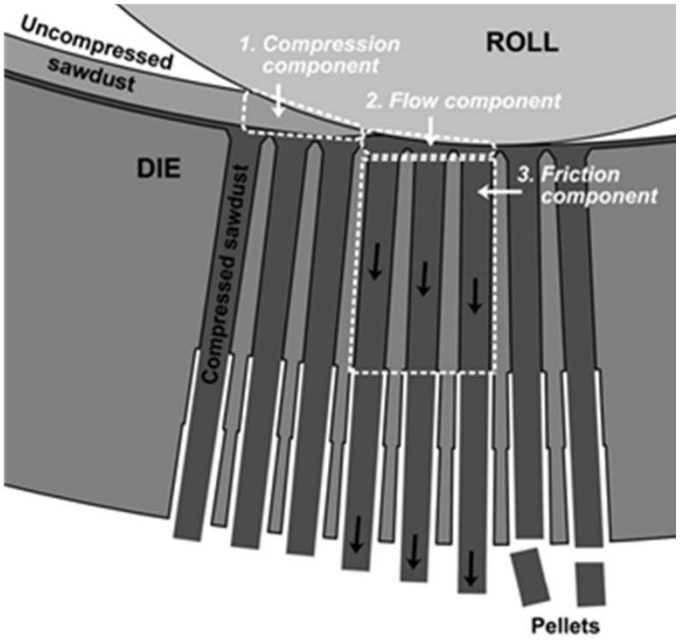
- Pelletizing process





Pelletizing process can be separated into different stages

The energy required for the process is a sum of these parts

Single pellet press method

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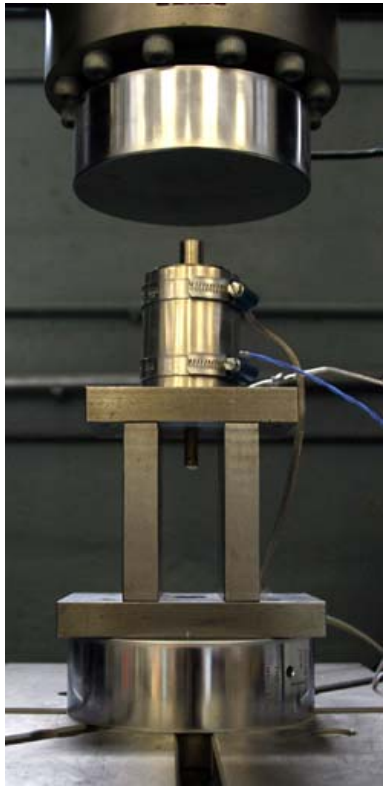

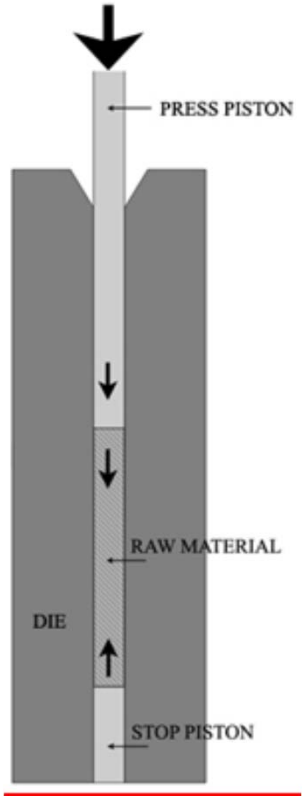

For every biomass type we test 4 parameters

1. Compression of biomass
2. Static & dynamic friction

After pelletization…

3. Pellet compression strength
4. Pellet density

Single pellet press method

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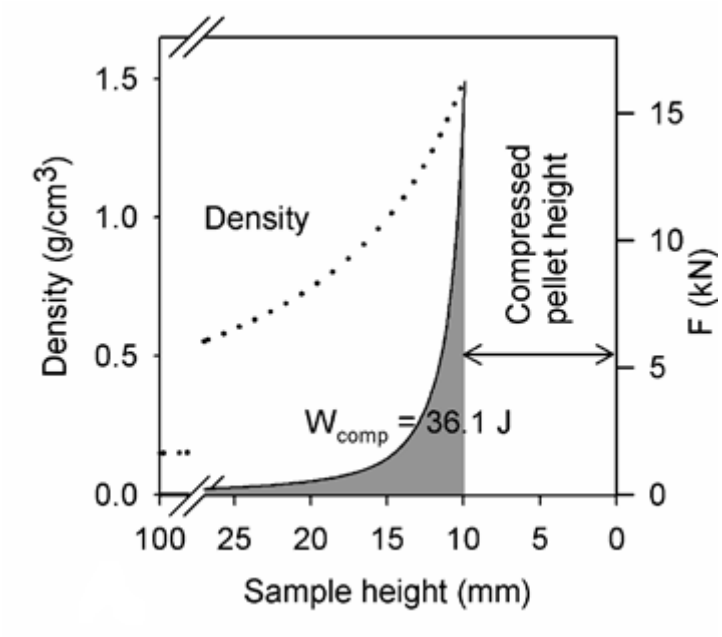
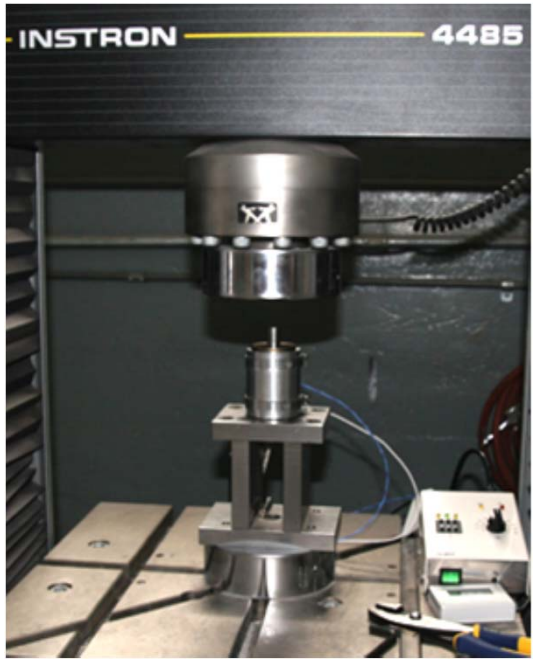
1. Compression





8 mm diameter

Temp. up to 200 °C

Instron Material test system

Force distance curves

750 mg of biomass

300 MPa pressure

Detection of force, integration over distance → W_{comp}

Single pellet press method

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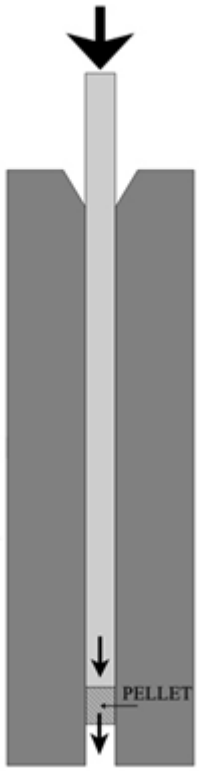
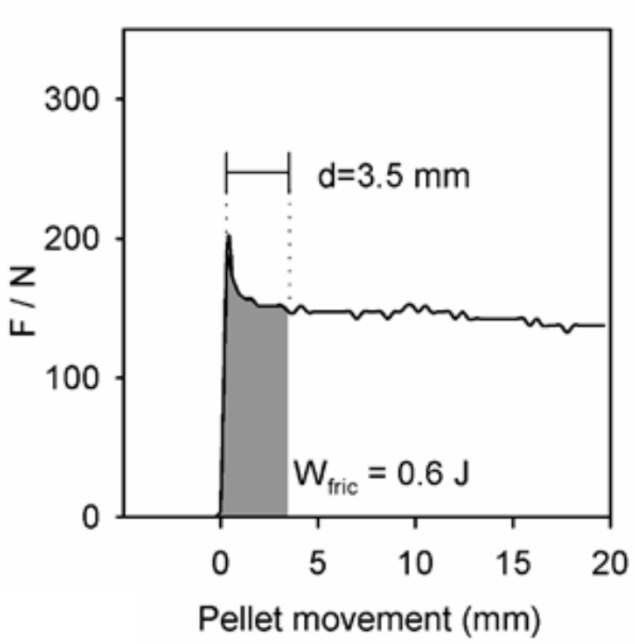
2. Static and dynamic friction





Static friction: Force to make the pellet move

Dynamic friction: Force to keep it going

Pellet is moved over a defined distance (here 3.5 mm)

Calculation of W_{Fric}

Single pellet press method

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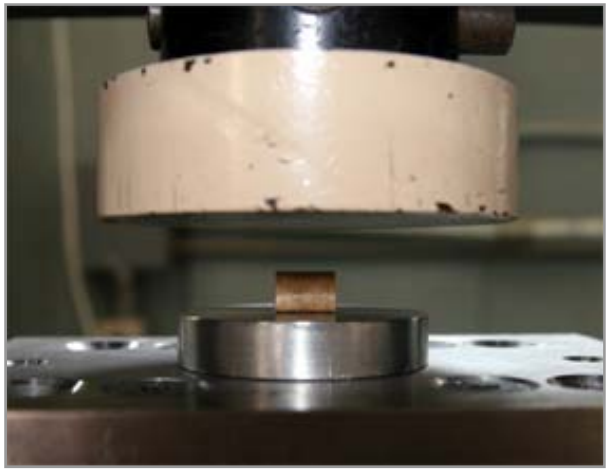
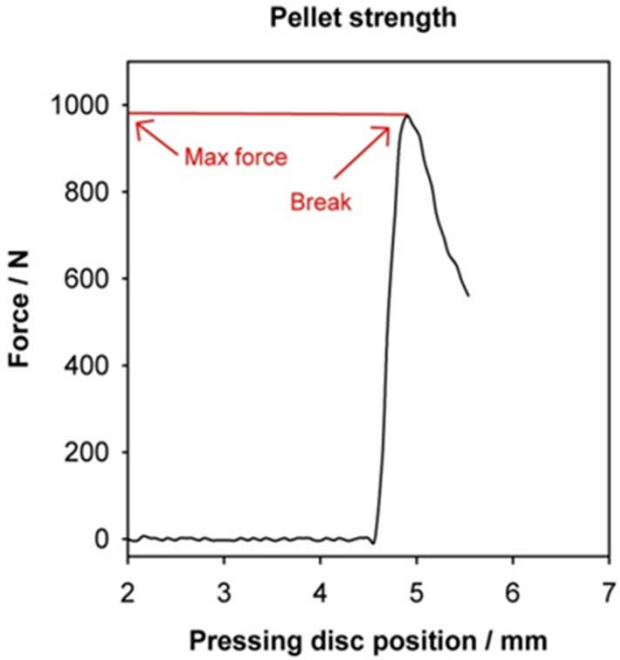
3. Pellet compression strength
4. Density





The pellet quality is determined by compression testing

The pellet is placed perpendicular to its axis and crushed → force-distance curve

Pellet density is determined by length and weight measurement of pellets

Selected results

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- How to lower the friction when pelletizing torrefied biomass

Selected results

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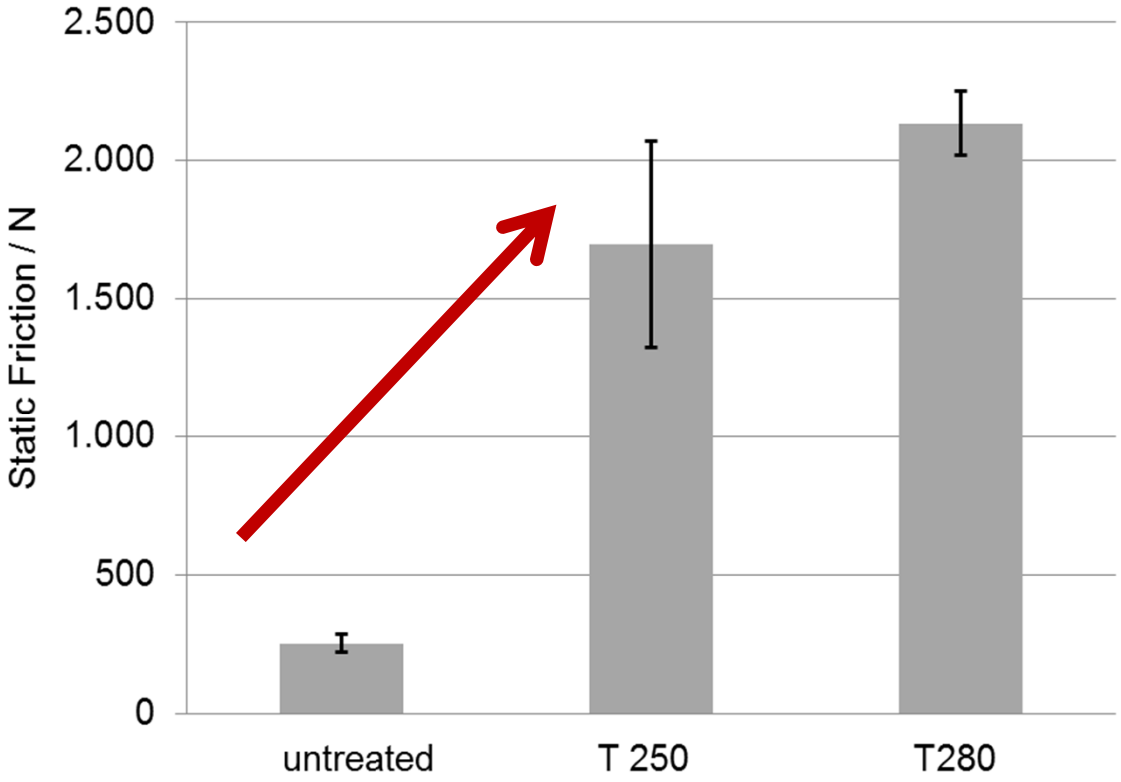
- Friction increase when pelletizing torrefied pine tree



Strong increase of friction for torrefied biomass

Pellet mill:

Energy requirements increase

Capacity gets lower

More heat development in press

Torrefied pine tree / 0.5 % MC / 125 °C die temperature

Selected test results

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- What can we do to improve the pelletizing properties?
  - Increase moisture content
  - Increase die temperature
  - Add a lubricant to reduce friction
  - Additives
  - Change press channel dimensions
  - Torrefaction parameters
    - Temperature
    - Reaction time
  - …

We have looked on a few of them
Some examples

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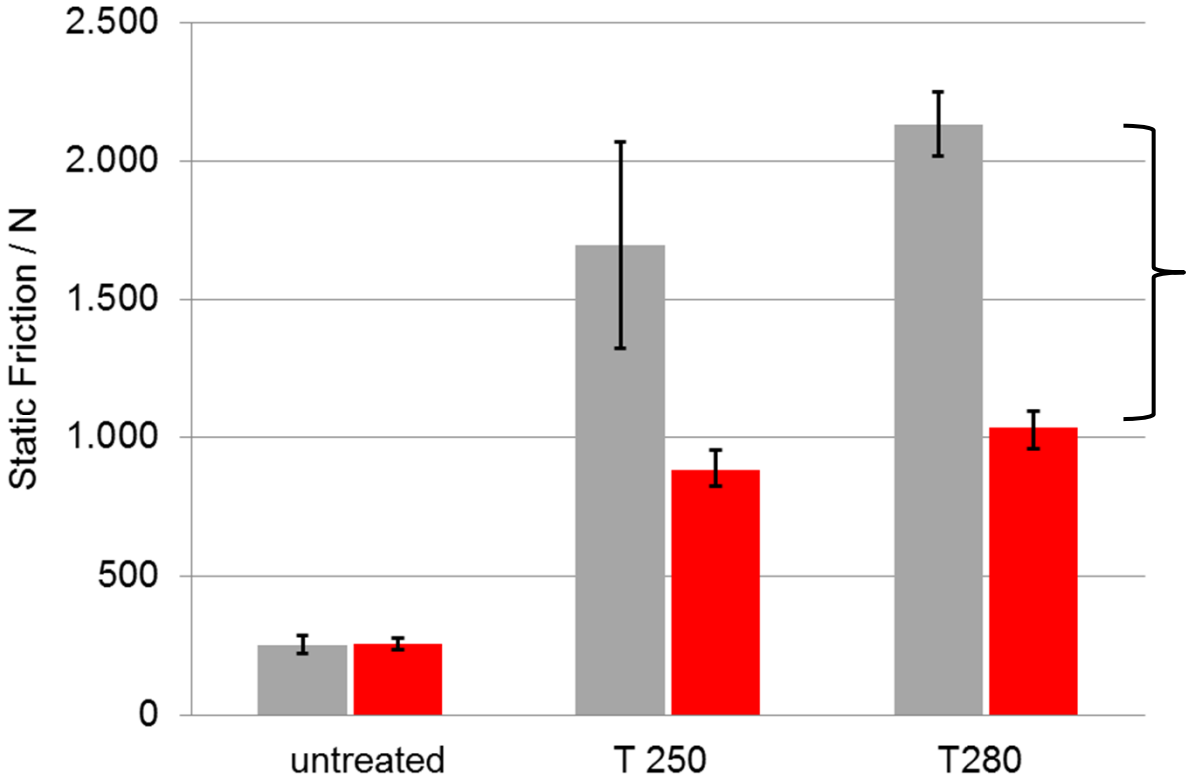
Selected results

- Increase of die temperature 125 → 190 °C



Friction is reduced by 50%

No effect on the untreated pine tree

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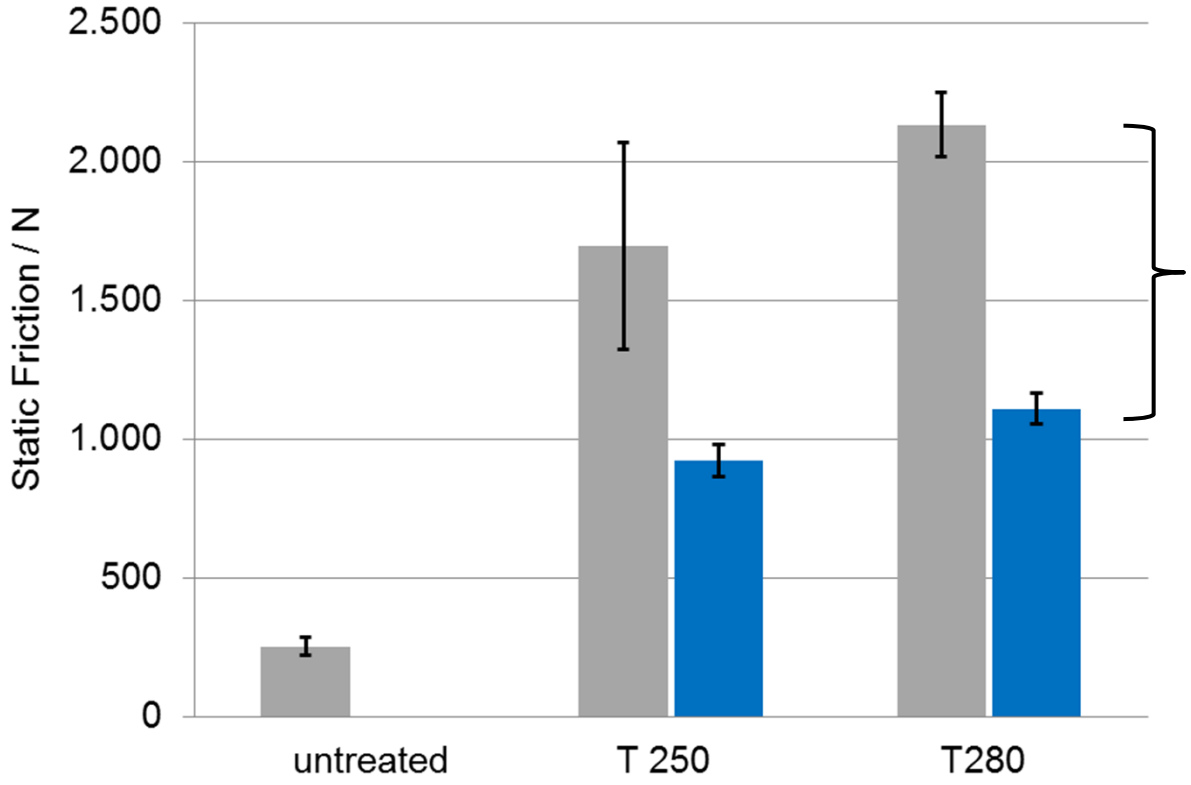
Selected results

- Increase moisture content from 0.5 to 5% (wb)



Friction is reduced by 50%

Selected results

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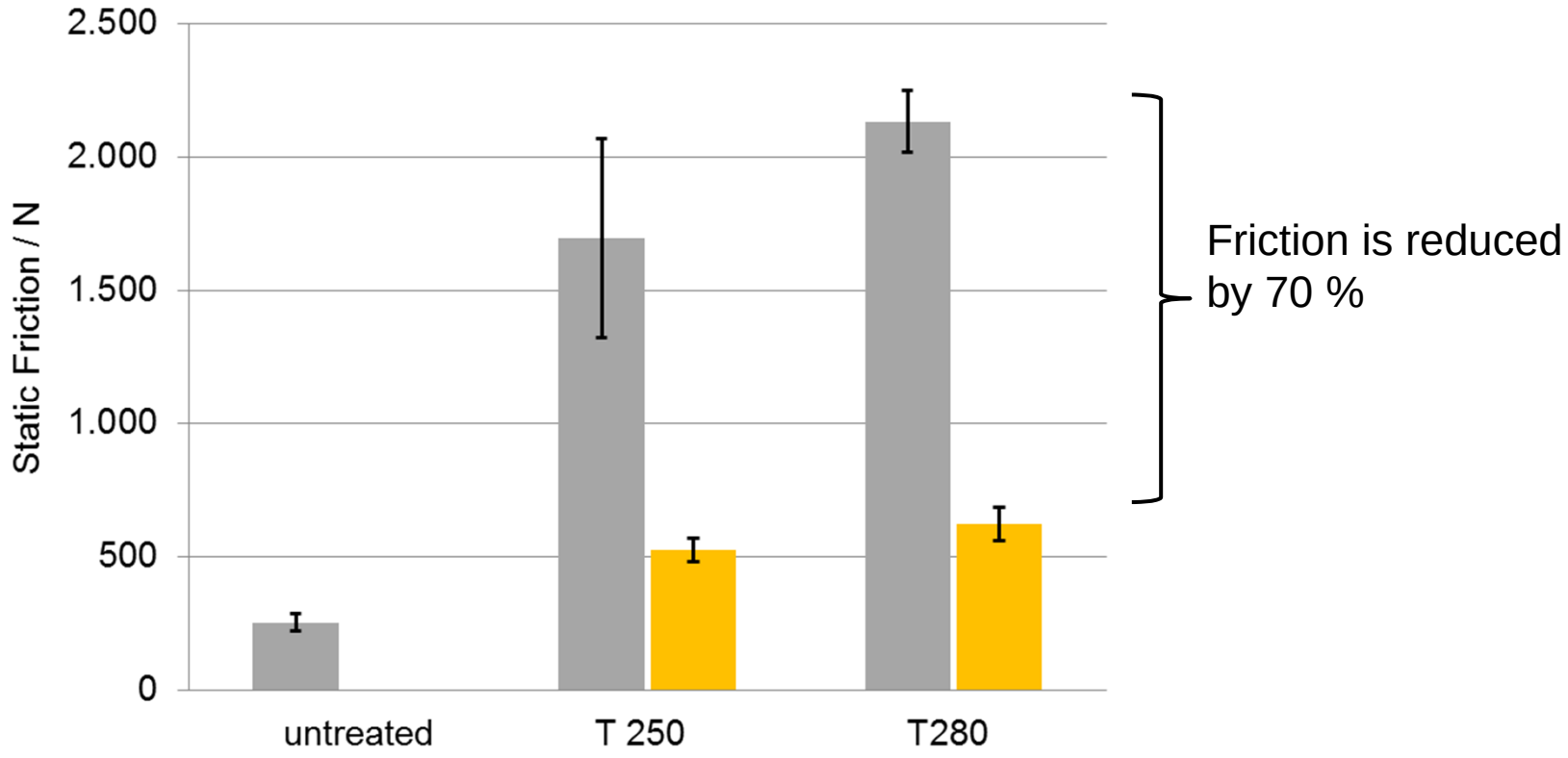
- Add a lubricant (2% oil)



Single pellet press vs. pellet mill

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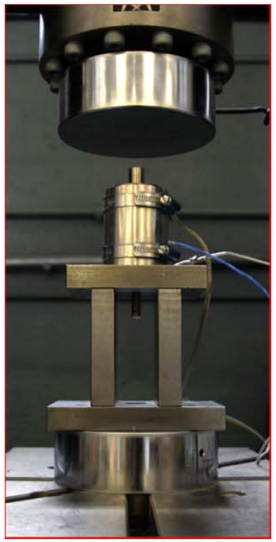

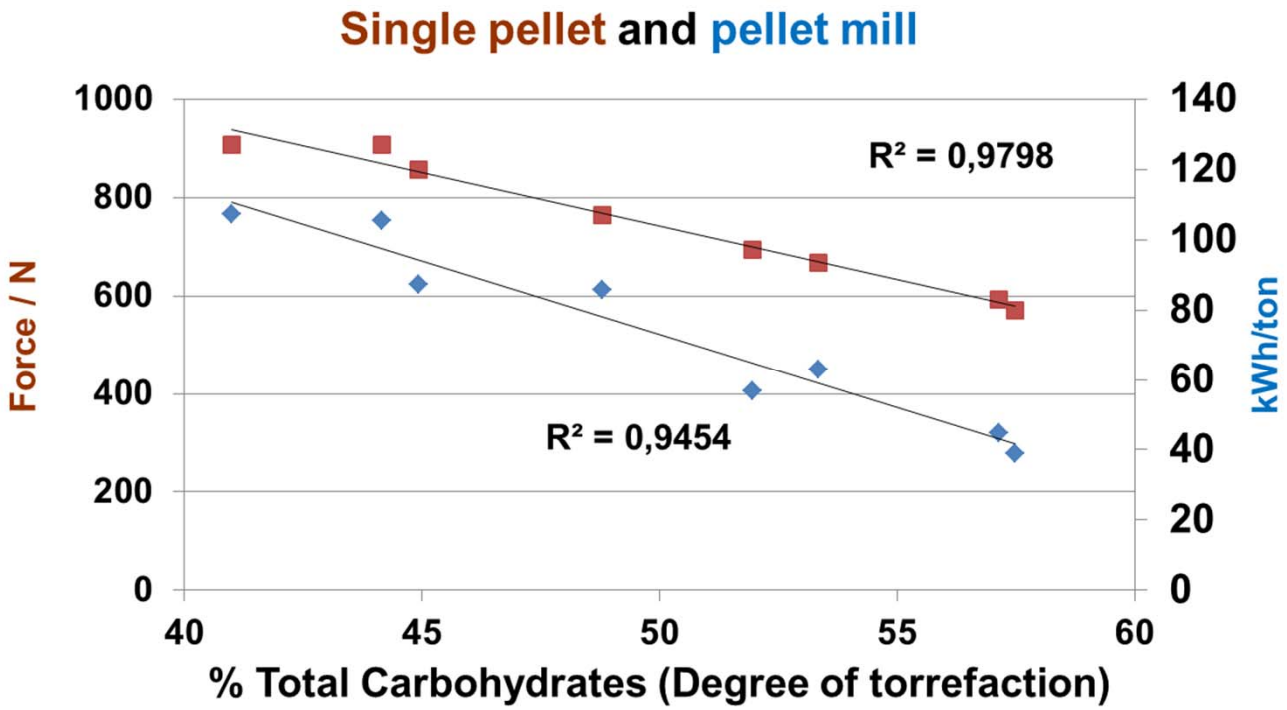

Good correlation between single pellet press and production size pellet mill data

Static friction from single pellet press (N)

Energy consumption of press (kWh/t)

Selected results

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- How to improve the quality of torrefied pellets

Selected results

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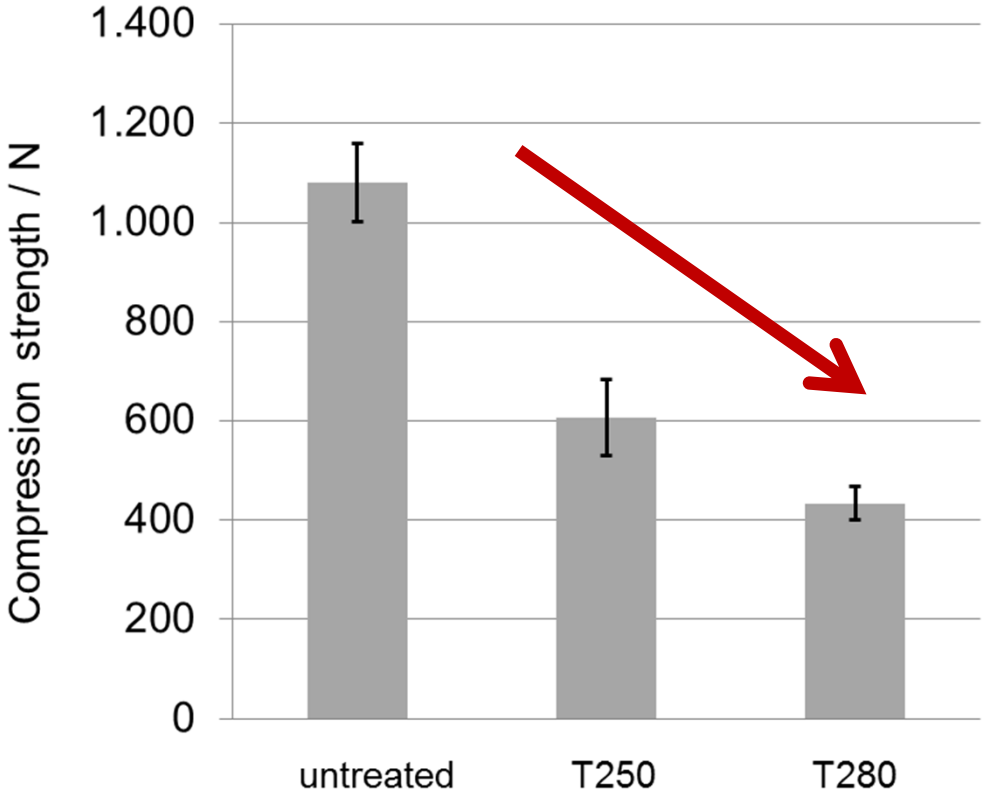
- Effect of torrefaction on pellet strength



Decrease of pellet strength with torrefaction temperature

Positive/Negative effects

Better grinding properties
Coal mills can be used to crush torrefied pellets

Dust and fines formation under transportation

Selected results

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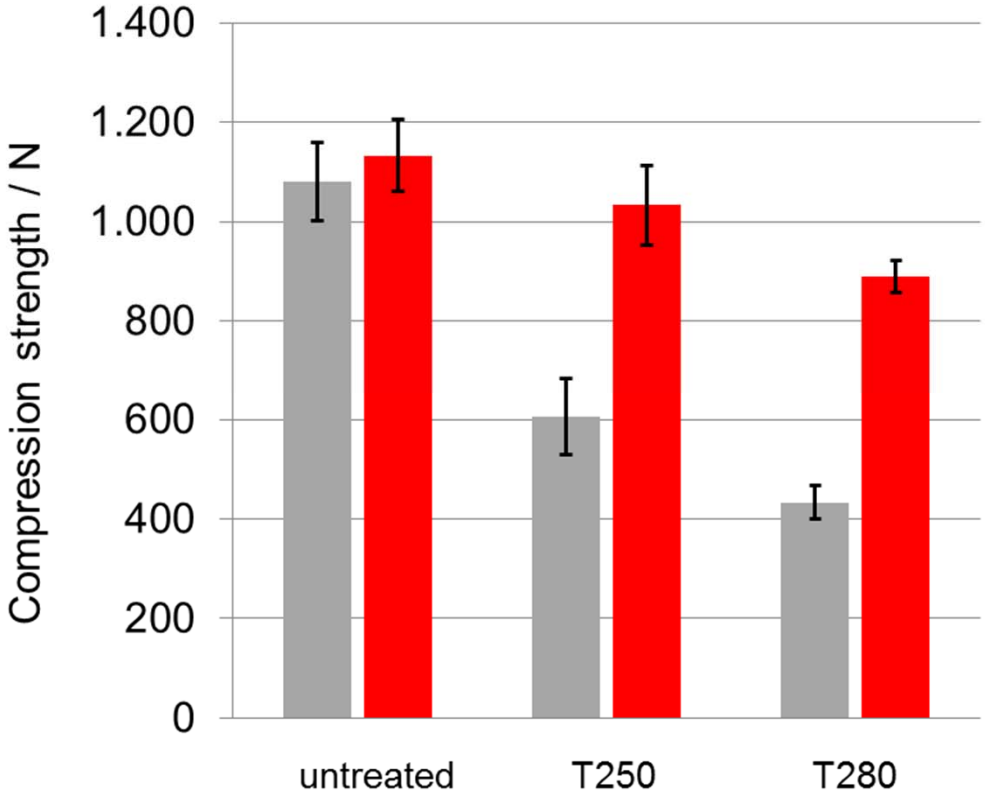
- Increase of die temperature to increase pellet quality



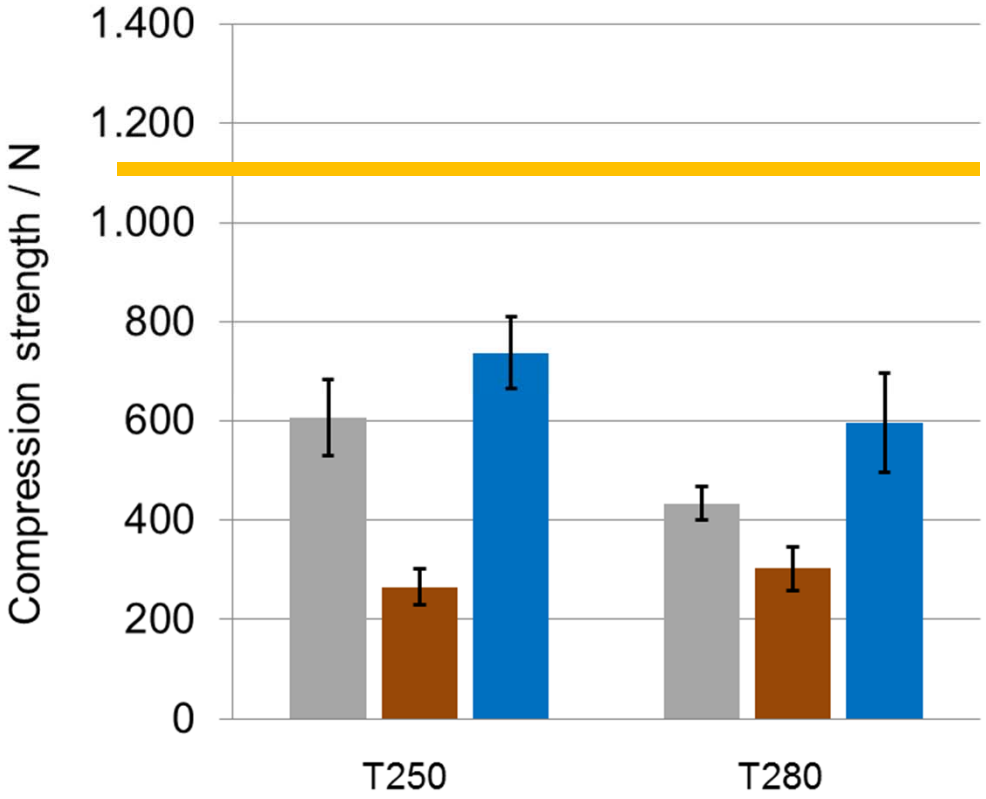
Increasing pelletizing temperature improves the pellet strength

Heating up the die
- Requires Energy
- Not possible in most cases

Feeding hot biomass directly after torrefaction?

Selected results

- Effect of oil and water addition



Oil and water lower the friction in the pellet press

Oil addition reduces pellet strength

Water addition results in an improvement of pellet strength

Quality is acceptable > 500 N

What can be learnt from these trials

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- Pelletization of torrefied biomass without additives is possible
- Process is not straight forward
- Issues when pelletizing torrefied biomass
  - Increase of energy uptake
  - Decrease of pellet strength
- → Many parameters influence the pelletizing process and pellet quality
- Pelletizing can be improved by heating the die or the addition of moisture and/or lubricants

Can briquetting be used as alternative?

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- Briquetting of torrefied biomass is a possible alternative
- Similar results have been observed for briquetting trials
  - Some materials are easier to press into briquettes than others
  - Variation in density
  - Improvement when briquetting at higher temperatures (pre-heating of die)
  - Moisture addition eases briquetting process

C.F. Nielsen, Denmark

What can be learnt from these trials

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- Densification of torrefied biomass is not straight forward
- Many parameters influence densification processes and product quality
- Lacking knowledge and experience

→ **SECTOR project**

→ Process and product optimization

→ Economic and sustainable production of solid energy carriers by means of torrefaction

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- **Thank you for your attention!**

For more information please contact:

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