Exploring the potentialities of torrefaction of biomass as a pre-treatment

Patrick Rousset (Cirad/KMUTT-JGSEE)
Patrick.rousset@cirad.fr

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ASEAN BIOMASS PROJECT (PHASE II)
Meeting with Industries

1. Biomass
2. Pre-treatment of biomass
3. Torrefaction as a pre-treatment technology
4. Torrefied biomass advantages
5. Application of torrefied biomass
6. Technical challenges
7. Torrefaction initiatives
8. Conclusions

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1. Limitations of biomass as fuel

Compared to fossil fuel resources:

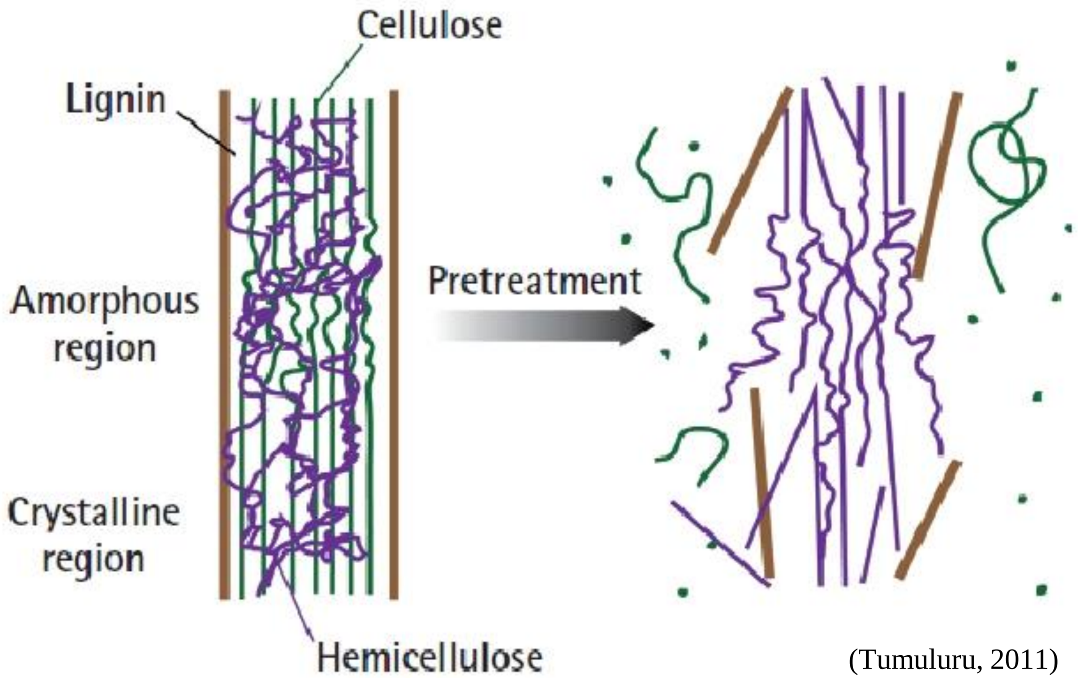
- low bulk density,
- high moisture content,
- hydrophilic nature,
- low calorific value

Consequences:

- Raw biomass difficult to use on a large scale
- High volumes of biomass are needed
  - *Problems associated with storage, transportation, and feed handling, …*
- Impact logistics and final energy efficiency

2. Pre-treatment of biomass

Pre-treatment alters the amorphous and crystalline regions of the biomass and bring significant changes in structural and chemical compositions.



(Tumuluru, 2011)

The fibre structure is destroyed through the breakdown of hemicellulose and to a lesser degree of cellulose molecules

3. Torrefaction as a pre-treatment

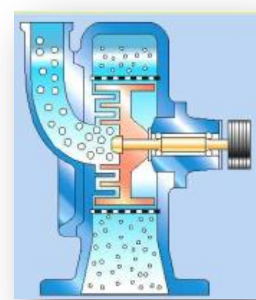
- **Torrefaction** is a thermal pretreatment process defined as slowly heating biomass in an inert environment and temperature range of 200–300° C.

- During the process, the biomass partly decomposes giving off various condensable and non-condensable gases. The final product is a carbon rich solid, which is referred to as torrefied biomass.

<u>2 main objectives:</u>

• Mechanical modifications

• Production of condensables



4. Torrefied biomass advantages

Promising results:

- 70% of the mass is retained as a solid product containing 90% of the initial energy.
- Energy density does increase noticeably
  - Handling, transport
- the carbon content and calorific value of torrefied biomass increases by 15–25%.
  - Co-firing capabilities
- Material hydrophobic : the moisture content decreases to <3%.
  - Storage, less degradation
- Torrefaction decreases the grinding energy by about 70%.
  - Pulverized system

Torrefaction before pelletization:

- Produces uniform feedstock with consistent quality,
- reduces by a factor of 2 the required pressure and energy consumption,
- the density material varied in the range of 750–850 kg/m3 compared to wood pellets 520–640 kg/m3.

5. Applications of torrefied biomass

- **Co-firing in pulverised coal fired power plants:**

The advantages of torrefaction are particularly recognized for use in (older) and existing pulverized coal (PC) fired power plants.
New coal fired power plants are designed for high co-firing ratios of lignocellulosic biomass, much further than 40% with torrefied biomass (5-10% raw biomass)

- **Gasification:**

The relatively low moisture content, good grindability and attractive C/H/O ratios make torrefaction an interesting pretreatment technology for gasification

- **Blast furnaces:**

There is a large potential for substituting coal in blast furnaces, given the lack of alternatives for CO2 reduction.

- **Standalone combustion:**

This makes them much more fuel flexible in terms of the fuel characteristics that are influenced through torrefaction

6. Technical challenges

Developers of new torrefaction technologies have to meet basic requirements like flexibility of feedstock, durability, simplicity (low maintenance cost and short shutdown time), scaling-up the process, process control, product quality/consistency and economic affordability

1. Flexibility (of feedstock):

- The currently developed torrefaction technologies have relatively limited feedstock flexibility in terms of particle size (5 to 20 mm) and moisture content (not exceeding 15% on wet basis).
- Most projects currently process wood, further R&D effort are needed in order to torrefy agriculture biomass

2. Scaling up the process:

- Depending on the reactor type, it can be a serious challenge to scale up torrefaction processes from pilot (typically 20-600 kg/h) to commercial scale (5-10 ton/h or larger).
- Roasting in a shorter time (20-50mn)

For example limited for screw reactors, drum reactors or belt conveyors; need establish multiple production lines in parallel.

7. Torrefaction initiatives

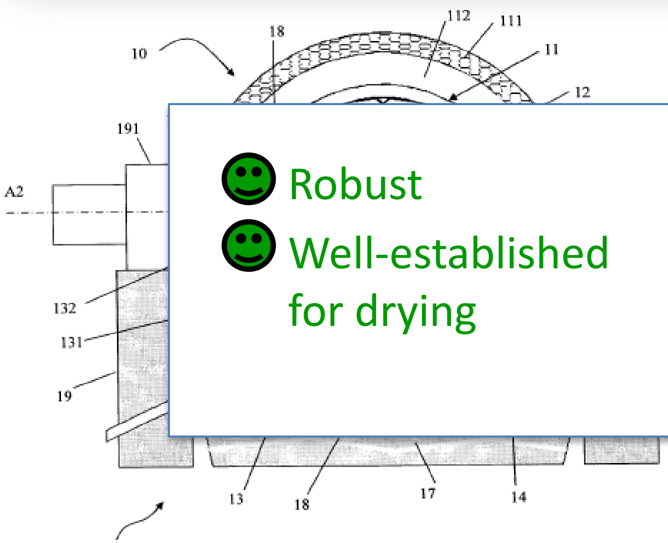
- Currently, there are close to 100 patents and/or patents pending relating to the Torrefaction of Biomass, the first dating back to the 15 th of January 1901, almost of them are in the public domain.
- In general, all reactor technologies are proven technology in others application : combustion, drying and gasification and are being modified to perform torrefaction.
- Almost all kind of industrial furnace have been tried
- Currently, no continue technology at industrial scale

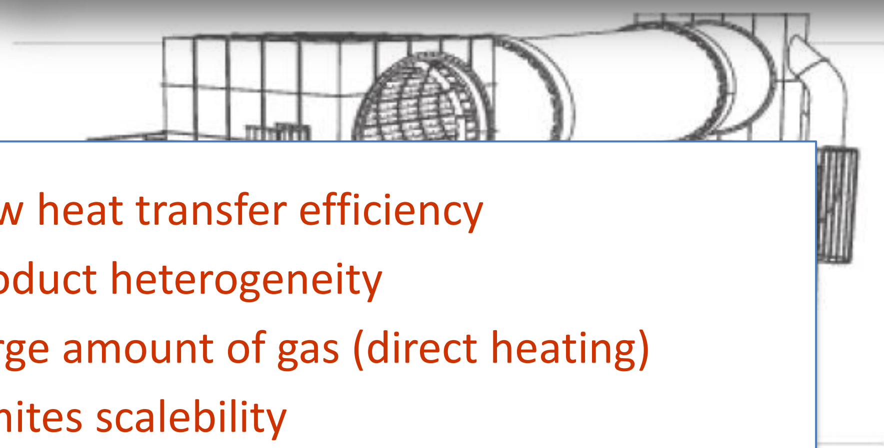
The most important reactor technologies and the companies involved.

Reactor technologies	Companies involved
Rotating drum	CDS (UK), Torr-Coal (NL), BIO3D (FR), EBES AG (AT), 4Energy Invest (BE), BioEndev/ ETPC (SWE), Atmosclear S.A. (CH), Andritz , EarthCare Products (USA)
Screw reactor	BTG (NL), Biolake (NL), FoxCoal (NL), Agri-tech Producers (US)
Herreshoff oven/ Multiple Hearth Furnace (MHF)	CMI-NESA (BE), Wyssmont (USA)
Torbed reactor	Topell (NL)
Microwave reactor	Rotawave (UK)
Compact moving bed	Andritz/ECN (NL), Thermya (FR), Buhler (D)
Belt dryer	Stramproy (NL), Agri-tech producers (USA)
Fixed bed	NewEarth Eco Technology (USA)
Vibriting reactor	Revtech (FR)

7. Torrefaction initiatives

Rotary drum: torr-coal





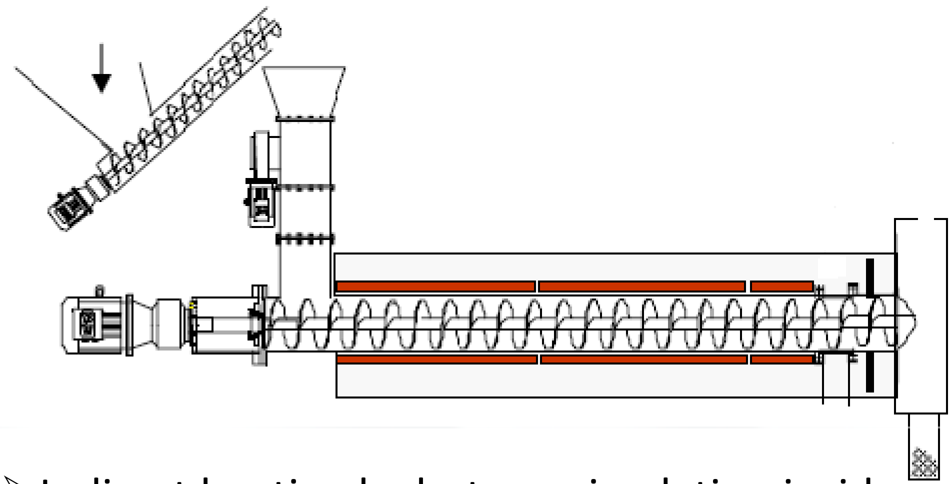
- Robust
- Well-established for drying

- Low heat transfer efficiency
- Product heterogeneity
- Large amount of gas (direct heating)
- Limites scalebility

Process within the reactor controlled by varying the internal temperatures, the rotational velocity, length and angle of the drum: 35000t/y.

7. Torrefaction initiatives

Screw reactor: BTG, Agritech, …



- Indirect heating by hot gas circulation inside the walls and the screw
- Gas come from a combustion chamber

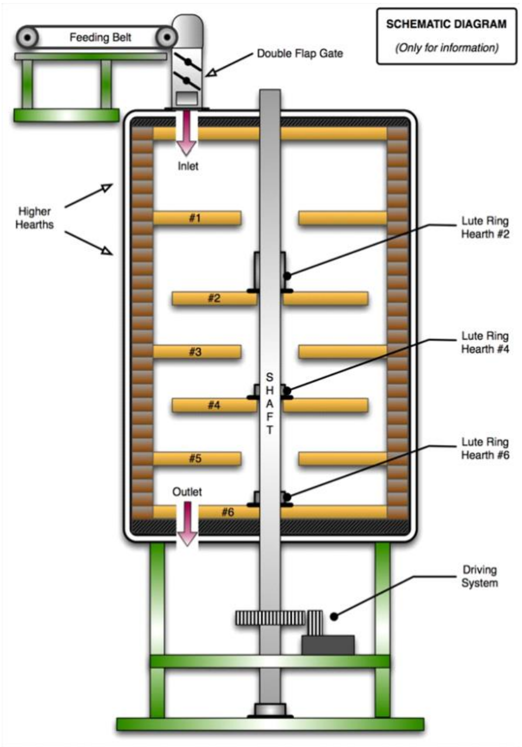
↳ Possible use of torrefaction gas

☺ Robust
☺ Well known

☹ Limited Scale-up
☹ Low mixing of the bed
☹ Cleaning difficult
☹ low Suitability with various feedstocks

7. Torrefaction initiatives

Multiple Hearth Furnace: CMI-NESA (BE), Wyssmont (USA)



- Direct heating:
    - Radiation from a combustion flame
    - Convection particles/hot gas
- Feedstock flows down by gravity
- Different rotating systems:
    - Wyssmont: rotation of the floors
    - CMI: rotation of arms on the floors
- Developed for other applications:
    - Wyssmont: drying/CMI: calcination

Technology well known

Large range of biomass

Independant heating for each floor

Easy scale-up

Temperature heterogeneity

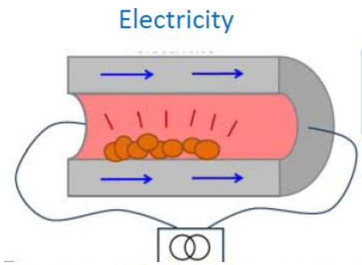
No re-use torrefaction gas + combustion gas

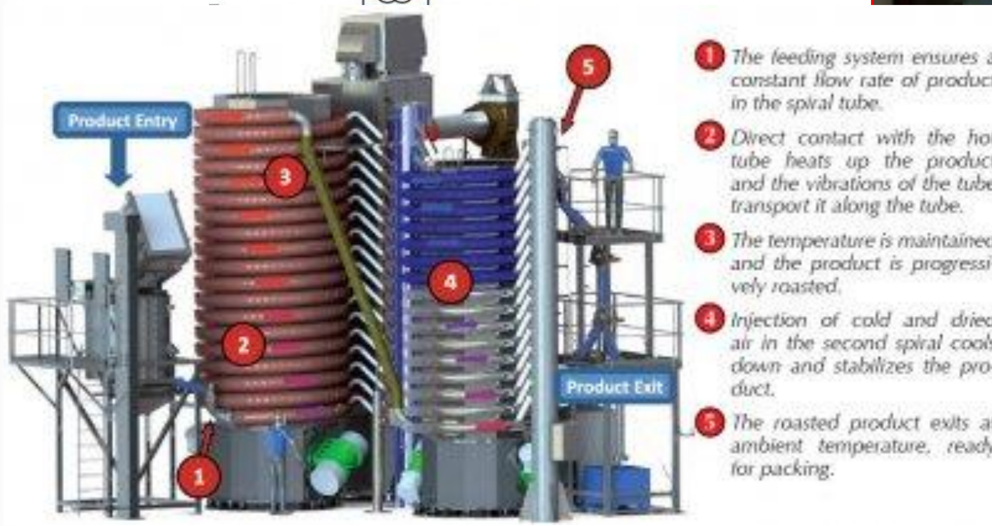
Partial inert bed, low mixture = heterogeneity

Application to torrefaction

7. Torrefaction initiatives

Vibriting reactor: Revtech (FR), Cirad (FR)





- Particle flow and mix by vibration, heated with an electrical impedance tube
- Direct heating by conduction to the wall + convection with hot gas circulation ⇨ Very good heat transfer
- Toating, roasting, sterilization, , chemical products

Simple and Compact

Homogeneous treatment

Suitable with various feedstocks

Scaling-up

Electrically heated: consume approximately 250 kW h/ton

No re-use gas for torrefaction.

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8. Conclusions

1. The torrefaction technology is now proven in pilot scale, and the first initiatives are underway to demonstrate the technology at commercial scale

2. The most important technical challenges in the development of torrefaction processes relate to achieving :
   - constant and well controlled product quality,
   - scaling up the process,
   - obtaining high system efficiency through proper heat integration,
   - flexibility in terms of input materials,
   - be able to densify the material,

3. The technical and economical advantages of torrefied pellets are recognised by most of the larger power producers: more contracts between end-users and suppliers

4. Torrefaction suppliers face the challenge to torrefy waste streams like agriculture residues

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Thank you


Hm Hm!...Good idea, but we need to transform a little !...
SCRITCH SCRTCH SKR
BIOMASSE
BIOCARBURANT
ASTER