ISSCT Factory Workshop

"Technologies for profitable Cogeneration"

Cane harvest residues-Experiences in Colombian sugar industry

cenicaña

Gold Coast, Australia 8-12 May, 2011

CONTENTS

- Cane harvest residues: Current situation of the Colombian sugar industry
- Conceptual Engineering.
- Computational Fluids Dynamics for modeling trash separation
- Size reduction and densification-knifing and briquetting machines
- Pyrolysis of sugar cane trash.
- Advances in Second Generation Ethanol

Cane harvest residues: Current situation of the Colombian sugar industry

- Approximately 30 % of cane is being mechanically harvested both green and burnt.
- Two mills are mechanically harvesting 50% of the rate.
- Harvesters are conventionally operated i.e. 10 % extraneous matter in average.
- Only one mill is operating a trash separation system since 1998. Obtains ~100t of residues per day.
- Trash extraction from fields, size reduction and boiler performance has been reported (ISSCT 2005)



Residues from green cane manually harvested

- **TCH: 120 TCH**
- **Residues: ~50 TRH**



Residues left on the field. Manual green harvest



Hand rowing of residues

Fuente: Banco de Imágenes Digitales y Análogas, BIDA. Cenicaı

Use of residues (Trials 1999-2002)

- Harvest residues extracted from the fields, size reduced and transported to the mill. Logistics, Boilers performance and costs were assessed. (2001,Cenicaña-Incauca).





Trash handling for boilers





Conceptual Engineering-1

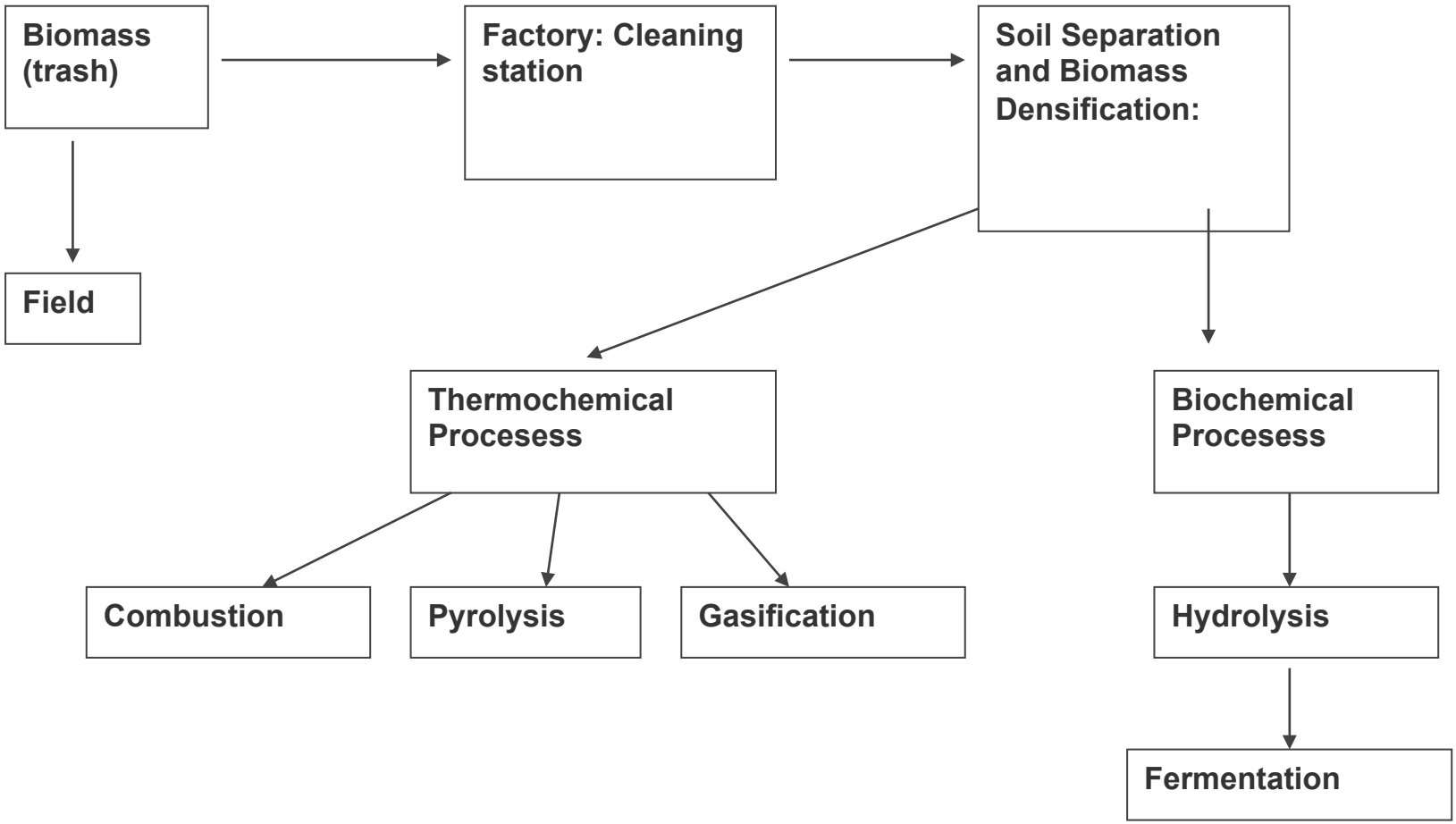
- To assure at least one sound kit of technology for direct use of trash in boiler combustion.
- To define technologies to extract and prepare trash .
- Trash logistics. Impact on cane transportation.
- To explore distributed energy densification.

Conceptual Engineering-2

- To define prioritize processes for other energy products .
- Distributed Pyrolysis. Biochar for physical soil properties improvement . Pyrolytic Oil for fuel and others.
- Second generation ethanol.
- To define Research and Applied Engineering tasks



Sugar Cane trash for energy



Technical subjects

- Trash separation modeling
- Trash Size reduction- Densification.
- Pyrolysis experiments and research.
- Second Generation Ethanol.



Computational Fluids Dynamics for modeling trash separation

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Objectives

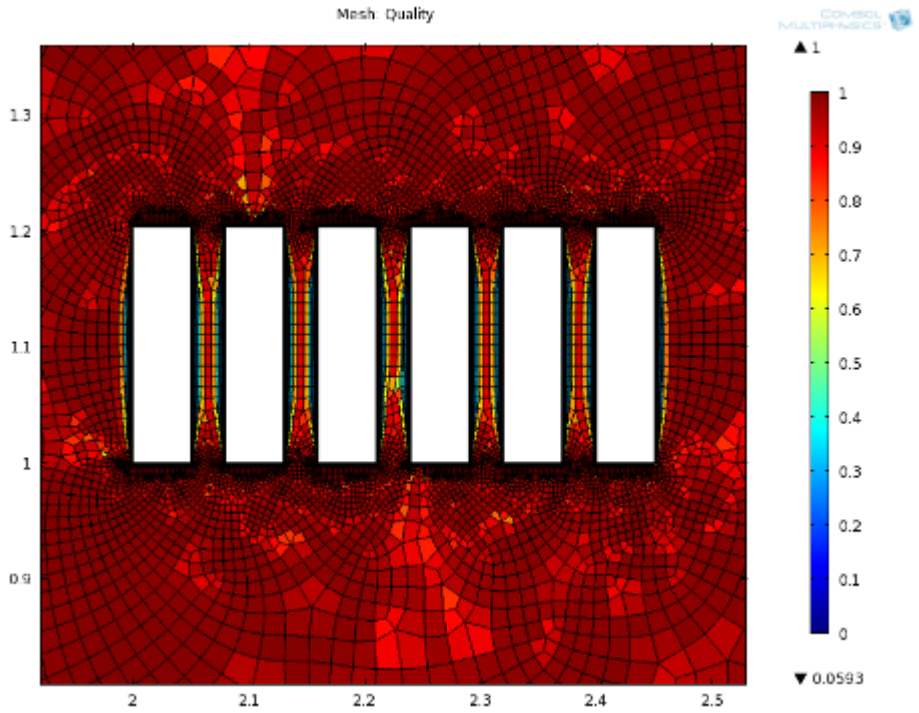
With numerical and experimental approaches:

- **To define optimal geometry of Inertial chambers (after feed table and between conveyor belts).**
- **To specify air flows and conditions required.**

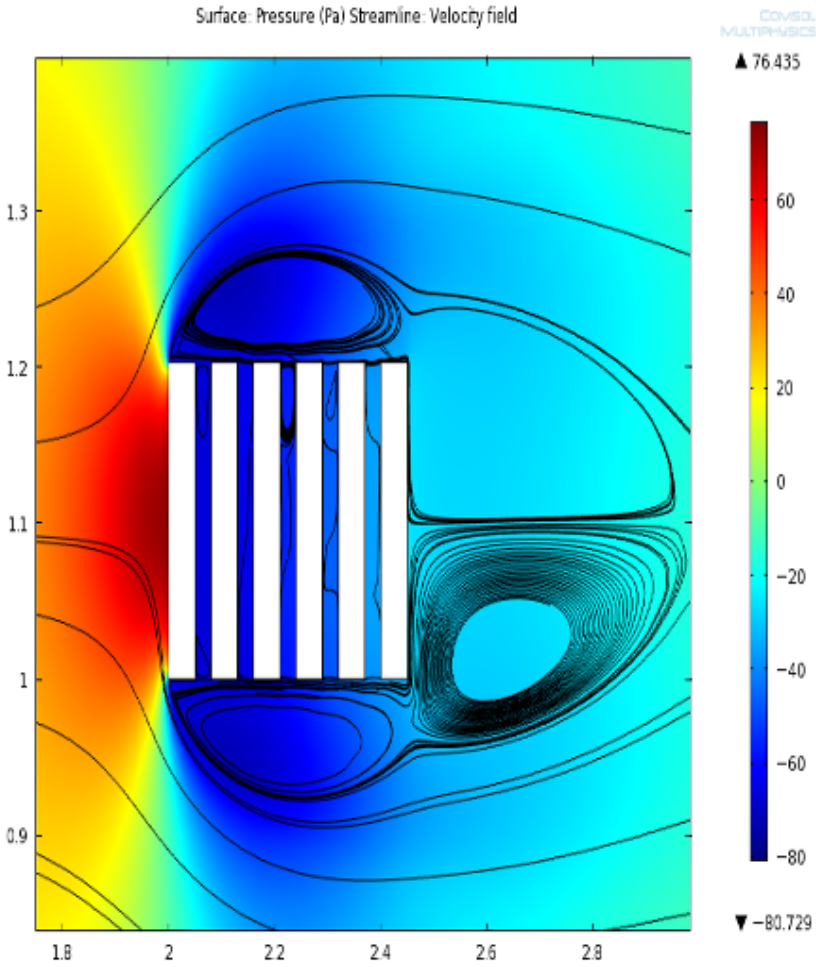


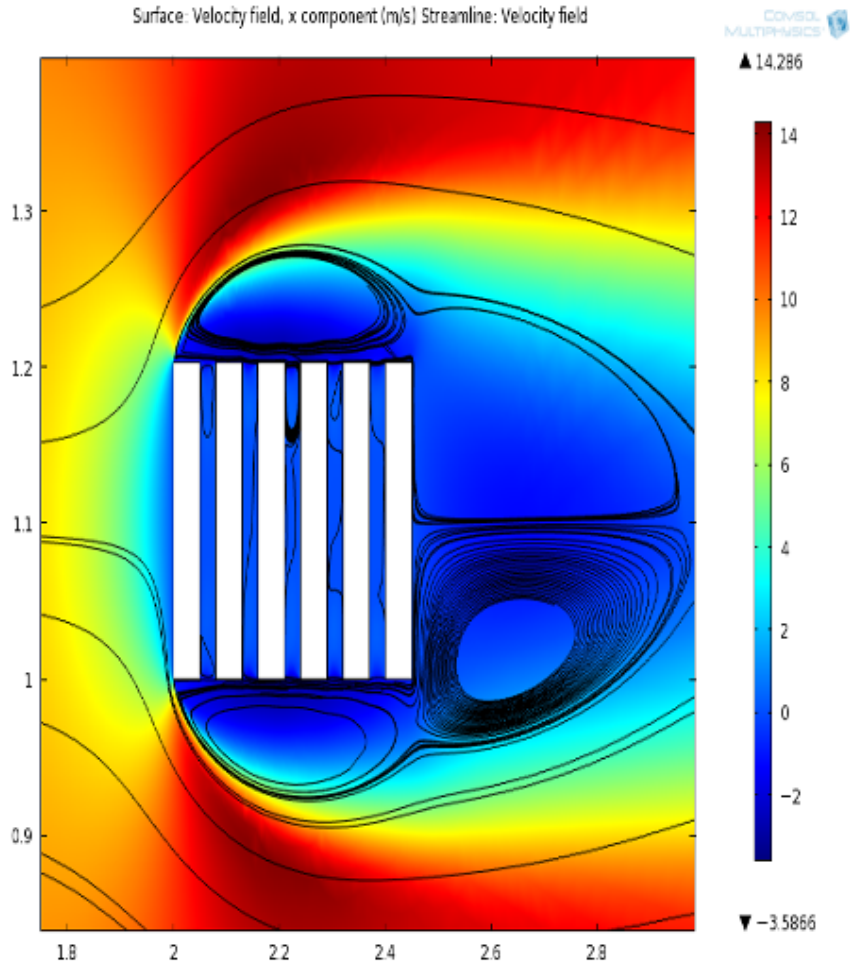
Some modeling conditions:

- Cane billets (2 in diameter and 8 in long cylindrical elements) inside wind tunnel.
- Turbulent fluid : K-E model
- Air inlet Velocity in: 10 -15 m/s
- Relative Pressure out: 0

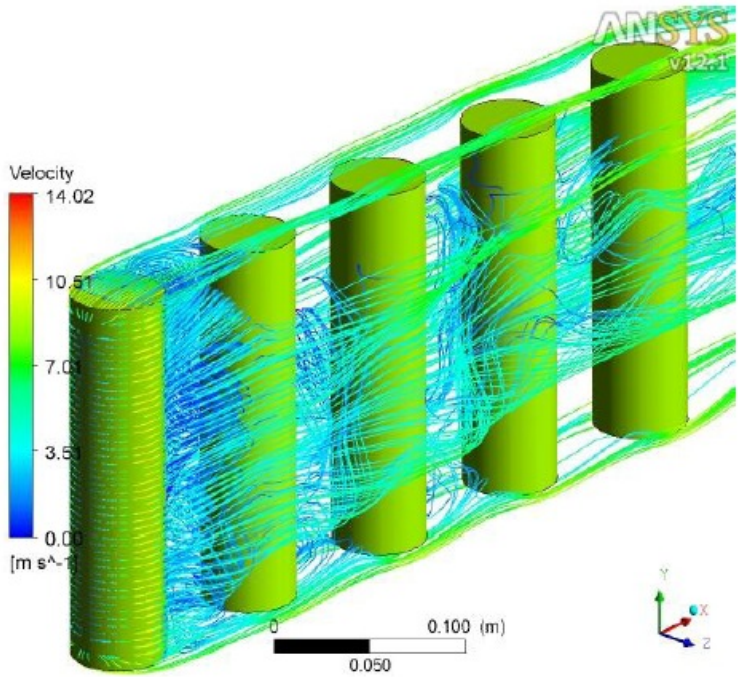


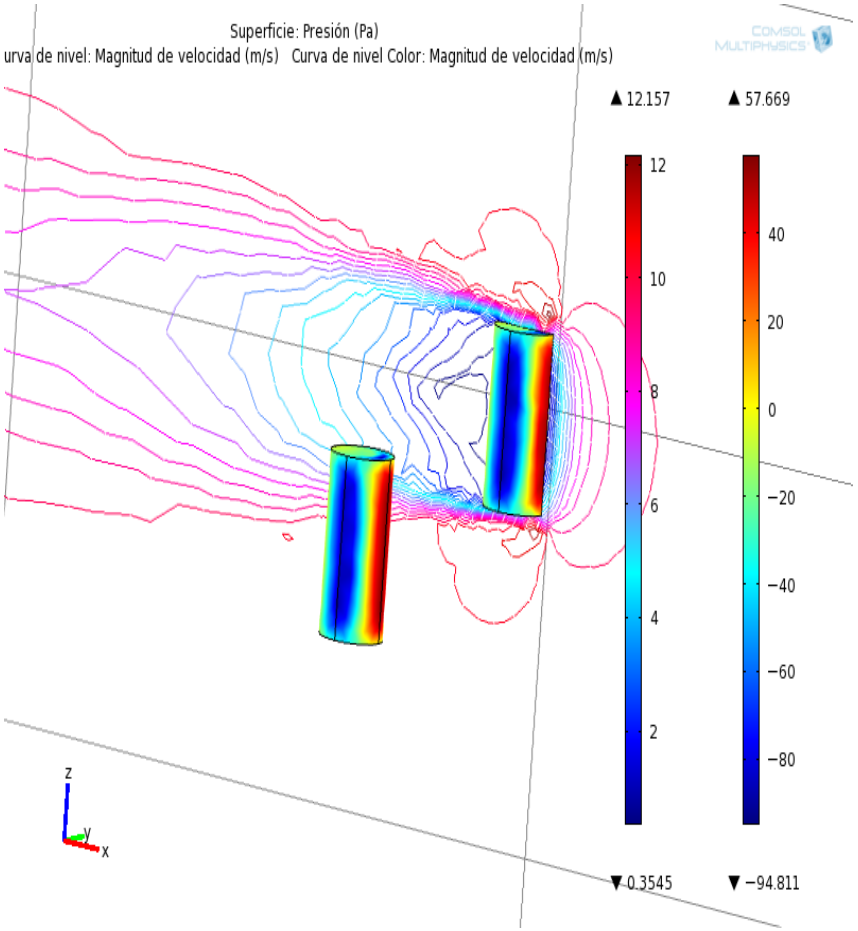
Pressure and velocity fields: Some Results





2D and 3D- One phase models





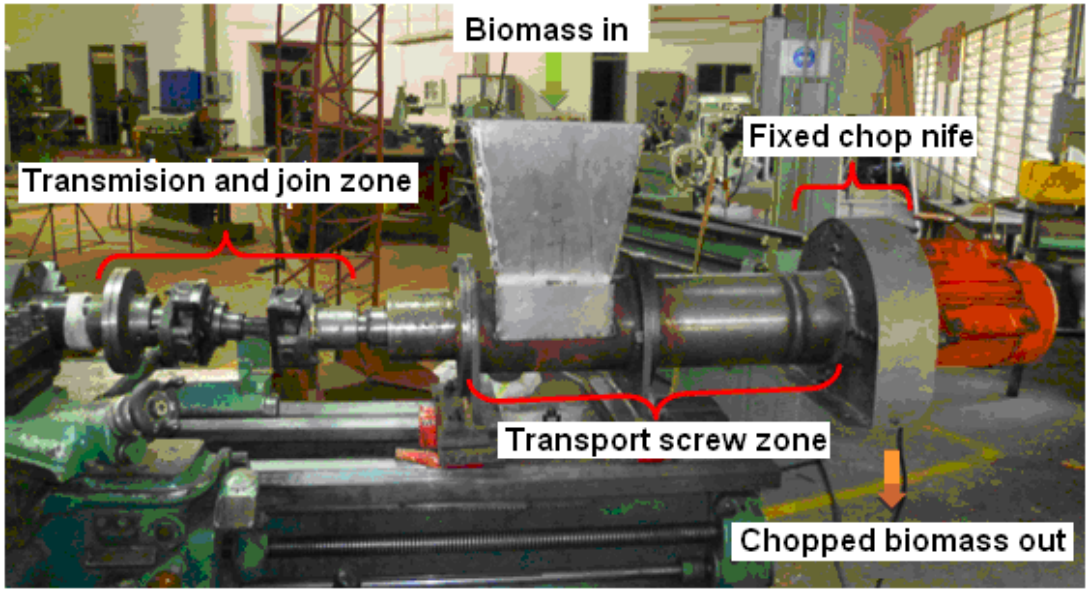
Size reduction and densification. Prototypes of knifing and briquetting machines

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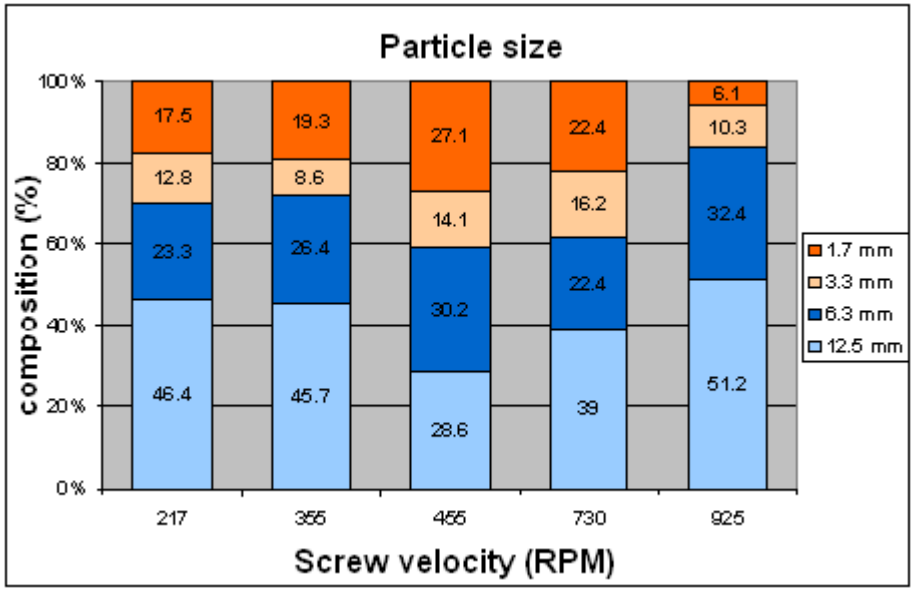
Sugar cane trash knifing





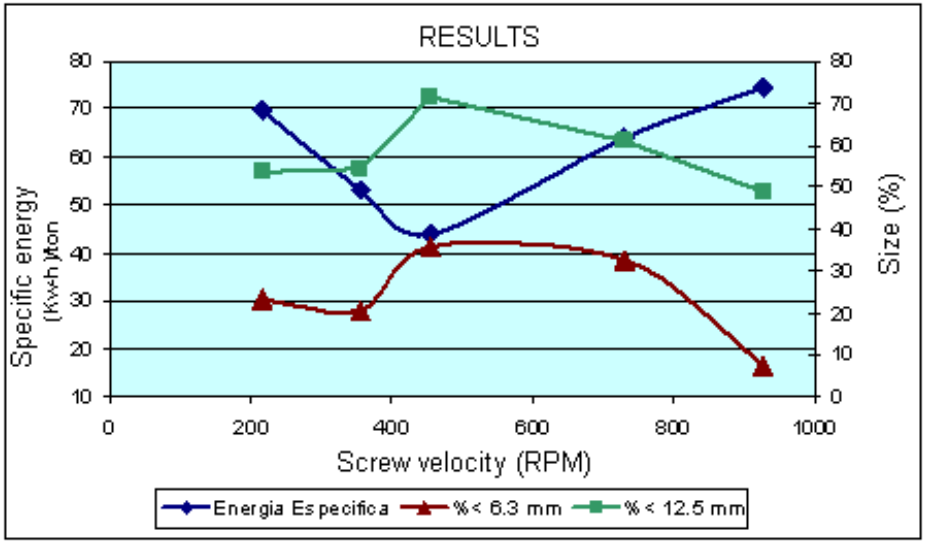


Some Results

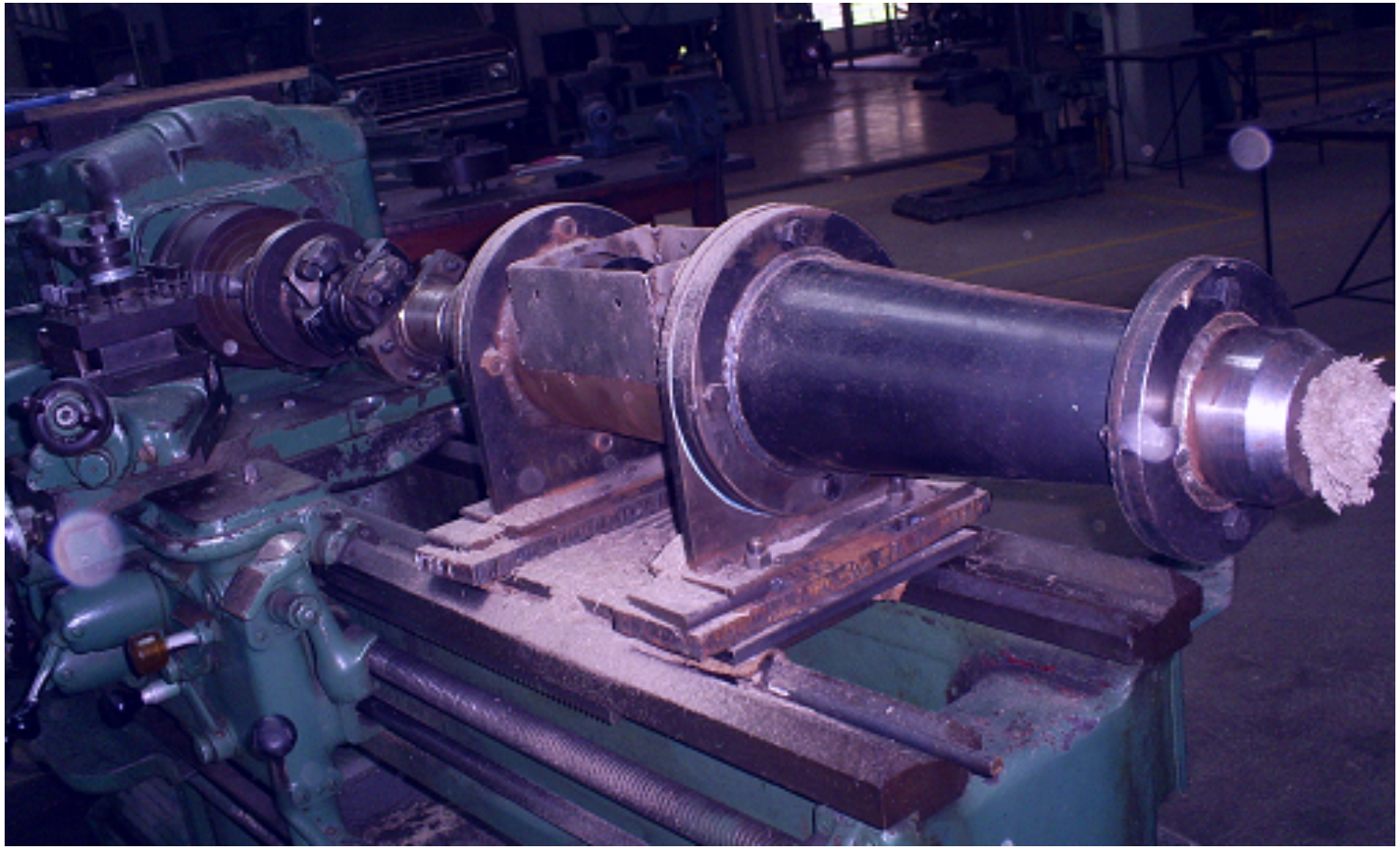


Transport screw velocity with better results (smaller particle size) was 455 rPM.

Specific energy at 455 RPM, 43.3 Kw-h/ton



Bagasse briquetting
Experiments and prototyping





Projections

- Scaling to handle trash from manually harvested cane.
- Study trash feeding to the knifing disc with simultaneous soil separation.
- Determine the optimal angle of the cutting blades
- To assess knives wear.
- Briquettes from residues.



Pyrolysis of sugar cane trash

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Laboratory scale batch experiments

Driying
biomass
105 °C



Size reduction
Jeffco
Shredder





Cyclotec mill 1093





-200g of biomass
- 20 minutes





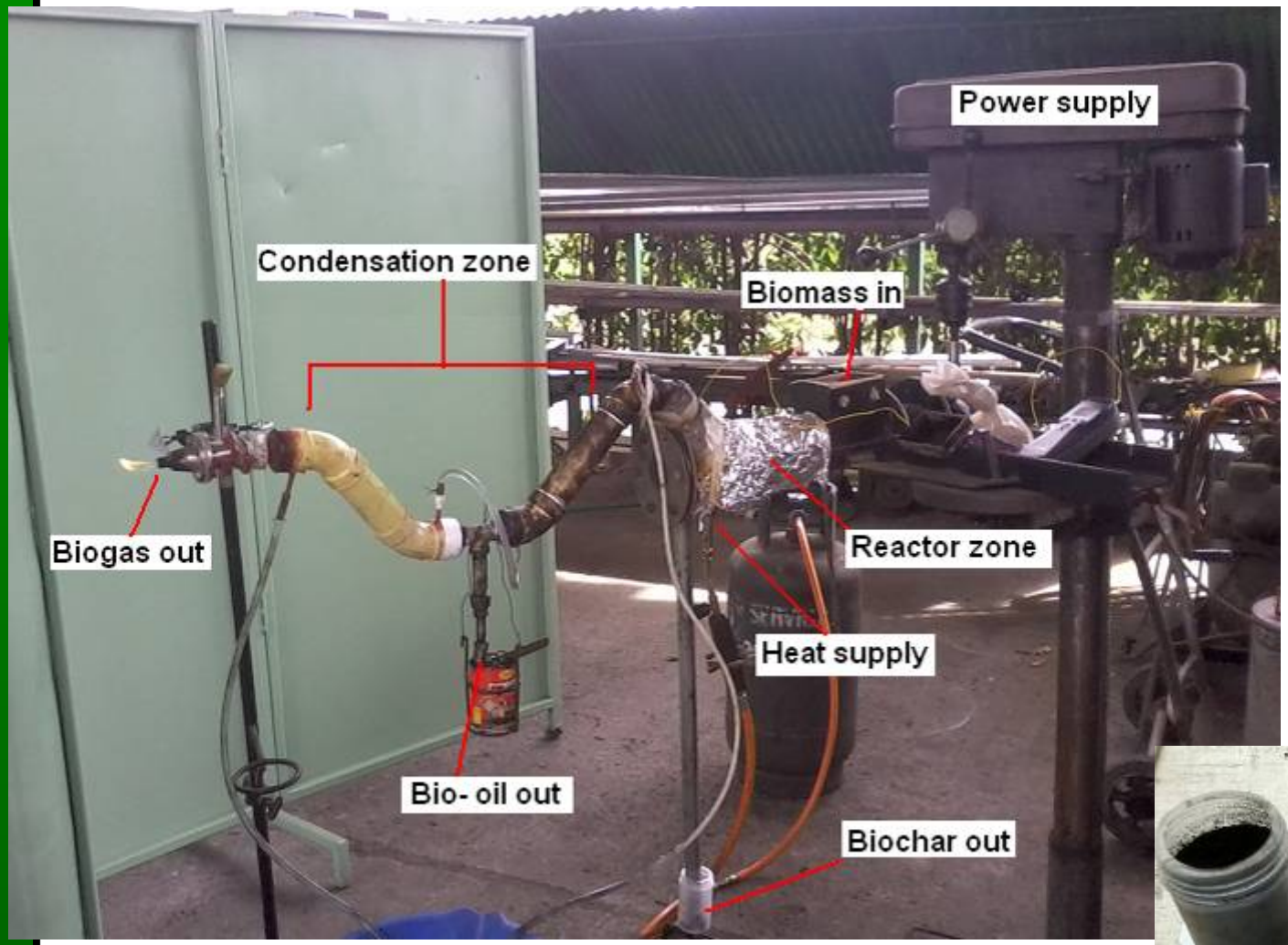
Bio-oil

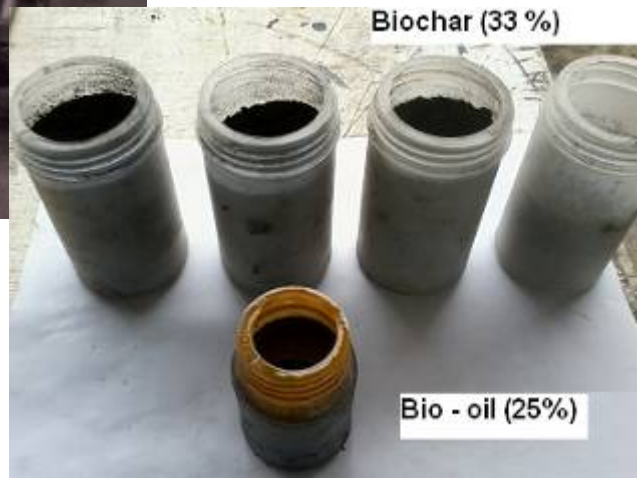


Bio-char

Products

Continuous pyrolysis micro-reactor





Results

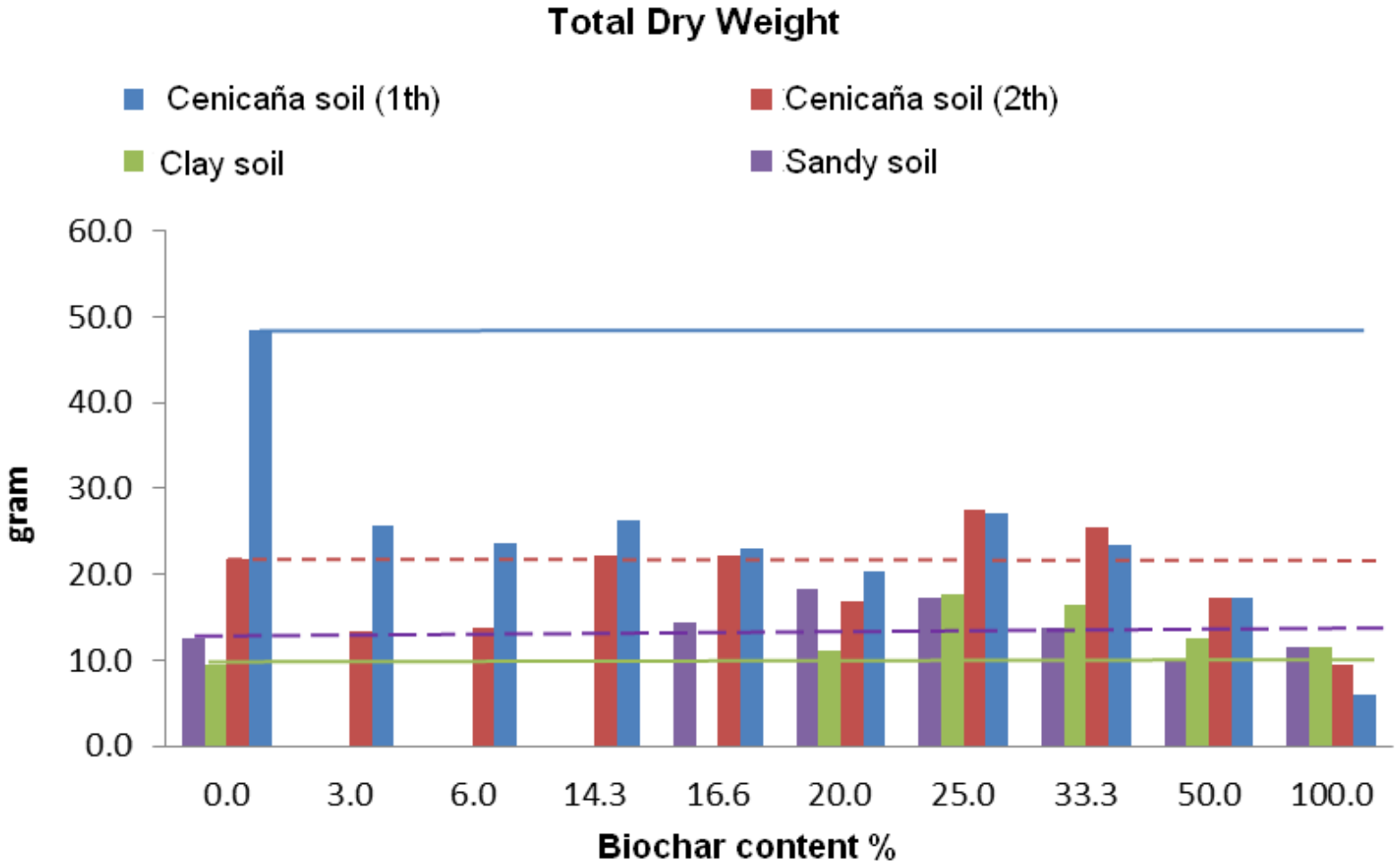
- The best configuration for the continuous micro- reactor is:
  - Screw velocity: 12 rpm.
  - Outside Reactor temperature : 500°C.
  - Condenser cold water inlet temperature : 11°C.
- The yield, so far, is:
  - 25% bio-oil
  - 33% biochar

Preliminary studies about biochar use to amend soils for cane growing

- **Experimental time: 2 months.**
- **Soil types:**
  - **Sandy soil.**
  - **Clay soil.**
- **Seven treatments (three replicates): 100%, 50%, 33%, 25%, 20%, 16%, 14% of biochar + witness (0% of biochar).**



Results


Total Dry Weight
Cenicaña soil (1th)
Cenicaña soil (2th)
Clay soil
Sandy soil
60.0
50.0
40.0
30.0
20.0
10.0
0.0
gram
0.0
3.0
6.0
14.3
16.6
20.0
25.0
33.3
50.0
100.0
Biochar content %

Projections

- Physicochemical characterization of obtained pyrolysis products in cooperation with NREL (National Renewable Energy Laboratories USA).
- Construction and testing of a bigger continuous reactor (1 ton / h).
- Bio-oil catalytic cracking, in cooperation with Universidad del Valle (Cali/ Colombia).
- Biochar experimentation in soils on a larger scale.
- To establish preliminary economics models

Advances in Second Generation Ethanol

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Factory Program Process
Cenicaña

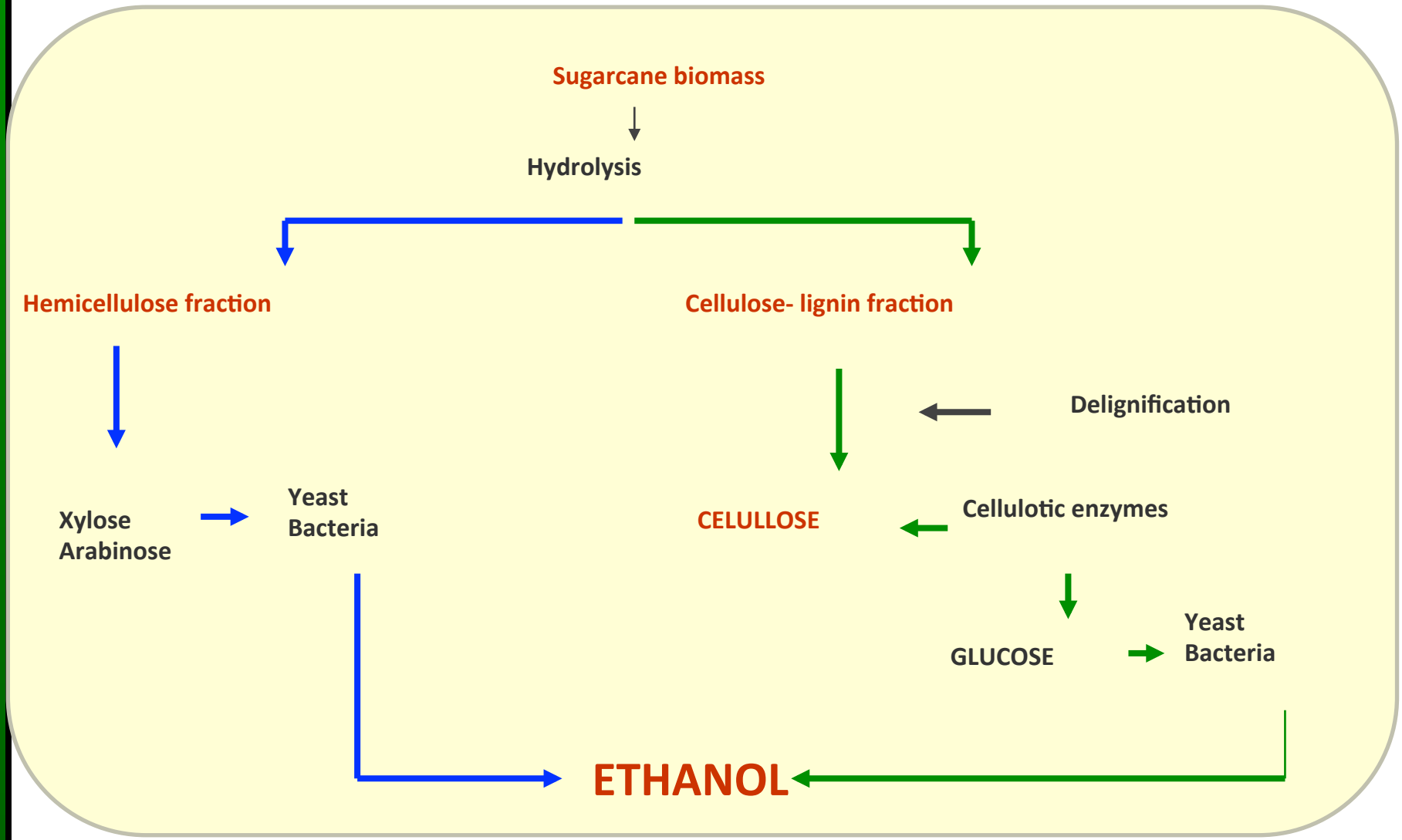






Colombian Sugarcane Research Center

Second generation ethanol flow diagram

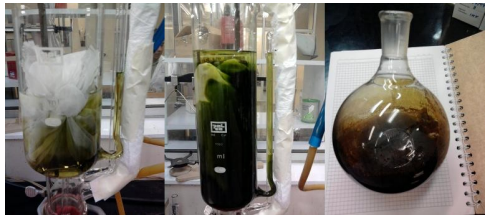


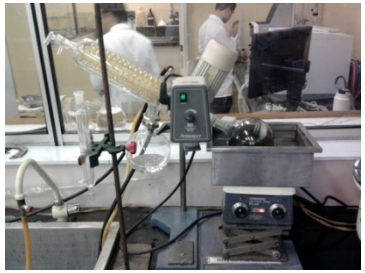
Extractives determination in sugarcane biomass



Soxhlet: extraction of soluble materials in ethanol and water.

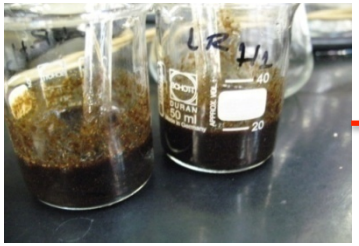
107± 3°C; 24 h





Solvent recovery system

Carbohydrate and lignin determination

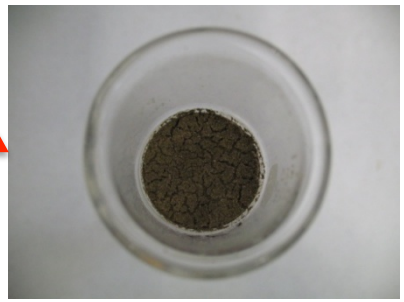


Concentrate acid (H_2SO_4 72%), 2 h, ambient temperature

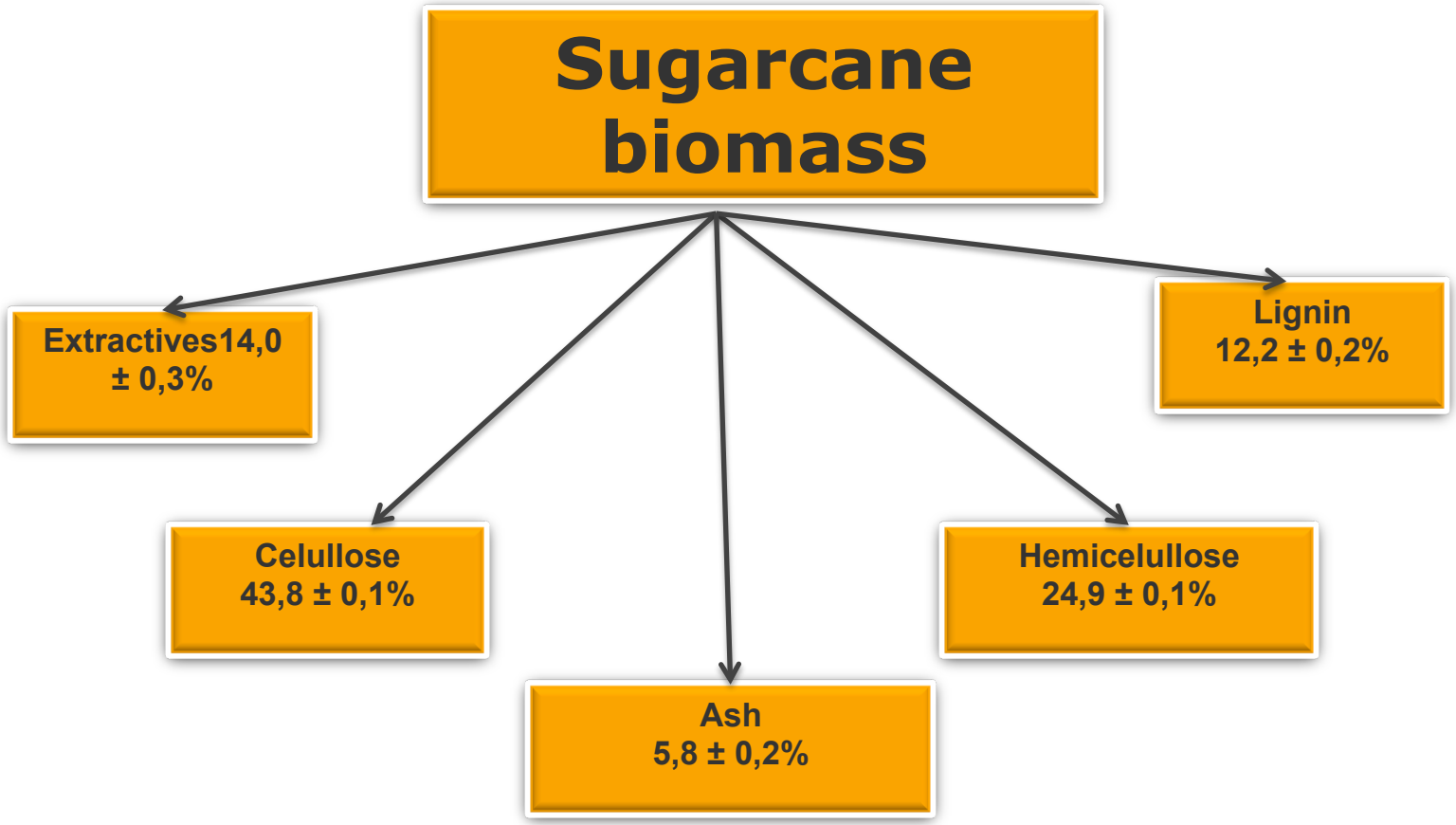


Dilute acid (H_2SO_4 al 3%) 4 h, boiling temperature





Sugarcane biomass composition



Sugarcane biomass production: 9 – 11 millions ton/year

Biomass feedstock recollection

Harvesting



Pretreatment and hydrolysis

Size reduction





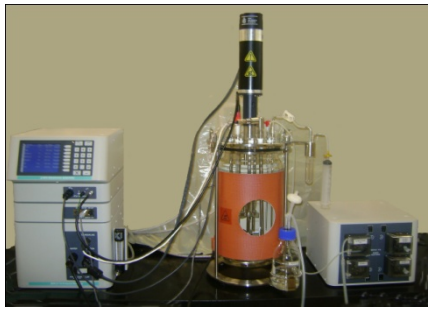
Hydrolysis



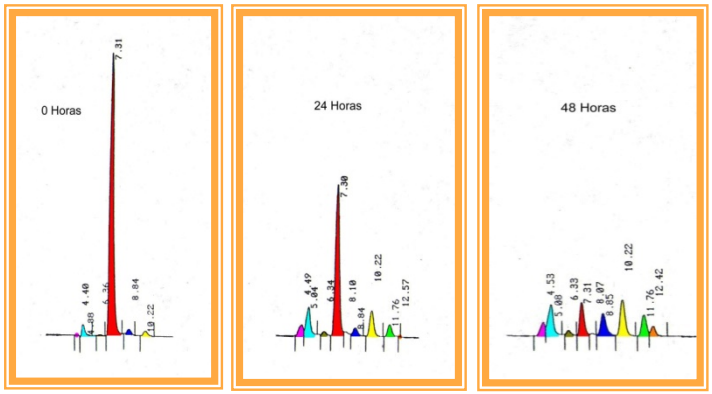
C5 & C& sugars fermentation







Microorganisms



Transformation of sugars to ethanol



Native strain bank

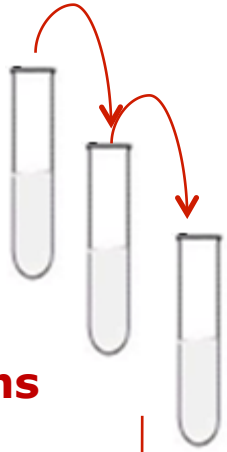


Lignocellulosic biomass



Culture media





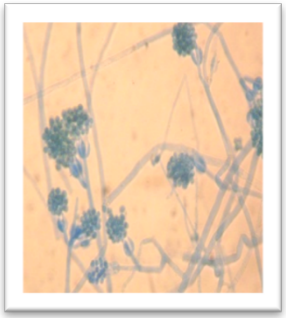
Isolation of microorganisms





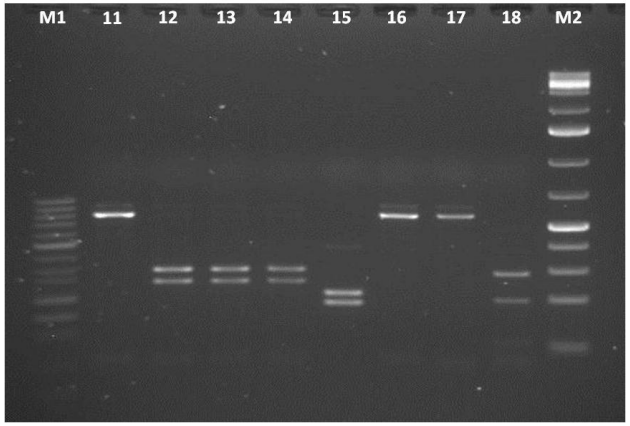
2000 microorganism isolated

Microorganisms identification

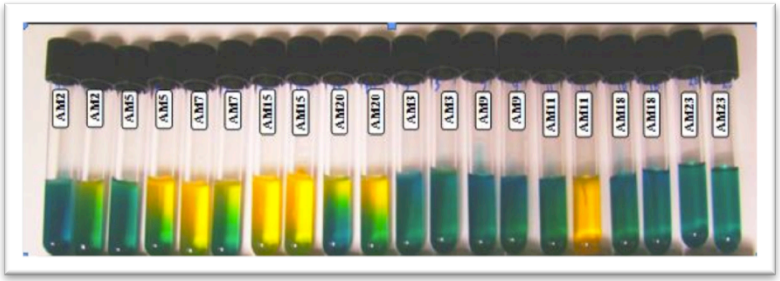


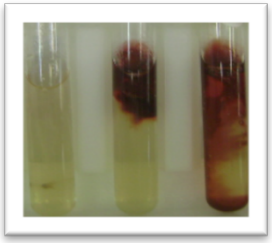


Morphologic characterization



Molecular Characterization

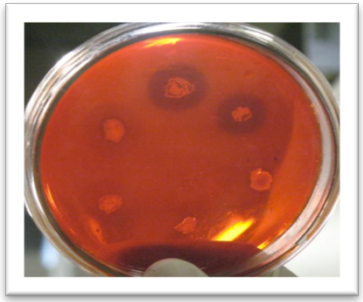




Biochemistry characterization

Microorganism evaluation

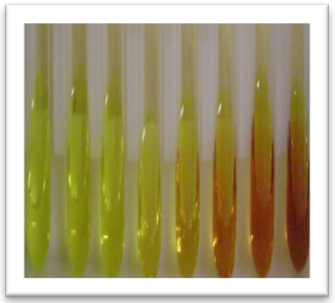
Qualitative enzymatic activity

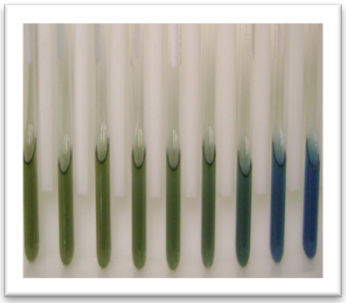


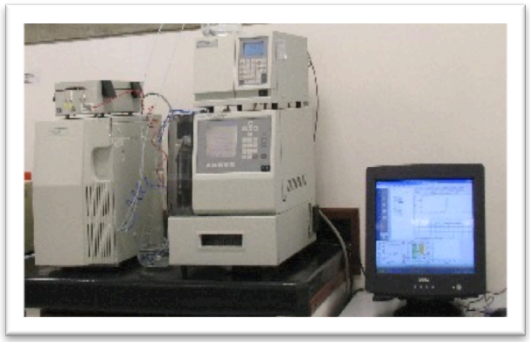


Congo red technique

Quantitative enzymatic activity







Sugars determination by (HPLC)

Achievements

- **Formulation of culture selective media to isolate native microorganisms for enzymatic hydrolysis of cellulose and hemicellulose and oxidation of lignin.**

- **Methodologies to characterize and evaluate promissory native microorganisms.**

Potential strains for hydrolysis of cellulose and hemicellulose

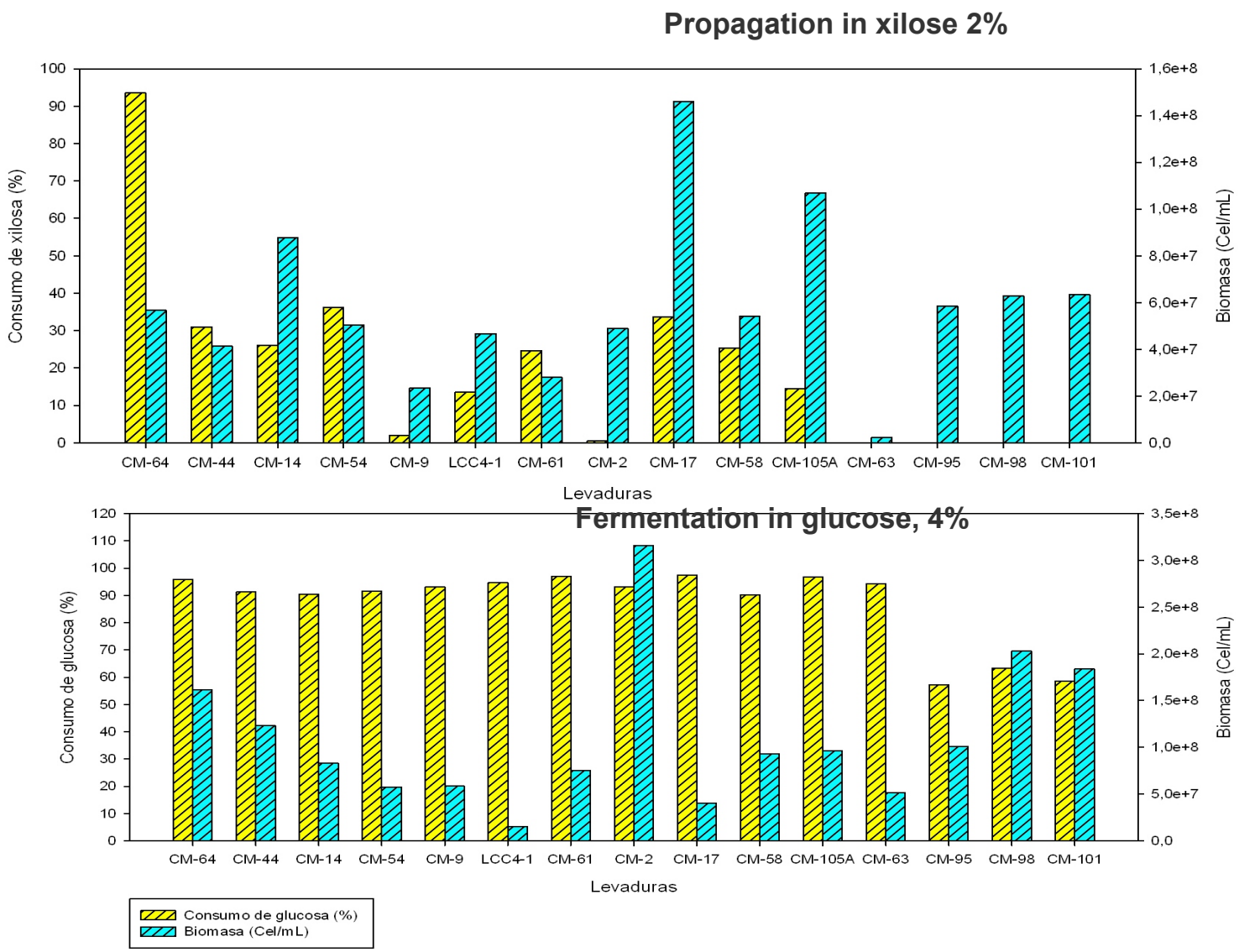
- Lignin: 50 strains
- Cellulose: 29 strains
- Hemicellulose: 21 strains

Native microorganims to ferment C5 and C6 sugars

- **Strains able to ferment xilose (C5) and glucose (C6): 63**
- **Best results: 6 yeast**

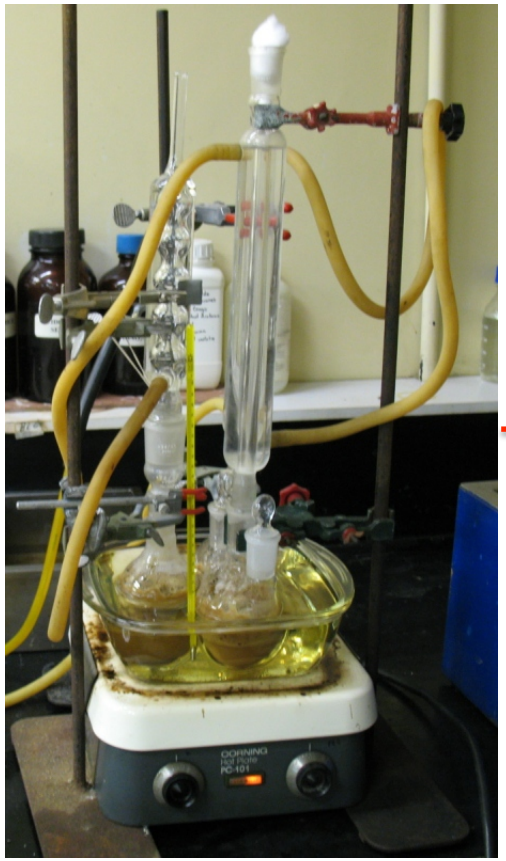
Perfomance of native strains in propagation and fermentation Of xilose and glucose

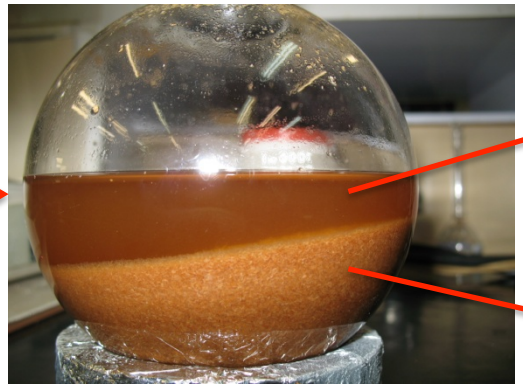




Chemical hydrolysis

Dilute acid hydrolysis of sugarcane biomass



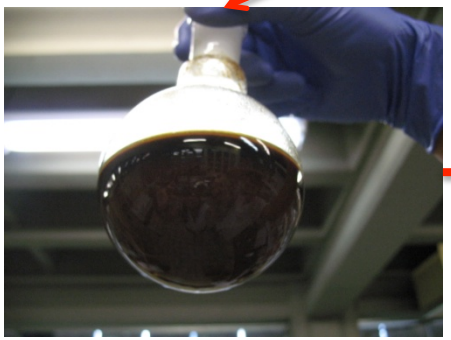


78 % xylose from hemicellulose.

Cellulose 69% lignin 29%

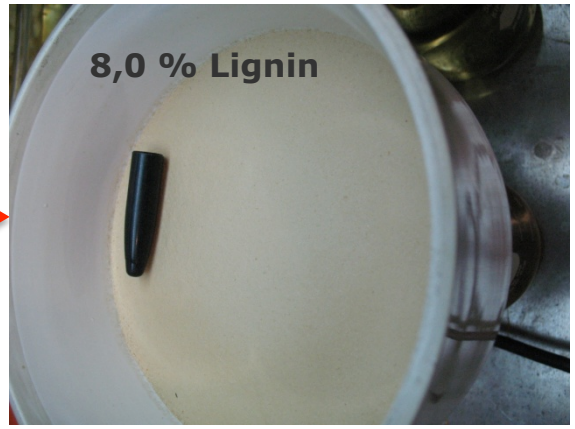
Organosolv delignification





EtOH 50% + NaOH 3%

120°C; 2 h



Sugarcane biomass partial delignificated

Thank you

cenicaña

