TNB RESEARCH

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Reduction of Biomass Gasification Power Plant Maintenance Problem using Catalysts Mixture of Coal Bottom Ash:Dolomite

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Outline

- Introduction
- Project Methodology
- Results and Discussion
- Conclusions
- Recommendations

Introduction

- Impurities from biomass gasification – tar, particulate matters, ammonia, HCl, H_2S and SO_2
- Tar formation in biomass gasification – main problem
- Tar causes blockage and corrosion of equipment or reducing overall efficiency of process

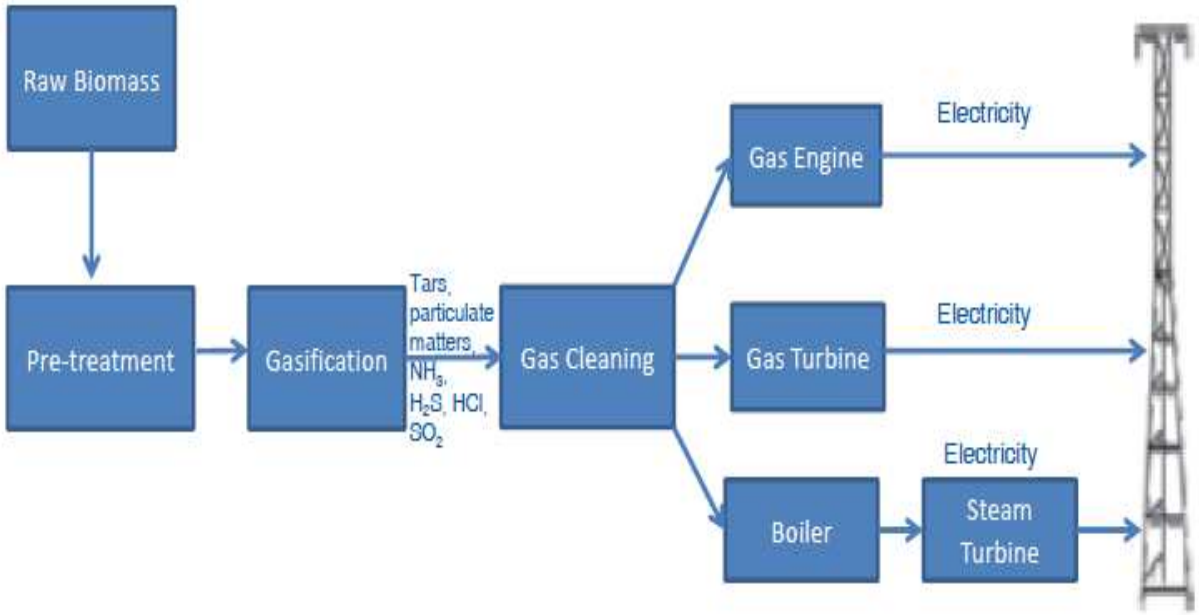


Figure1. Flow sheet diagram for power generation using biomass gasification gas (Asadullah, 2014).

Photo 1. Image of tar.

Tar reduction / cracking

- **Tar**: a complex mixture of mostly aromatic hydrocarbons and condensable at ambient temperature; and blocks the narrow pipeline
- Reactions

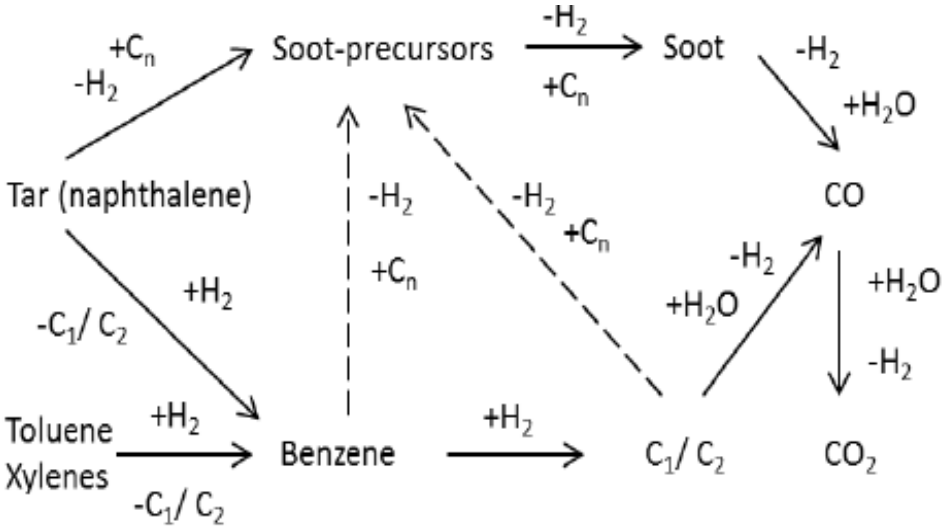
Cracking: $pC_nH_x \rightarrow qC_mH_y + rH_2$

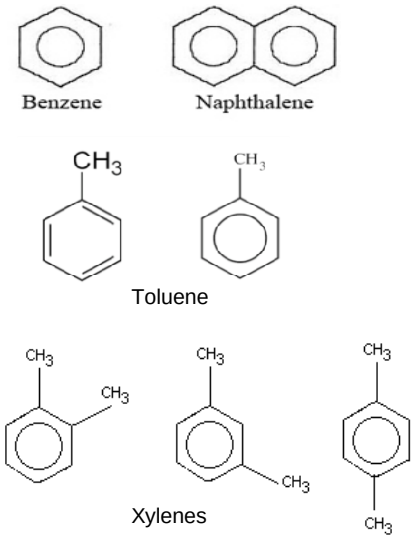
Steam reforming: $C_nH_x + nH_2O \rightarrow (n + x\ 2)H_2 + nCO$

Dry reforming: $C_nH_x + nCO_2 \rightarrow (x\ 2)H_2 + 2nCO$

Carbon formation: $C_nH_x \rightarrow nC + (x\ 2)H_2$

- Benzene (C_6H_6) key component in tar decomposition





(Bosmans et al, 2013)

Hyphothesis

- In this study, Coal Bottom Ash (CBA) is used to replace Nickel (Ni) as catalyst

- Ni criteria:
  i. able to reduce tar
  ii. deactivation effect towards H_2S
  iii. expensive

- CBA criteria:
  i. contain metals (eg. Ca, Mg, Al, Fe) in CBA
  ii. no Ni in CBA, deactivation effect of Ni towards H_2S reduced
  iii. waste, at no price

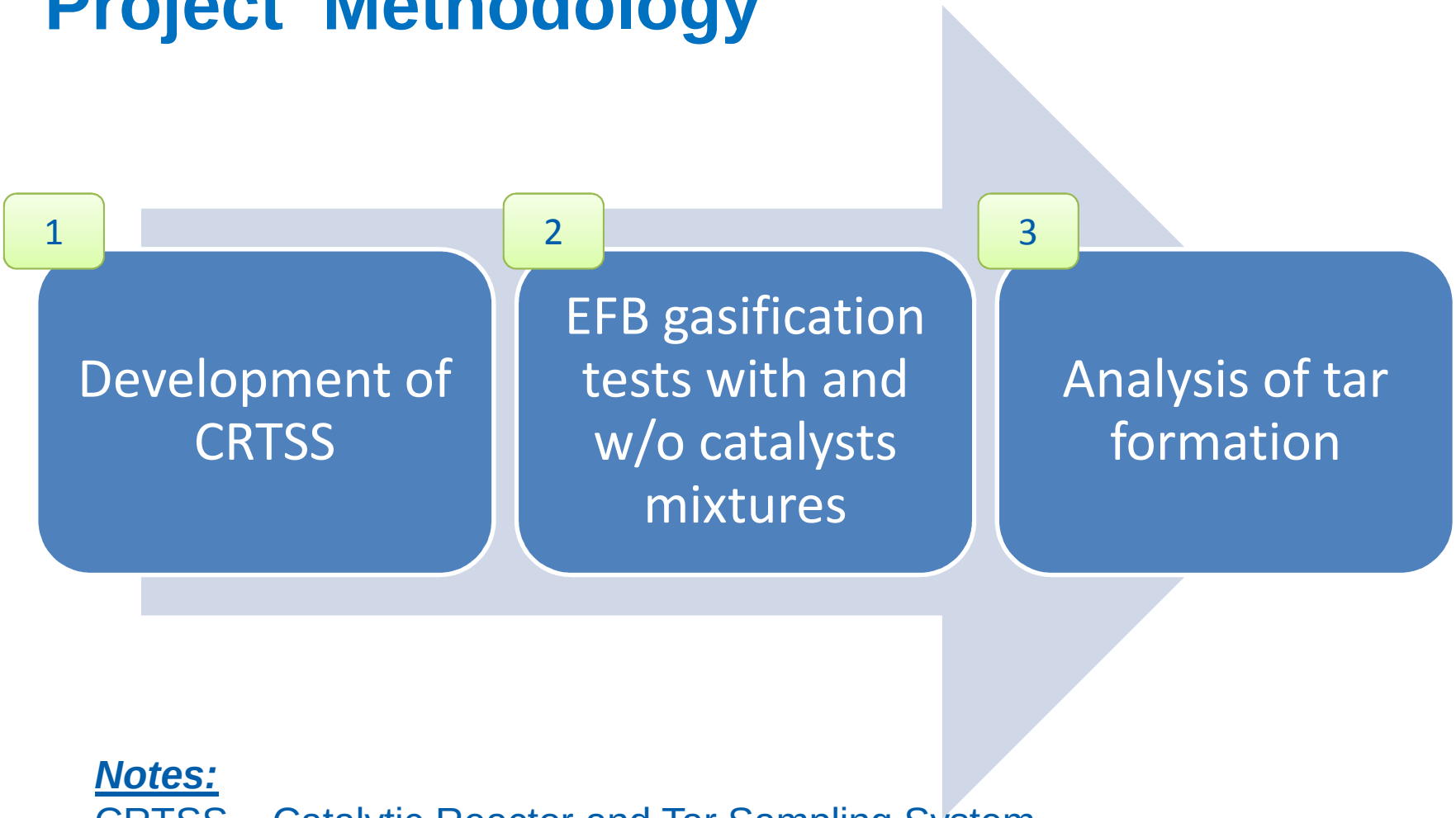
Project Objective

- To identify optimum mixture of catalysts for tar reduction

Project Deliverable

- Tar reduction to 50-100 mg Nm^{-3} for syngas utilisation in gas engine and gas turbine.

Project Methodology



Notes:

CRTSS – Catalytic Reactor and Tar Sampling System

EFB – Empty Fruit Bunch

Catalysts mixtures – dolomite and coal bottom ash

(e.g. ratios- 100:0, 0:100, 75:25, 50:50, 25:75)

1. Development of CRTSS

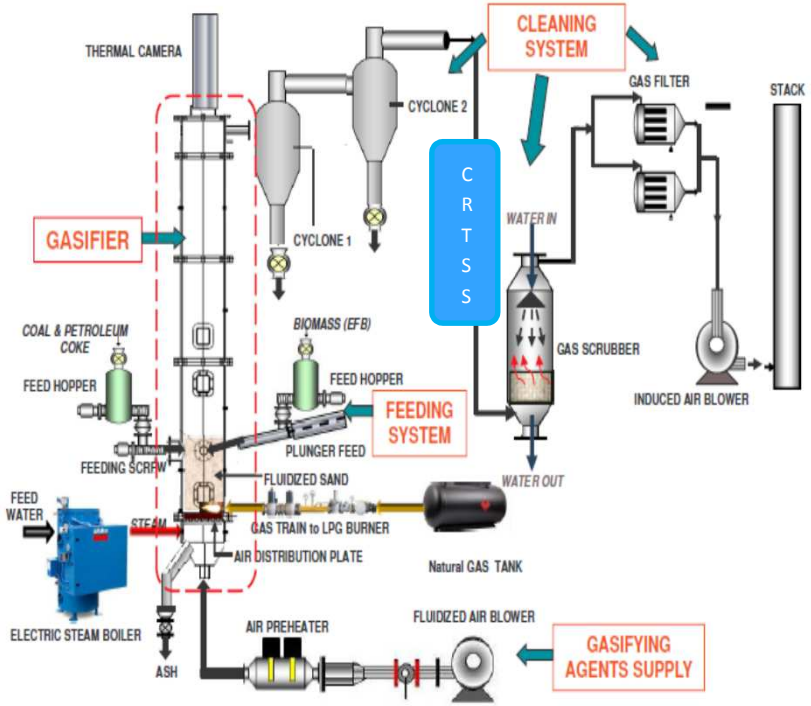
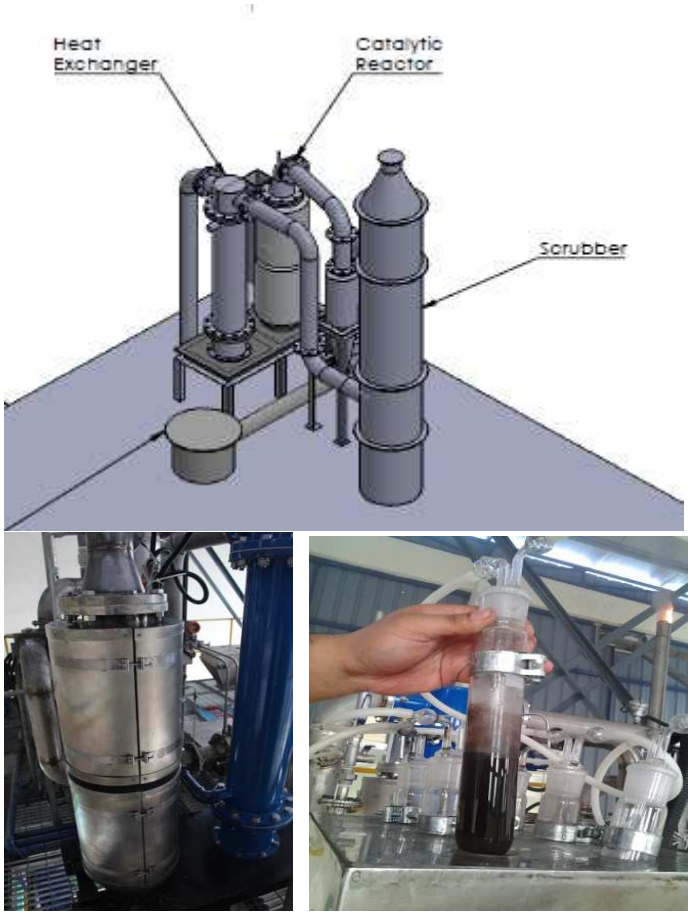


Figure 2. Schematic Diagram of Pilot Scale Gasification Plant



(a) (b)

Figure 3. (a) Catalytic Reactor and, (b) Tar Sampling System

- CRTSS is installed after cyclone 2

2. Empty Fruit Bunch (EFB) Gasification Tests

- EFB pellets were used during the tests
- Different catalysts mixtures were used in the catalytic reactor to reduce tar

Figure 4. Empty Fruit Bunch (EFB) pellets

Table 1. Different Catalysts Mixtures

No.	Catalysts Mixtures
1	100:0 CBA:DO
2	75:25 CBA:DO
3	50:50 CBA:DO
4	25:75 CBA:DO
5	0:100 CBA:DO
6	w/o catalyst

Notes:
CBA – Coal Bottom Ash, DO - Dolomite

3. Analysis of Tar Formation

i. Tar collections using impinger bottles

ii. Tar separations from solvent using rotovap

iii. Tar weighing

Tar Reduction with the Addition of Catalysts

- The optimum catalysts mixture is 25:75 (CBA:Dolomite), with the lowest tar content of 94.1 mg/Nm^3
- Acceptance range of tar content in syngas of 50-100 mg/Nm^3 for gas engine and gas turbine application (Bridgwater, 1995; Hasler & Nussbaumer, 1999)

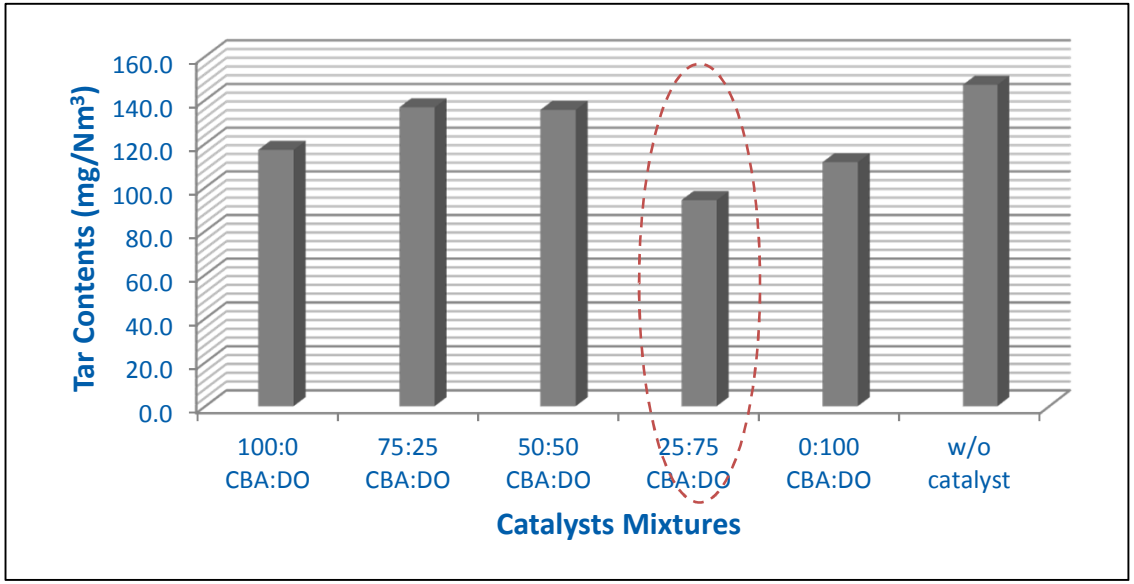


Figure 5. Graph for Tar Contents against Different Catalysts Mixtures

Table 1. Tar Contents for Different Catalysts Mixtures

Catalysts Mixtures	Tar Contents (mg/Nm^3)
100:0 CBA:DO	117.1
75:25 CBA:DO	136.6
50:50 CBA:DO	135.5
25:75 CBA:DO	94.1
0:100 CBA:DO	111.5
w/o catalyst	146.9

Conclusions

- Catalysts Mixtures (CBA:DO) had reduced tar contents in syngas
- The best catalysts mixture is 25:75 (CBA:DO), to reduce tar contents up to 94 mg/Nm^3
- CBA has a potential to replace nickel as catalyst for large scale biomass plant application

Recommendations

- Tar can be further reduced using:

  i. dolomite as in-bed material for gasifier, to meet tar tolerance level for gas engine and gas turbine application (50-100 mg/Nm^3)

  ii. higher plant operating temperature (>800^oC)

  iii. steam as gasifying agent

THANK YOU

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