Plasma Induced Biomass tar reformation: Thermodynamic Modelling and Experimental Validation

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Abstract: This study reports thermodynamic modelling and experimental validation performed on the reformation of tar present in syngas produced from Municipal Solid Waste gasification. Findings demonstrate that energy consumption during tar reformation can be brought down with addition of air, while additional heating is required to prevent losses occurring to combustible concentration in syngas.

1. Introduction

While biomass gasification is promising avenue to derive energy from municipal solid waste, formation of tar is a major drawback of this technology. Tar can reduce energy conversion efficiency and limit syngas applications [1]. Conventional tar degradation methods are limited by cost, soot formation, and complexity; plasma-based tar reformation methods presents a less expensive and simple alternative to conventional tar degradation methods [2]. Present work investigate energy requirements and product formation during plasma induced steam reformation of tar present in syngas from municipal solid gasification with an inlet temperature of 300°C and 30% moisture content.

2. Methods

In this study, thermodynamic modelling was conducted using Gibbs free energy minimization method and experimental validation with the aid of a reverse vortex flow gliding arc plasmatron. In both investigations syngas inlet temperature was 300 °C and its molar composition prior tar reformation was as follows:
$H_2(\sim 20\%), CO(\sim 21\%), N_2(13\%), CH_4(\sim 3\%), H_2O(\sim 30\%), CO_2(2-10\%)\ and\ tar\ (3-6\%)$.

3. Results and Discussion

Figure 1 shows degradation of tar as a function of energy input. Thermodynamic model predicted complete tar degradation when 0.12 kWh/kg of energy is supplied, experimental investigation found 0.16 kWh/kg of energy was required for complete tar degradation. Thermodynamic investigation into the effect of air addition showed that adding up to 30% air lowered energy requirement for tar degradation by 75%, indicating that oxidizing a portion of raw syngas can significantly lower energy consumption by increasing reaction zone temperature. Experimental investigations into changes occurring to syngas composition showed that lower syngas inlet temperatures (300°C) and significant moisture content (30%) lead to reduction in H_2 and CO concentration, indicating that additional heat input is required to prevent losses occurring to syngas combustibles during reformation of tar present in raw syngas with low inlet temperatures.

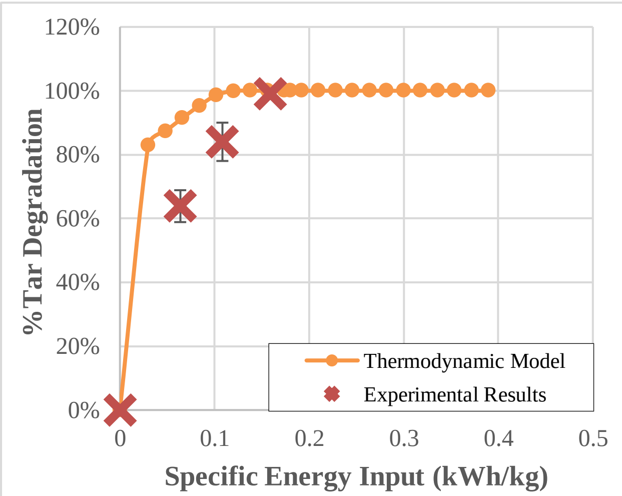

Figure 1:%Tar degradation as a function of energy input

5. Conclusion

Thermodynamic Modelling and experimental investigations into plasma induced reformation of biomass tar found that addition of air can significantly lower energy requirements for tar degradation. Concentration of combustibles in syngas after tar degradation is affected by low inlet temperatures, increasing reaction zone temperature with 'waste heat' can prevent such losses.

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References

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