High-moisture refuse incineration has recently presented several problems, such as consuming a great deal of petroleum fuel and releasing pollution after the process if the incinerator has a low efficiency. This research, therefore, purposes to study biomass-producing gas derived from the gasification process to incinerate high-moisture materials by conducting a laboratory scale experiment. Then, a Computational Fluid Dynamics analysis was carried out by referring to the experimental results in order to investigate the combustion and flow characteristics inside the actual scale of the incinerator.

In Chapter 1, overviews of recent problems regarding high-moisture refuse incineration, advantages of biomass energy resource and significant objectives of this research are introduced.

In Chapter 2, details about literature are reviewed for both biomass gasification and incineration technologies. In addition, the principal calculations used for an experimental apparatus (gasifier and incinerator) design are described.

Chapter 3 explains the methodology to calculate and design a biomass gasifier and incinerator prototype used for experimental conduction. The existing capacity of the gasifier is equal to 30 kilowatts-thermal. The designed incinerator contains a double chamber, in which the volume for the primary and secondary chamber is 0.104 and 0.03 m³, respectively.

Chapter 4 describes the details about setting up the experimental apparatus with the biomass property and sampled material. Four kinds of biomasses were examined for proper fuel to produce biomass fuel gas. Five kilograms with a 60% moisture content of fresh meat were selected as a high moisture sample. During the experimental conduction, necessary data were measured and recorded, such as the temperature, electricity consumption, gas and air volumetric flow rate, and the opacity of the combustion exhaust gas. In addition, some biomass producer gas was sampled and analyzed by Gas Chromatography.

In Chapter 5, the experimental conduction procedures are presented with the experimental results. It was found that the biomass gas quality became best when the temperature of the gasifier’s reduction zone achieved more than 900 deg-C with a rich constituent of CO and the highest calorific value. The temperature of the incinerator’s primary and secondary combustion chambers achieved the highest temperature at approximately 750 deg-C if the combustion equivalent ratio in the gas burner was set to 0.9, and the temperature decreased gradually if the equivalent ratio was lower than 0.9. In addition, the
best result for high moisture material combustion inside the primary chamber occurred when the amount of excess air was 100% of the meat’s stoichiometric air. By this condition, the temperature of both primary and secondary combustion chambers was 500 and 750 deg-C, respectively, and the pollution release was 10% of the opacity exhaust gas. In contrast, the overall temperature decreased if there was a large amount of air in the combustion chamber, which was 150% and 230% excess air, and there was a tendency towards the instability of the combustion chamber’s temperature. Moreover, an evaluation system energy balance was also carried out. It was found that the efficiency of the incinerator was 15% when both primary and secondary combustion chambers were operated.

In Chapter 6, the CFD analysis was implemented in the standard model of a high-moisture refuse incinerator in order to investigate the temperature profile and combustion characteristics. A standard k-epsilon model, SIMPLE algorithm, and the first-order upwind method were used to solve the fluid flow numerical problem. The simulation results showed that the maximum temperature occurring from fuel gas-air combustion became highest at 1,700 K, which is close to the theoretical flame temperature of biomass producer gas. The modified model simulation resulted in a more efficient heat distribution and turbulent intensity compared with the traditional model. In addition, it was discovered that the rate of NO formation became highest if there was only primary burner in operation and the rate decreased when both primary and secondary chambers were in operation. These simulation results also support the advantages of the double-chambered incinerator for pollution reduction.

Chapter 7 explains the conclusion of this research, summarizing how the biomass producer gas derived from the gasification process can be applied to high-moisture refuse incineration using the double-chambered incinerator, because significant combustion properties, such as maximum temperature and emission preventing availability, are similar to those using petroleum as a fuel source. Accordingly, the benefit of biomass utilization for high-moisture refuse incineration is not only able to replace petroleum fuel, but it is also able to reduce the environmental impact from petroleum fuel combustion.

In conclusion, the results obtained from this research will be available for other combustion applications concerning biomass producer gas use as a fuel, as well as for the possibility of research and development of gasification and incineration technology in order to gain a higher effectiveness in the future.