SLUDGE LIGNIN RECYCLING IN THE ENVIRONMENT OF HIGH-FREQUENCY PLASMA

V. I. Rastorguev, I. Yu. Novoselov
Supervisor – Assistant Professor I. Yu. Novoselov

National Research Tomsk Polytechnic University
Russia, Tomsk, Lenin Ave, 30, 634050
vir12@tpu.ru

Plasma gasification technology offers a potential solution for repurposing sludge lignin. By subjecting the waste to high temperatures in a controlled environment, it can be converted into syngas, a valuable fuel source. This process not only reduces the volume of waste but also provides a sustainable energy alternative. Additionally, plasma gasification can help address the challenge of carbon-heavy industrial waste by converting it into useful materials. By utilizing this technology, industries can reduce their environmental impact and work towards a more circular economy model. Further research and development in plasma gasification technology are necessary to optimize its effectiveness in handling sludge lignin and other industrial wastes. Collaborations between researchers, industries, and policymakers can help accelerate the adoption of this technology and drive sustainable waste management practices.

This study is centered on investigating techniques for plasma treatment of sludge lignin with a high-frequency torch discharge. The goals involve finding the optimal water-organic mixture, running thermodynamic simulations, evaluating the results, and suggesting ways to apply the process.

Significant energy savings can be achieved by using plasma treatment to convert sludge lignin into combustible water-organic compositions (WOC). The key factor for determining the combustibility of these mixtures is their adiabatic combustion temperature T_{ad} [1]. Recent studies have shown that the complete and efficient combustion of liquid combustible waste from specific organic materials occurs in chambers with minimal heat loss at T_{ad} more than 1200 °C. This temperature is crucial and sufficient for the self-sustaining incineration of waste [2].

Sludge lignin typically has a solids content of about 10 %. Following our analysis, we propose using a mixture of water and sludge lignin in a ratio of 70 % water to 30 % sludge lignin. The energy consumption for reprocessing this WOC is estimated to be around 20 MJ/kg, resulting in the potential generation of 2 MW/h•t of thermal energy through plasma treatment.

To identify the combinations of gases and condensed materials produced when WOC is processed using plasma, the calculations were done. This assessment was carried out at standard atmospheric conditions over a wide range of temperatures (up to 5000 K). The simulation was based on the standard chemical composition of sludge lignin, as indicated by its stoichiometric formula.

At a plasma temperature of 3200 K and a high air mass fraction of 89 %, the primary gases generated are nitrogen oxide, carbon dioxide and water vapor. Additionally, solid compounds such as silicon (IV, VI) dioxides and calcium titanate, which likely originate from impurities in the process, as well as carbon (soot) are also produced. The findings indicate that operating with such a high air plasma coolant mass fraction may not be the most efficient approach.

Raising the air mass fraction from 89 % to 90 % leads to the removal of soot in the outcome obtained from plasma reprocessing sludge lignin in air plasma. The lack of soot and low levels of carbon and nitrogen monoxides indicate that the plasma reprocessing of sludge lignin as WOC is working effectively.

References

1. *Novoselov I.Yu., Podgornaya O.D., Shlotgauer E.E., Karengin A.G., Kokarev G.G. Plasma utilization and magnetic separation of modeling waste from spent nuclear fuel reprocessing // Russian Physics Journal. – 2014. – Vol. 57. – Iss. 2/2. – P. 26–30 [In Russ.].*
2. *Bernadiner M.N., Shurygin A.P. Fire processing and disposal of industrial waste. – M. : Chemistry Pub., 1990. – 304 p [In Russ.].*