UPGRADING FUEL CHARACTERISTIC OF POULTRY SLUDGE VIA WET TORREFACTION

İbrahim DİKER* G.Memduh ÖZKAN*
*****Department of Mechanical Engineering, Faculty of Engineering Cukurova University
01330 ADANA, TURKEY, idiker@cu.edu.tr, gmozkan@cu.edu.tr

Extended Abstract: The use of fossil fuels as an energy source brings many environmental problems like global warming and pollution. The search for alternative fuels has directed the scientists to various renewable energy sources, e.g., solar energy, geothermal energy, wind energy, and bioenergy. Compared to fossil fuels, biomass is a promising energy source as it can be found more easily and in abundance in almost every region of the world and different varieties. However, biomass cannot be used directly as an efficient fuel due to its high humidity, ash, and oxygen levels. Dewatered poultry sludge (DPS), which is difficult to dispose of, is a substance that has the aforementioned biomass disadvantages but has a high calorific value potential (26586.66 J/g). The wet torrefaction process, by avoiding the biomass drying process, is considered quite efficient in eliminating the negative side of the fuel properties of biomass. The wet torrefaction process is usually carried out in the temperature range of 180-280 °C because it takes advantage of the properties of subcritical water. Subcritical water has unique properties suitable for biomass conversion, for example, both density and dielectric constant decrease with temperature while the ionic product increases. Besides, during the hydrothermal torrefaction of biomass, water acts as both the reaction medium and the reactant, so the feedstock does not have to be dried. In this study, reaction temperature (T), reaction time (Δt), and feed concentration (wt%) are determined as parameters. Furthermore, the response surface method was used to design the experiment and investigate the interaction between the selected operating parameters. The responses were termed as the calorific value, and solid yield. Regarding the wet torrefaction process results, the parameter that has the most prominent effect on the calorific value and solid yield is the feed concentration. As shown in Figure 1, the calorific value peaked at the highest feed concentration and reaction temperature. The interactive effect of the reaction temperature with the reaction time is very low as shown in Figure 2. Moreover, it can be observed from Figure 3 that the feed concentration is more effective at medium and high reaction times. The increase in feed concentration caused a significant increase in both calorific value and solid yields. Generally, the calorific value of torrefied DPS increased with increasing reaction temperature. On the other hand, the solid yield of torrefied DPS decreased with increasing reaction temperature. Although the reaction time does not affect the calorific value as much as the reaction temperature, it has been determined that the increasing reaction time has a positive effect on the calorific value. Besides, the highest calorific value (28867,0 J/g) with 83.31% solid was obtained at T=280 °C, 50wt%, and for Δt= 60min, whereas the optimum condition for both maximum solid yield and calorific value was evaluated at T=268°C, 50wt%, and for Δt= 47 min. Considering the proximate analysis results, fixed carbon was increased from 7.41 to 11.7wt% and volatile matter was slightly decreased from 67.5 to 66.1wt%. Furthermore, the amount of ash in the wet torrefied DPS is decreased from 25.09 to 22.18wt%. When elemental analysis results are examined, reduction in both the atomic reactions of *O/C* and *H/C* should be noted, so it can be stated that fuel

properties of torrefied DPS were upgraded and became more efficient sample for subsequent conversion methods such as gasification and pyrolysis. Moreover, the increase in carbon ratio, the decrease in oxygen content, and the amount of ash have transformed the torrefied DPS to a coal-like structure.

Keywords: dewatered poultry sludge, wet torrefaction, response surface methodology

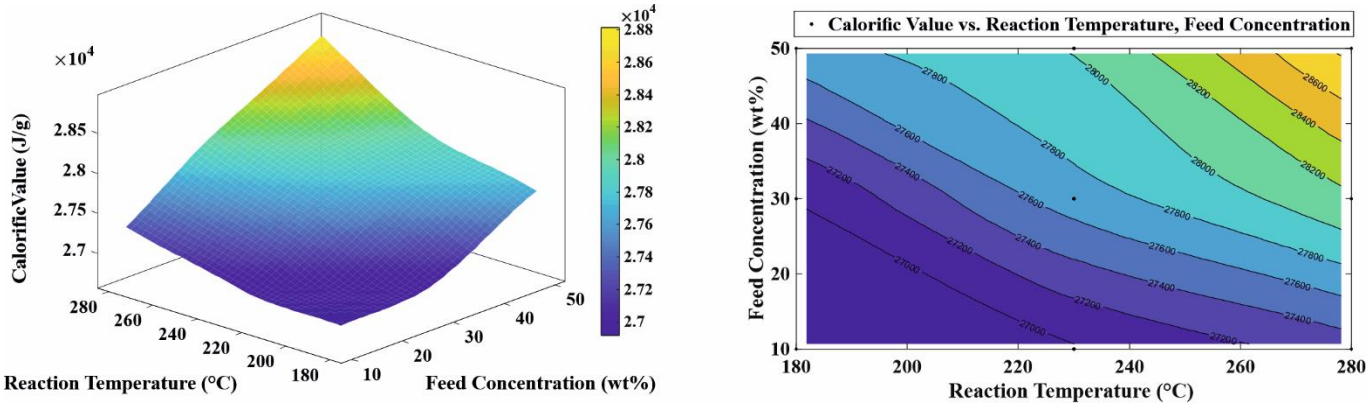


Figure 1. Surface and contour plots of the effect of reaction temperature and feed concentration on calorific value

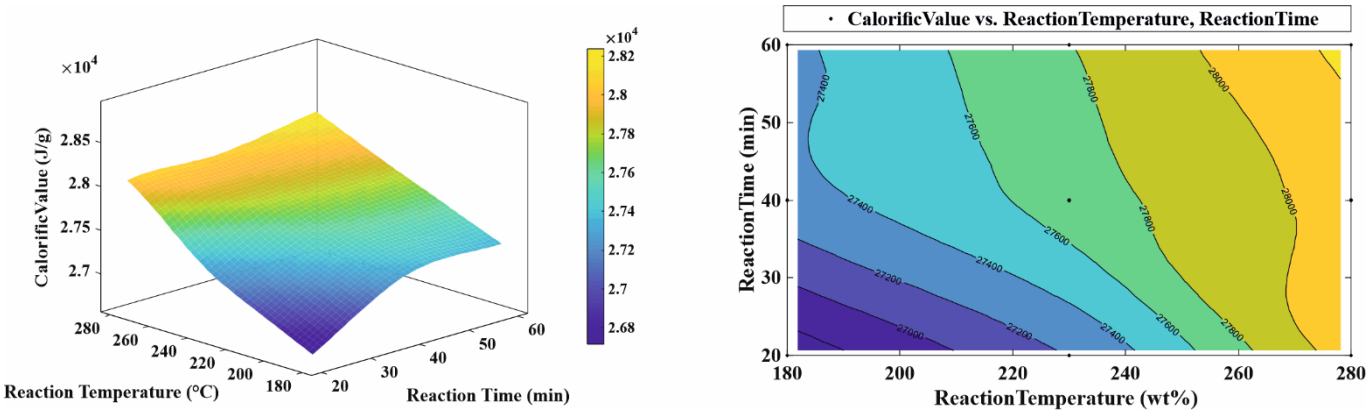


Figure 2. Surface and contour plots of the effect of reaction temperature and reaction time on calorific value

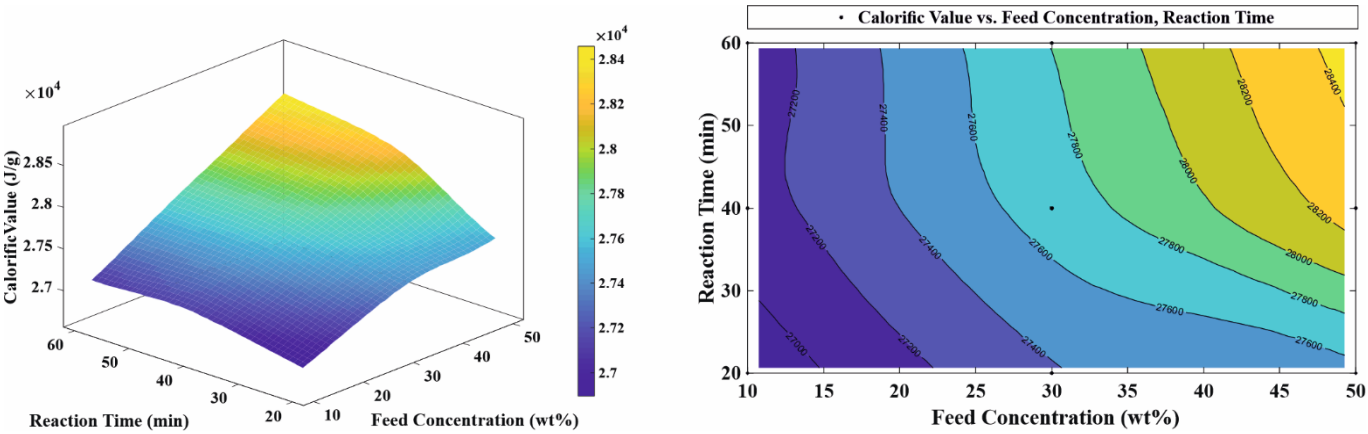


Figure 3. Surface and contour plots of the effect of reaction time and feed concentration on calorific value

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