Disposal and energy recovery from agri-food industry waste

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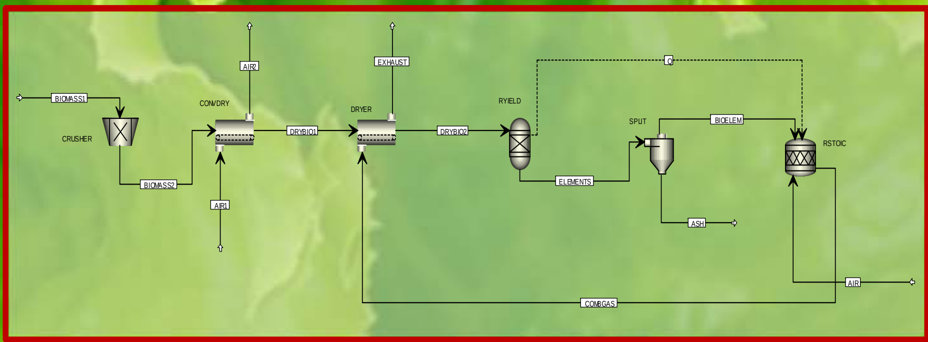

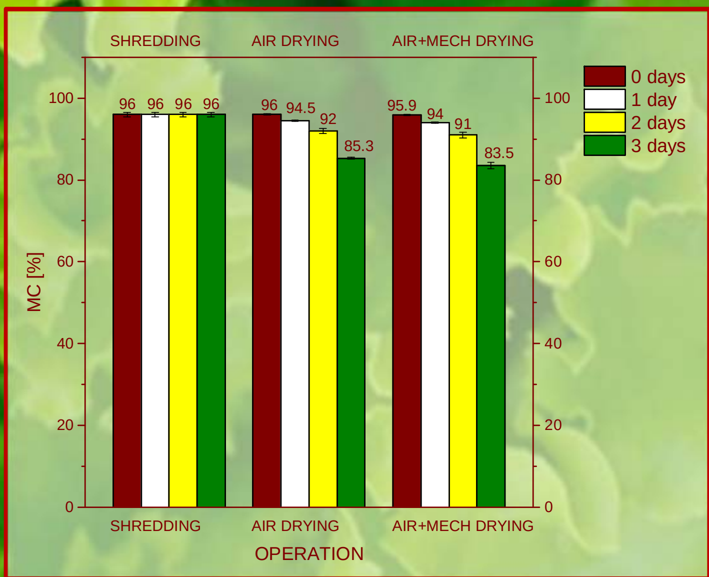

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UNIVERSITY OF SALERNO

Department of Industrial Engineering

Master Degree in Food Engineering

Disposal and energy recovery from agri-food industry waste

Master thesis in

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To my family

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Summary

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Abstract

This work has been focused on the study of plant configurations for the disposal and energy recovery from agri-food industry wastes.

Starting from an overview of the global actual situation in the use of renewable energy sources, the attention has been focused on the use of biomass as a renewable source of industrial interest. A general description of the main biomass properties in terms of ultimate and proximate analyses has been presented, and the advantages and disadvantages in its use as a fuel are listed.

Furthermore, the main industrial processes used to the exploitation of biomass fuels have been analyzed; the thermochemical and biochemical conversion technologies have been examined describing the processes, the operating conditions and the main advantages and disadvantages of their use. Then, the attention has been focused on the biomass combustion process, describing the main technologies used in industrial-scale plants and the biomass characteristics affecting this process.

Once the compositions of the biomass under study (lettuce residues) have been identified in literatures, in terms of ultimate and proximate analysis, its higher heating value has been evaluated by the Dulong's formula and its moisture content has been determined through drying tests. The integrated biomass drying/combustion model has been developed by performing the mass and energy balances that made it possible to determine the operating conditions to make the process self-sufficient. From the results of process analysis, the need to subject the biomass to pretreatments to bring it to optimal conditions for the process yields has been deduced.

The biomass conversion process has been implemented in Aspen Plus, a software useful to simulate the behavior of the plant and to analyze its performance. The blocks available in the software used to simulate

the unit operations and their operating conditions have been described, and the streams fed to the plants have been characterized. The simulation results confirmed the possibility to dispose the biomass under study by recovering the heat from the flue gases produced during the combustion process. Finally, a process on a production scale has been simulates using data from a company that works agricultural products.

Further studies may be conducted on the disposal of exhausted gases leaving the dryer, taking into account a cleaning treatment before the emission into the atmosphere. In addition, it will be also necessary to consider a treatment process for combustion ash. Finally, an economic analysis of the process can be performed to evaluate its cost effectiveness in comparison with other technologies.

Abstract

L’obiettivo del lavoro di tesi è stato lo studio delle configurazioni impiantistiche per lo smaltimento e il recupero energetico da scarti dell’industria agroalimentare.

Partendo da una panoramica sulla situazione attuale nell’utilizzo delle fonti di energia rinnovabili, l’attenzione è stata posta sull’uso della biomassa come fonte rinnovabile di interesse industriale. Sono state descritte le principali proprietà della biomassa utili per la sua caratterizzazione come combustibile ed elencati i vantaggi e gli svantaggi legati al suo utilizzo.

Inoltre, sono stati esaminati i processi industriali principalmente impiegati nello sfruttamento della biomassa come combustibile. Le tecnologie di conversione termochimica e biochimica sono state analizzate descrivendone il processo, le condizioni operative e i principali vantaggi e svantaggi del loro utilizzo. A seguire, l’attenzione è stata focalizzata sul processo di combustione della biomassa con la descrizione delle tecnologie impiegate in ambito industriale e le caratteristiche della biomassa che influenzano tale processo.

Della biomassa oggetto di studio (residui di lattuga), una volta individuate, in letteratura, le composizioni, in termini di analisi elementare e prossimale, sono stati valutati il potere calorifico superiore, attraverso la formula di Dulong, e il contenuto di umidità, attraverso prove sperimentali di essiccamento. È stato sviluppato il modello integrato essiccamento/combustione della biomassa e, attraverso la risoluzione di bilanci di materia ed energia, è stato possibile determinare le condizioni operative necessarie per rendere il sistema autosufficiente. Dai risultati ottenuti analizzando il processo è stato dedotto che fosse necessario sottoporre la biomassa a dei

pretrattamenti per portarla alle condizioni ottimali per le rese del processo.

Il processo di conversione della biomassa è stato implementato in Aspen Plus, un software utilizzato per simulare il comportamento di un impianto e valutarne la performance. Sono stati descritti i blocchi disponibili nel software, utilizzati per simulare le unità operative, e le loro condizioni di processo e, inoltre, sono state caratterizzate le correnti che alimentano l'impianto. I risultati ottenuti dal modello di simulazione hanno confermato la possibilità di smaltire la biomassa oggetto di studio recuperando il calore dai fumi prodotti durante il processo di combustione. Infine, è stato simulato un processo su scala produttiva utilizzando i dati di un'azienda che si occupa della lavorazione di prodotti agricoli di IV gamma.

Potranno essere condotti ulteriori studi sullo smaltimento dei fumi esausti in uscita dall'essiccatore, tenendo conto della necessità di un trattamento di pulizia degli stessi prima della loro emissione in atmosfera. In aggiunta, sarà necessario considerare anche un processo di trattamento per lo smaltimento delle ceneri da combustione. Infine, potrà essere eseguita un'analisi economica del processo per valutarne la sua convenienza in confronto alle altre tecnologie.

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“La vita è un insieme di avvenimenti, di cui l’ultimo potrebbe anche cambiare il senso di tutto l’insieme” (Cit. I. Calvino)

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