



Ain Shams University

Faculty of Engineering

Design and Production Engineering Department

# **Study of the Appropriate Conditions for the Production of Pellets as a Solid Biofuel from Agricultural Residues**

A Thesis Submitted in Partial Fulfilment for the Requirements of the  
Degree of Master of Science in Mechanical Engineering

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# Statement

This thesis is submitted in partial fulfilment for the degree of Master of Science in design and production engineering, to the faculty of engineering, Ain Shams University. The work included in this thesis was carried out by the author, primarily at the laboratories of the Design and Production Engineering Department, Faculty of Engineering, Ain Shams University. No Part of this thesis has been submitted for degree or qualification at any other university.

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# Abstract

This work targets the investigation and studying of the appropriate conditions for the production of pellets as a solid biofuel from agricultural residues. Agricultural residues in Egypt have been studied and characterized in order to select the most promising and suitable raw materials for the purpose of bio-pellets production.

Agricultural residues have been characterized based on amounts, availability, geographic distribution, collection prices, current utilization methods and physio-chemical properties of the residues. Trading off between these parameters is based on a screening matrix; in which every factor affecting the production of pellets was weighted on a 0 to 100 scale and the highest score raw material was selected to produce pellet samples for factory tests and experimentations. Based on the screening matrix results, rice straw, cotton stalks, and sorghum stalks have been chosen for study.

Agro-pellet samples were produced from rice straw, cotton and sorghum stalks with different water and molasses concentrations. The associated quality parameters of the produced pellet samples in terms of calorific value, single pellet density, bulk density of pellets and mechanical durability index were measured and compared to the requirement of international standards for agro-pellets. International agro-pellet standards' lower limits are 12 MJ/kg for calorific value, 1.2 g/cm<sup>3</sup> for single pellet density, 600 kg/m<sup>3</sup> for bulk density and 96.6% mechanical durability index. A maximum water content of 10% and natural additives at a maximum of 2% is permitted. The results show that the produced agro-pellets well satisfy these international standards requirements.

Producing rice straw pellets with 1.1% water content (w.b.) will result in high quality pellets satisfying the requirements of international standards in terms of calorific value, single pellet density, bulk density of pellets and mechanical durability, their values were found to be 15.45 MJ/kg, 1.435 g/cm<sup>3</sup>, 717.5 kg/m<sup>3</sup> and 99.904%, respectively.

Producing cotton stalks pellets with 1.95% water content (w.b.) results in high quality pellets satisfying the requirements of international standards in terms of calorific value, single pellet density, bulk density of pellets and mechanical durability.

Sorghum stalks require the addition of 1.6 % water in order to produce sound agro-pellets satisfying the international demands.

Generally, all agro-fibres doped with 2 % molasses proved to be successful agro-pellets. Despite the slightly reduced calorific value associated with the use of molasses, the use of this binding agent proved to be beneficial in terms of energy reduction along the pelleting process.

# Contents

<b>Abstract .....</b>	<b>v</b>
<b>1. Introduction.....</b>	<b>1</b>
<b>2. Literature Review .....</b>	<b>5</b>
2.1. Biomass Energy .....	5
2.1.1. Benefits of Bioenergy .....	6
2.1.2. Energy Conversion Techniques .....	7
2.1.3. Requirements for Biomass Energy Production .....	10
2.1.4. Physical Characteristics of Biomass.....	11
2.1.4.1. Size and Density .....	11
2.1.4.2. Moisture Content .....	12
2.1.4.3. Energy Content .....	13
2.1.4.4. Chemical Composition.....	13
2.2. Agricultural Residues .....	15
2.2.1. Classification of Agricultural Residues .....	15
2.2.2. Structure of Lignocellulosic Materials .....	18
2.2.3. Uses of Agricultural Residues.....	20
2.2.4. Location and Distribution of Agricultural Residues in Egypt .....	21
2.3. Production of Bio-pellets .....	24
2.3.1. The Pelleting Process.....	24
2.3.2. The Bonding Mechanism.....	27
2.3.3. Energy Consumption during the Pelleting Process.....	29
2.4. Quality Parameters of Biofuel Pellets .....	29
2.4.1. Density of Bio-pellets .....	29

2.4.2. Mechanical Durability of Bio-pellets .....	30
2.4.3. Calorific Value of Bio-pellets.....	30
2.4.4. Ash content of Bio-pellets .....	31
2.5. Factors Affecting Pellet Quality .....	31
2.5.1. Effect of Moisture Content on Pellet Quality.....	32
2.5.2. Effect of Binders on Pellet Quality .....	33
2.5.3. Effect of Particle Size on Pellet Quality.....	33
2.6. Impact of Biomass Production on Food Supply and Prices ....	34
<b>3. Objective &amp; Work Plan .....</b>	<b>35</b>
<b>4. Experimental Work .....</b>	<b>37</b>
4.1. Materials.....	38
4.1.1. Selection of Agro-residues .....	38
4.1.2. Binding Agents .....	40
4.2. Preparation of Agro-residues.....	41
4.3. Preparation of Agro-pellets.....	46
4.4. Characterization of Agro-pellets .....	49
4.4.1. Moisture Content .....	49
4.4.2. Fiber Length and Fiber Length Distribution .....	49
4.4.3. Single Pellet Density .....	50
4.4.4. Bulk Density of Pellets .....	50
4.4.5. Mechanical durability .....	50
4.4.6. Calorific value .....	51
4.4.7. Energy consumption.....	51
4.5. Matrix of Experiments .....	52
<b>5. Results and Discussion .....</b>	<b>54</b>
5.1. Preliminary Screening Matrix.....	54

5.2. Characterization of Agro-pellets .....	56
5.2.1. Fiber Length and Fiber Length Distribution .....	59
5.2.2. Single Pellet Density .....	61
5.2.3. Bulk Density of Pellets .....	64
5.2.4. Mechanical Durability.....	66
5.2.5. Calorific Value .....	68
5.2.6. Energy Consumption.....	71
5.3. Correlation between Pelleting Process Parameters.....	74
5.3.1. Effect of Single Pellet Density on the Calorific Value.....	74
5.3.2. Effect of Single Pellet Density on Mechanical Durability .....	76
5.3.3. Effect of Single Pellet Density on Energy Consumption.....	78
5.3. General Discussion .....	81
<b>6. Field Survey and Feasibility Study.....</b>	<b>85</b>
6.1. Field Survey.....	85
6.2. Feasibility Study.....	86
6.2.1. Methodology.....	86
6.2.2. Pelleting Plant Production Capacity .....	86
6.2.3. Production Plant Area .....	87
6.2.4. Project Expenses .....	87
6.2.4.1. Location.....	87
6.2.4.2. Infrastructures .....	88
6.2.4.3. Pelleting Production Line .....	88
6.2.4.4. Total Fixed Cost of Assets.....	89
6.2.4.5. Pre-operating Costs .....	89
6.2.4.6. Contingency Reserve Costs .....	90
6.2.4.7. Net Working Capital.....	90