

ABSTRACT

Biomass cogeneration systems can generate power and process heat simultaneously from a single energy resource efficiently. The sugar cane industry represents one of the most important biomass cogeneration systems which using sugar cane bagasse as fuel. In this study, the useful concept of energy and exergy utilization is analyzed and applied to the boiler, turbine, mills, and DSHS of elgunied sugar factory. Energy and exergy flow in these components is shown in this study. The percentage ratio of the exergy destruction to the total exergy destruction is found to be maximum in the boiler (81.393%) so that the boiler is the major source of irreversibilities in the power plant (34.393MW) exergy destruction compare with near value (2.857MW) exergy destruction in mills. So that, to improve the system performance a greater attention must given mainly to the boiler.

المستخلص

انظمة التوليد التي تعمل بالكتلة الحيوية يمكن ان تولد قوة كهربائية وتقوم بالمعالجات الحرارية في آن واحد من نفس مورد الطاقة وبكفاءة، حيث تمثل صناعة السكر احدى اهم انظمة توليد الكتلة العضوية التي يستعمل فيها مخلفات قصب السكر (البقاس) فيها كوقود. في هذه الاطروحة، تم تحليل مفهوم استخدام الطاقة والاكسيري في كل من الغلاية، التوربين، الطواحين والمحمص لمصنع سكر الجنيد. كما تم تبين سريان الطاقة والاكسيري لكل من هذه المكونات. وقد وجد بعد التحليل ان اكبر نسبة لتحطيم الاكسيري تكمن في الغلاية اذ تبلغ 81.393% لذا فان الغلاية تعتبر اكبر مصدر للارجوعية في عملية التوليد (34.393 ميغاوات) اكسيري محطة مقارنة ب (2.857 ميغاوات) اكسيري محطة في العصارات. لذلك لتحسين اداء النظام يجب شد الانتباه بشكل رئيسي لاداء الغلاية ورفع كفاءتها.

DEDICATION

I dedicate this work with much appreciation and love to:

My mother who cares of me Kindly

My brothers and sister who are always helpful

My friends and teachers

ACKNOWLEDGMENTS

This thesis would not have been possible without the support of my supervisor Dr. A. A. A. Abuelnuor for his extraordinary guidance and support throughout my entire process. I would also take this opportunity to express my great appreciations to the Faculty of Engineering and Elgunied sugar factory's engineers (Abdelnasir A Hamed and Ahmed m Elhassan) they have provided all the assistance and support to me. Finally, I am very grateful to all my lovely family, for their support and encouragement.

Table of Content

Content	Page
Abstract English	I
Abstract Arabic	II
Dedication	III
Acknowledgments	IV
Table of content	V
List of figures	viii
List of tables	IX
Nomenclature	X
Chapter one	
Introduction	
1.1 Background	2
1.2 Problem statement	5
1.3 Objectives of the research	5
1.4 Scope	6
1.5Significance of Research	6
1.6Thesis outline	6
Chapter Two	
Literature Review	
2.1 Introduction	9
2.2 Current Studies	10
2.2.1 Bagasse Feeder	11
2.2.2 Excess Air for Combustion of Bagasse	12
2.2.3 Products of Bagasse Combustion	12
2.3 Quantity of Steam Obtainable From Unit Weight of Bagasse	13
2.3.1 Condensation heat loss (L_c)	13
2.3.2 Sensible Heat Loss (L_s)	14
2.3.3 Loss of Heat Due To Incomplete Combustion (L_i)	14
2.4 Boiler Heat Balance	15

2.5 Steam Turbines	16
2.5.1 Mechanical Drive Turbines and Electrical Drive Turbines	17
2.5.2 Specific steam rate of the steam turbine	17
2.6 Energy and Exergy	18
2.6.1 Definition of Energy and Exergy	18
2.6.2 The reference point	19
2.6.3 Energy and Exergy Analysis	19
2.6.4 Energy and Exergy Formulations	20
2.7 Efficiency laws	21
2.7.1 Energy Conversion Efficiencies	21
2.7.2 Exergetic (second law) efficiency	21
2.7.3 Energy and Exergy Analyzed Of Elgunied Sugar Factory	22
Chapter Three	
Energy and Exergy Analysis of Elgunied Sugar Factory	
3.1 Energy and Exergy Analysis of Elgunied Sugar Factory	28
3.1.1 Gross Calorific Value of Bagasse GCV or HCV	28
3.1.2 Net Calorific Value of Bagasse NCV or LCV	28
3.2 Energy and Exergy Analysis of Elgunied Sugar Factory	30
3.2.1 Energy and Exergy Analysis for a Boiler	30
3.2.1.1 First Law Analysis on Combustor	30
3.2.1.2 Second law analysis on combustor	31
3.2.1.3 First law analysis on heat exchanger	31
3.2.1.4 Second law analysis of heat exchanger	32
3.2.2 Energy and Exergy Analysis for a Turbine	33
3.2.2.1 First Law Analysis of Turbine	33
3.2.2.2 Second law analysis of Turbine	34
3.2.2.3 Exergy Destruction	35

Chapter Four	
Results And Discussions	
4.1 Introduction	41
4.2 Results and Discussions	41
Chapter Five	
Conclusion And Recommendations	
5.1 Conclusion	50
5.2 Recommendations	51
References	52

List of Figures

Figure No	Description	Page
1.1	Electricity generations by fuels 2009	3
2.1	Diagram For Exergy Flow Through Steam Turbine At 70 %MCR	24
2.2	Diagram for Exergy Flow Through Steam Turbine At 85 %MCR	25
2.3	Exergy destruction in simple back pressure cogeneration plant	26
3.1	Flow diagram of Elgunied Sugar Factory power plant	29
3.2	Schematic diagrams of combustor and heat exchanger in a boiler	30
4.1 a	Exergy Destruction Rate (MW) of Components	45
4.1 b	Exergy Destruction Rate (MW) of Components	46
4.2	Exergy Destruction % of Components	46
4.3	Exergy Destruction % of Elgunied Sugar Factory and Yung C. Lien sugar industry	47
4.4	Exergy efficiency %	48

List of Tables

Table No	Description	Page
3.1	Expressions for Exergy Destruction Rate and Exergy Efficiency for Elgunied Sugar Factory's Components	36
3.2	Main Data for Elgunied Sugar Factory	36
3.3	Chemical Composition of Bagasse	37
3.4	Properties of the Reference Environment	37
3.5	Operation Data of Plant	38
3.6	Enthalpy and Entropy Values of Steam Flow	39
4.1	Boiler Heat Balance	42
4.2	Energy and Exergy Analysis of Elgunied Sugar Factory	43
4.3	Expressions of Exergy Destruction Rate and Exergy Efficiency for Elgunied Sugar Factory's Components	44

NOMENCLATURE

LHV	Lower Heating Value .kJ/kg
HHV	Higher Heating Value .kJ/kg
GCV	Gross calorific value of bagasse
NCV	Net calorific value of bagasse
$\dot{m}$	Mass flow rate, kg/s
h	Specific enthalpy ,kJ/kg
s	Specific entropy, kJ/kg K
$\dot{W}$	Work produces, kW
P	Pressure, kPa
Q	Heat transfers, kW
L_C	Condensation heat loss
L_S	Sensible heat loss
L_U	Unburned bagasse loss
L_R	Radiation loss
L_i	Incomplete combustion loss
α	Coefficient of heat loss for UN burnt bagasse
β	Coefficient of heat loss radiation
γ	Coefficient of heat loss incomplete
Ψ	specific exergy
$\dot{X}$	exergy rate kg/s
$\dot{X}_d$	exergy destruction kW
w	moisture per unit bagasse
S	Sucrose in bagasse