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Analysis Of The Influence Of Heating Element Power, Pressure, Operating Time On Ethanol Volume In Palm Sap Distillation Equipment As One Of The Alternative Energy Sources"

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Abstract :
The current energy sources used still largely rely on fossil fuels, which are depleting and could eventually run out at some point. Therefore, there is a need to develop renewable energy sources by harnessing natural potentials. Ethanol represents a biotechnological breakthrough that can serve as an environmentally-friendly alternative renewable energy source. Ethanol is developed using modern technology, making it a renewable energy source, meaning it's not finite like fossil fuels. The purpose of this research is to predict and optimize input variables to achieve the best possible output variables.In this research, there are several input variables that will have an impact: Heating Element Power (w), Pressure (p), Operating Time (t), while the Output Variable is the Volume of ethanol (m). An analysis is conducted first using Response Surface Methodology (RSM) to understand the relationships between variables, which can be visualized in surface plots, and to identify main factors. This analysis aims to obtain the optimum values for the output variable.
Keywords -*Ethanol, Energy RSM*

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I. INTRODUCTION

The use of oil-based fuels in Indonesia has surpassed the equilibrium point between production and consumption. Consequently, Indonesia has transitioned from being an oil exporter to an oil importer. To meet the ever-increasing energy demands, the utilization of alternative energy sources such as coal, natural gas, and renewable energy is continually being developed, both for electricity generation and as a substitute for oil-based fuels.Fuel substitution involves the use of alternative fuels to replace fossil fuels that are becoming scarcer and more expensive. One common example of fuel substitution is the use of biofuels, which are produced from organic materials like plants or other renewable organic waste. Biofuels can be used as substitutes for fossil fuels such as gasoline or diesel and can reduce greenhouse gas emissions because they are derived from plants that absorb carbon dioxide from the air during their growth. In addition to biofuels, other alternative fuels such as hydrogen and electricity can be used as substitutes for fossil fuels. Hydrogen can be used as a fuel for fuel cell vehicles, while electricity can power electric vehicles.

Ethanol is a type of fuel produced from natural resources such as corn, wheat, sugarcane, or cassava through the fermentation process. Ethanol can be used as an alternative fuel for motor vehicles. One advantage of using ethanol as a fuel is its environmentally friendly nature compared to fossil fuels like gasoline and diesel. Ethanol is cleaner in terms of carbon dioxide emissions and can improve air quality. However, there are some drawbacks to using ethanol as a fuel, including its relatively higher production cost compared to fossil fuels and its higher energy consumption during production. Additionally, the use of ethanol can reduce fuel efficiency in vehicles, requiring more fuel to cover the same distance. Nonetheless, the development and testing of ethanol as an alternative fuel continue to address environmental issues and reduce dependence on fossil fuels.

Palm sap distillation is the process of purifying palm sap through heating and condensation. The aim is to separate water from the sugar and minerals contained in palm sap, resulting in purer palm sugar. The palm sap distillation process involves heating palm sap to a high temperature until the vapor rises and then directing it to a cooler place to condense and produce pure palm sugar. This distillation process is typically carried out using distillation equipment consisting of a heating tank, condenser, and a collection point for the distillation product.

However, it's important to note that palm sap distillation can only be performed on palm sap that has been fermented beforehand, so the alcohol content is not too high. If palm sap is not fermented, the distillation process can produce alcohol that can be harmful to health. Therefore, palm sap distillation should preferably be carried out by experienced experts or palm sugar producers.

The processing of ethanol at the farmer level can face several challenges, including technology, as farmers may lack access to modern and up-to-date technology used in ethanol processing, affecting the quality and quantity of ethanol produced. Resources, such as raw materials, water, energy, and labor, are required for ethanol processing, and farmers may not have adequate access to these resources, limiting their ethanol production. Marketing ethanol can be a challenge for farmers, especially if they do not have a distribution network or access to a wide market, which can restrict the potential profits from ethanol production. Regulations require farmers involved in ethanol production to adhere to strict safety standards set by the government, which may necessitate additional investments in safety infrastructure and equipment, affecting the cost of ethanol production. Farmers engaged in ethanol production may face competition from other ethanol producers, both domestic and international, which can influence the price and availability of raw materials and impact the profitability of ethanol production.

Response Surface Methodology (RSM) is a statistical technique used to design and analyze experiments to understand the relationship between input and output variables of a system or process. The primary objective of RSM is to optimize the response (output) of a system or process by minimizing or maximizing the desired response function. RSM can be used to model the relationship between input and output variables using mathematical equations known as response surface models. These models enable the analysis of how changes in input variable values affect the response variable and identify optimal points on the response surface.

There are several studies that have been conducted by other researchers or by the proposer/researcher, such as:Davim et al. attempted to investigate surface roughness prediction using artificial neural network (ANN).Asiltürk (2012) solely predicted the surface roughness of AISI 1040 steel material using ANN and multiple regression. Bhattacharya et al. (2010) evaluated the contribution of input parameters using ANOVA for the cutting depth of a specific type of cutting tool.The authors (Punuhsingon Charles, Rantung J, and Rembet, M., 2016) created a model for analysis and prediction using RSM and BPNN with constraints on input variables, including cutting speed, feed rate, and cutting depth for two different types of cutting tools.The Use of Artificial Intelligence to Predict and Optimize Fluid Flow Rate in a Spiral Pump as One of the Renewable Energy Sources (Thesis, 2022/Patent) by Charles Punuhsingin et al.The data above also show the researcher's roadmap or path, referring to the Strategic Plan (RENSTRA) of Unsrat Research 2021-2025 as the primary and up-to-date reference, prioritizing research outcomes in scientific journals. It is evident that there is a gap in some previous research as no one has yet examined the Analysis using RSM to assess input variables on the ethanol volume in the Palm Sap Distillation Equipment as one of the Alternative Energy Sources

The problem of this research is how to analyze the relationship between input variables and the ethanol volume in the Palm Sap Distillation Equipment as one of the Alternative Energy Sources. The aim of this research is to analyze the relationship between input variables and the ethanol yield in palm sap distillation equipment using Response Surface Methodology (RSM). The aim of this research is to analyze the relationship between input variables and the ethanol yield in palm sap distillation equipment using Response Surface Methodology (RSM).

II. METHODOLOGY

Research Location

The research was conducted in the Mechanical Engineering Laboratory at the Faculty of Engineering, University of Sam Ratulang Manado

Data Collection

In this experiment, we will use three factors: Volume (v), Pressure (p), and Heating Element Power (w). Each of these factors has three levels (low, medium, and high), and the Output Variable is the Mass of ethanol (m). We will obtain this data with the assistance of software to collect secondary data.

Method

The method used involves data collection using software for input parameters, which consist of Volume (v), Pressure (p), and Heating Element Power (w) at 3 different data collection levels, resulting in a total of 27 data points as input parameters. Subsequently, optimization will be performed using RSM in Minitab, followed by prediction using ANN in Matlab.

III RESULTS AND DISCUSSION

Design Planning of Response Surface Methodology

In this section, an experimental design has been created using the Response Surface Methodology (RSM) concept, where there are 3 input variables: Heating Element Power (w), Pressure (p), and Operating Time (t). The Output Variable is the ethanol volume (m). If represented, it will be as shown in Table 5.1, where each input variable has 3 levels of data, resulting in a total of 27 different combinations when combined."

Variable input and data level

Variabel Input	Level		
	low	Middle	High
x_1 Heating Element Power (w)	1	2	3
x_2 Pressure (p)	1	2	3
x_3 Operating Time (t)	1	2	3

Operating Time 30 minute, Pressure 1,1 atam

Heating Element Power(w)	Volume of ethanol (m)
1500	0,12
1800	0,55
2000	0,61

Operating Timen 30 minute, Presssure 1,2 atam

Heating Element Power(w)	Volume of ethanol (m)
1500	0,12
1800	0,57
2000	0,66

Operating Time 30 minute, Pressure 1,3 atam

Heating Element Power(w)	Volume of ethanol (m))
1500	0,13
1800	0,59
2000	0,80

Operating time 45 minute, Pressure 1,1 atam

Heating Element Power(w)	Volume of ethanol (m)
1500	0,52
1800	1,23
2000	1,25

Operating time 45 minute, Pressure 1,2 atam

Heating Element Power(w)	Volume of ethanol (m))
1500	0,52
1800	1,30
2000	1,40

Operating Time 45 minute, Pressure 1,3 atam

Heating Element Power(w)	Volume of ethanol (m)
1500	0,55
1800	1,31
2000	1,44

Operating Time 60 minute, Pressure 1,1 atam

Heating Element Power(w)	Volume of ethanol (m)
1500	1,10
1800	1,80
2000	1,87

Operating timme 60 minute, Pressure 1,2 atam

Heating Element Power(w)	Volume of ethanol (m)
1500	1,11
1800	1,86
2000	1,90

Operating time 60 menit, Pressure 1,3 atam

Heating Element Power(w)	Volume of ethanol (m)
1500	1,22
1800	1,85
2000	1,91

Values of Input Variables and Data Levels.

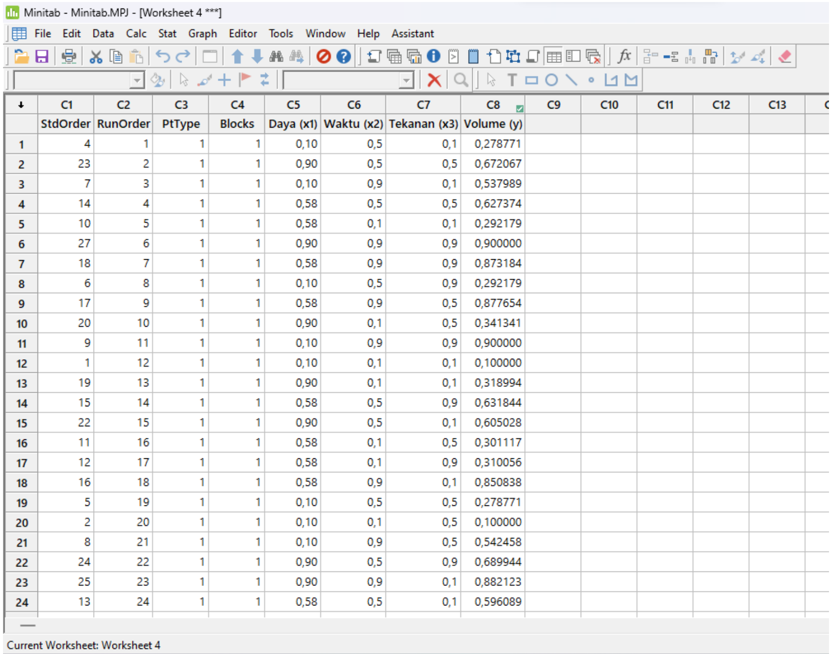
Variabel Input	Level		
	low	Middle	High
x_1 Heating Element Power (w)	0,9	1,2	1,5
x_2 Pressure (p)	5	6	7
x_3 Operating Time (t)	0,5	1,0	1,5

F**or better clarity, the combination of input variables with the output can be seen.**

Heating Element Power(w)	Pressure (p)	Operating Time (t)	Volume of ethanol (m)
1500	45	1,1	0,52
2000	45	1,2	1,4
1500	60	1,1	1,1
1800	45	1,2	1,3
1800	30	1,1	0,55
2000	60	1,3	1,91
1800	60	1,3	1,85
1500	45	1,3	0,55
1800	60	1,2	1,86
2000	30	1,2	0,66
1500	60	1,3	1,91
1500	30	1,1	0,12
2000	30	1,1	0,61
1800	45	1,3	1,31
2000	45	1,1	1,25
1800	30	1,2	0,57
1800	30	1,3	0,59
1800	60	1,1	1,8
1500	45	1,2	0,52
1500	30	1,2	0,12
1500	60	1,2	1,11
2000	45	1,3	1,44

2000	60	1,1	1,87
1800	45	1,1	1,23
1500	30	1,3	0,13
2000	30	1,3	0,8
2000	60	1,2	1,9

With the assistance of MINITAB software, the sequence of combinations of the p input variables, each at its respective level, is obtained using a Multilevel Factorial design, as shown in the sheet format, as depicted in the image.

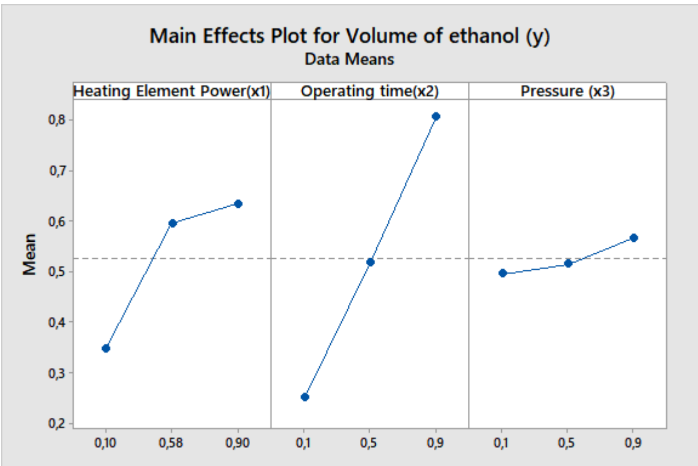


Minitab - Minitab.MPJ - [Worksheet 4 ***]

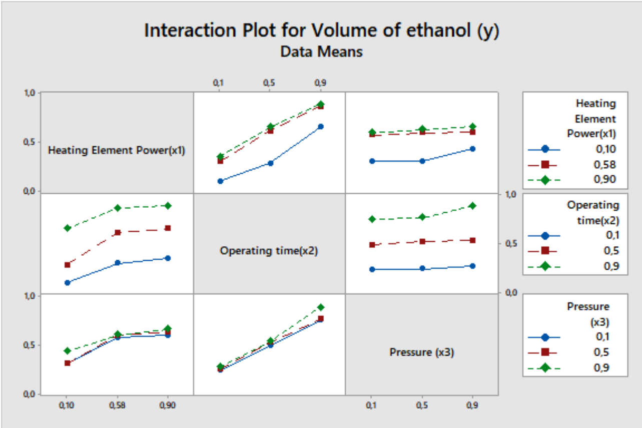
File Edit Data Calc Stat Graph Editor Tools Window Help Assistant

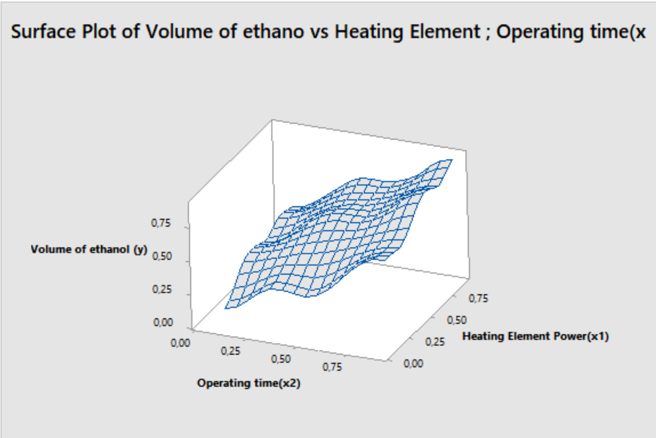
↓	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
	StdOrder	RunOrder	PtType	Blocks	Daya (x1)	Waktu (x2)	Tekanan (x3)	Volume (y)					
1	4	1	1	1	0,10	0,5	0,1	0,278771					
2	23	2	1	1	0,90	0,5	0,5	0,672067					
3	7	3	1	1	0,10	0,9	0,1	0,537989					
4	14	4	1	1	0,58	0,5	0,5	0,627374					
5	10	5	1	1	0,58	0,1	0,1	0,292179					
6	27	6	1	1	0,90	0,9	0,9	0,900000					
7	18	7	1	1	0,58	0,9	0,9	0,873184					
8	6	8	1	1	0,10	0,5	0,9	0,292179					
9	17	9	1	1	0,58	0,9	0,5	0,877654					
10	20	10	1	1	0,90	0,1	0,5	0,341341					
11	9	11	1	1	0,10	0,9	0,9	0,900000					
12	1	12	1	1	0,10	0,1	0,1	0,100000					
13	19	13	1	1	0,90	0,1	0,1	0,318994					
14	15	14	1	1	0,58	0,5	0,9	0,631844					
15	22	15	1	1	0,90	0,5	0,1	0,605028					
16	11	16	1	1	0,58	0,1	0,5	0,301117					
17	12	17	1	1	0,58	0,1	0,9	0,310056					
18	16	18	1	1	0,58	0,9	0,1	0,850838					
19	5	19	1	1	0,10	0,5	0,5	0,278771					
20	2	20	1	1	0,10	0,1	0,5	0,100000					
21	8	21	1	1	0,10	0,9	0,5	0,542458					
22	24	22	1	1	0,90	0,5	0,9	0,689944					
23	25	23	1	1	0,90	0,9	0,1	0,882123					
24	13	24	1	1	0,58	0,5	0,1	0,596089					

Current Worksheet: Worksheet 4

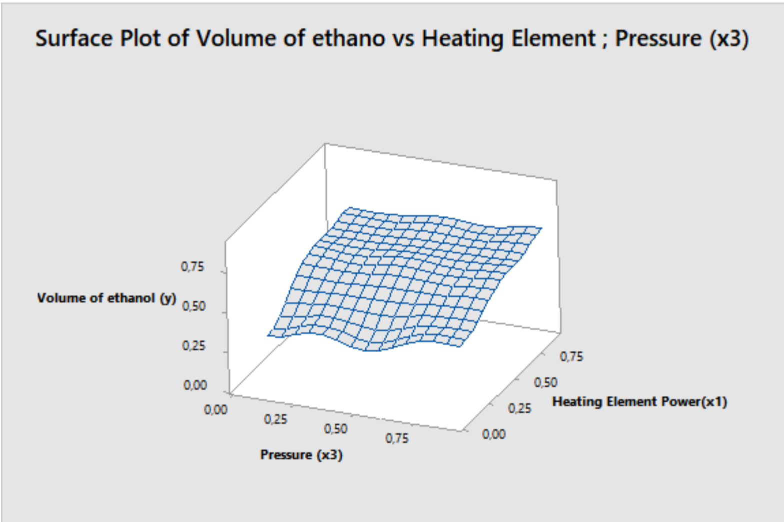


From the above image, it can be observed that the most influential factor on y is x2, which is the operating time.

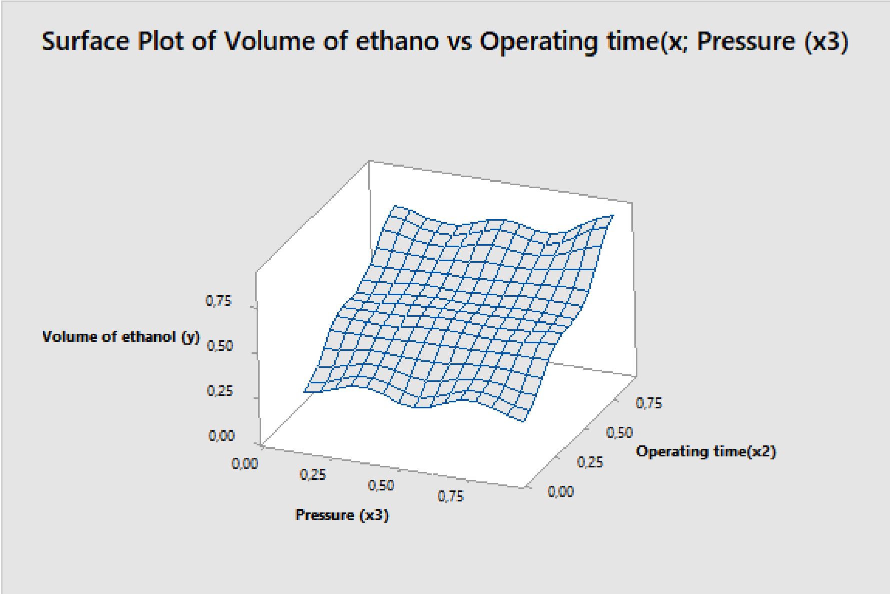




If the operating time is increased, the volume of ethanol will also increase. Additionally, when the operating time is high and the heating element is intensified, the volume of ethanol also iincreases.



It appears that pressure does not have a significant impact on the volume of ethanol, but what does matter is the heating element power. If the heating element power is increased, whether at low or high pressure, it will affect the volume of ethanol.



Similarly, it can be concluded that pressure does not have a significant impact on the volume of ethanol, and the most influential factor is the operating time on the volume of ethanol, even at low or high pressure.

IV CONCLUSION

Based on the previous analysis results, it can be concluded that the operating time is a critical factor that needs attention because it significantly affects the volume of ethanol. Following that, the heating element power is also influential, while pressure has no significant effect, whether it is low or high. It is also evident that when the pressure is low and the operating time is high, it directly impacts the volume of ethanol. Furthermore, it is observed that as the operating time increases, the heating element power also increases.

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