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LEVERAGING MACHINE LEARNING TO OPTIMIZE PRODUCTION PROCESSES AND CAPACITY IN THE BREWERY INDUSTRY.

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Abstract: The decrease in the production capacity that had crippled business activities that mostly depend on soft drinks to run their daily activities was overcame by introducing leveraging machine learning to optimize production processes and capacity in the brewery industry, to perfectly achieve this, it was done in this approach, characterizing and establishing the causes of poor production capacity in a brewery industry, designing a conventional SIMULINK model for production processes in the brewery industry, designing leverage machine learning rule base that will reduce the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity, training ANN in the designed machine learning rule base for effective reduction of the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity, designing a SIMULINK model for leverage machine learning, developing an algorithm that will implement the process, designing a SIMULINK model for leveraging machine learning to optimize production processes and capacity in the brewery industry and validating and justifying the percentage improvement in the production capacity of a brewery industry with and without leveraging machine learning. The results obtained were, that the conventional inefficient Process Control and Automation cause of poor production capacity in the brewery industry was 20%. On the other hand, when leveraging machine learning was introduced in the system, it drastically reduced inefficient Process Control and Automation caused poor production capacity in the brewery industry to 17.34% thereby enhancing the production capacity, the conventional Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry was10%. Meanwhile, when leveraging machine learning was incorporated into the system, it decisively reduced Lengthy Fermentation and Maturation Times caused by poor production capacity in the brewery industry to 8.7% and the conventional production capacity in the brewery industry was 50000 bottles of drink. On the other hand, when leveraging machine learning was inculcated in the system, it simultaneously enhanced the production capacity in the brewery industry to 6500 bottles of drink. Finally, with these results obtained, it showed that production capacity in the brewery industry was optimized by 33%.

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Keywords; learning, leveraging, machine, processes, production

1.1 Introduction

The brewery industry is highly competitive, with manufacturers continually seeking ways to optimize production processes, minimize waste, and maximize production capacity. Traditional methods of process optimization in breweries rely heavily on manual observations, fixed schedules, and historical data that may not adapt swiftly to changing conditions (Rathore & Tiwari, 2020). In recent years, machine learning (ML) has emerged as a transformative technology in industrial manufacturing, offering advanced data-driven solutions that significantly improve process control and forecasting capabilities (Zhou et al., 2021). Machine learning algorithms can analyze large volumes of production data in real time, providing insights that enhance decision-making, streamline operations, and improve resource utilization (Wuest et al., 2019). The brewery industry, due to its complex manufacturing processes involving various stages such as fermentation, bottling, and packaging, is uniquely positioned to benefit from machine learning applications. These algorithms can optimize fermentation times, monitor quality control in real time, and adjust operations dynamically based on demand and resource availability (Oliveira & Cunha, 2019). Furthermore, machine learning supports predictive maintenance, reducing equipment downtime and minimizing disruptions in production cycles (Agrawal et al., 2020). Given the need for sustainable operations, machine learning also contributes to achieving energy efficiency, which aligns with industry goals to minimize environmental impact (Lydon et al., 2021). However, integrating machine learning into brewery production faces several challenges, including the need for significant data infrastructure, skilled personnel, and an understanding of the nuances in applying AI-based solutions to traditional processes (Singh & Kumar, 2021). Despite these challenges, the potential benefits have spurred research into developing tailored ML models that address the specific needs of the brewing industry. This study aims to explore how machine learning can be effectively leveraged to optimize production processes and increase capacity within breweries, ultimately contributing to a more sustainable, efficient, and competitive brewing industry.

2.0 Methodology

To characterize and establish the causes of poor production capacity in the brewery industry.

Here's an example of how poor production capacity in the brewery industry can be characterized by causes, with percentages and their corresponding impact in terms of bottles of drinks produced per day:

Table characterized and established causes of poor production capacity in a brewery industry

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Cause of Poor Production Capacity	**Impact (%)**	**Impact (Number of Bottles per Day)**
Inefficient Process Control and Automation	20%	10,000 fewer bottles
Equipment Downtime and Maintenance Issues	25%	12,500 fewer bottles
Variability in Raw Material Quality	10%	5,000 fewer bottles
Suboptimal Scheduling and Resource Allocation	15%	7,500 fewer bottles
Lengthy Fermentation and Maturation Times	10%	5,000 fewer bottles
Limited Data Utilization and Real-Time Analytics	8%	4,000 fewer bottles
Energy Constraints and Environmental Regulations	7%	3,500 fewer bottles
Labor Shortages and Skill Gaps	5%	2,500 fewer bottles
Total Production Impact	100%	50,000 fewer bottles

i) The table indicates the estimated contribution of each cause to the reduction in production capacity, expressed as a percentage and in terms of the reduction in bottles of drinks produced per day.

ii) These values are estimates and may vary based on the specific brewery's production environment and operational parameters.

To design a conventional SIMULINK model for production processes in the brewery industry

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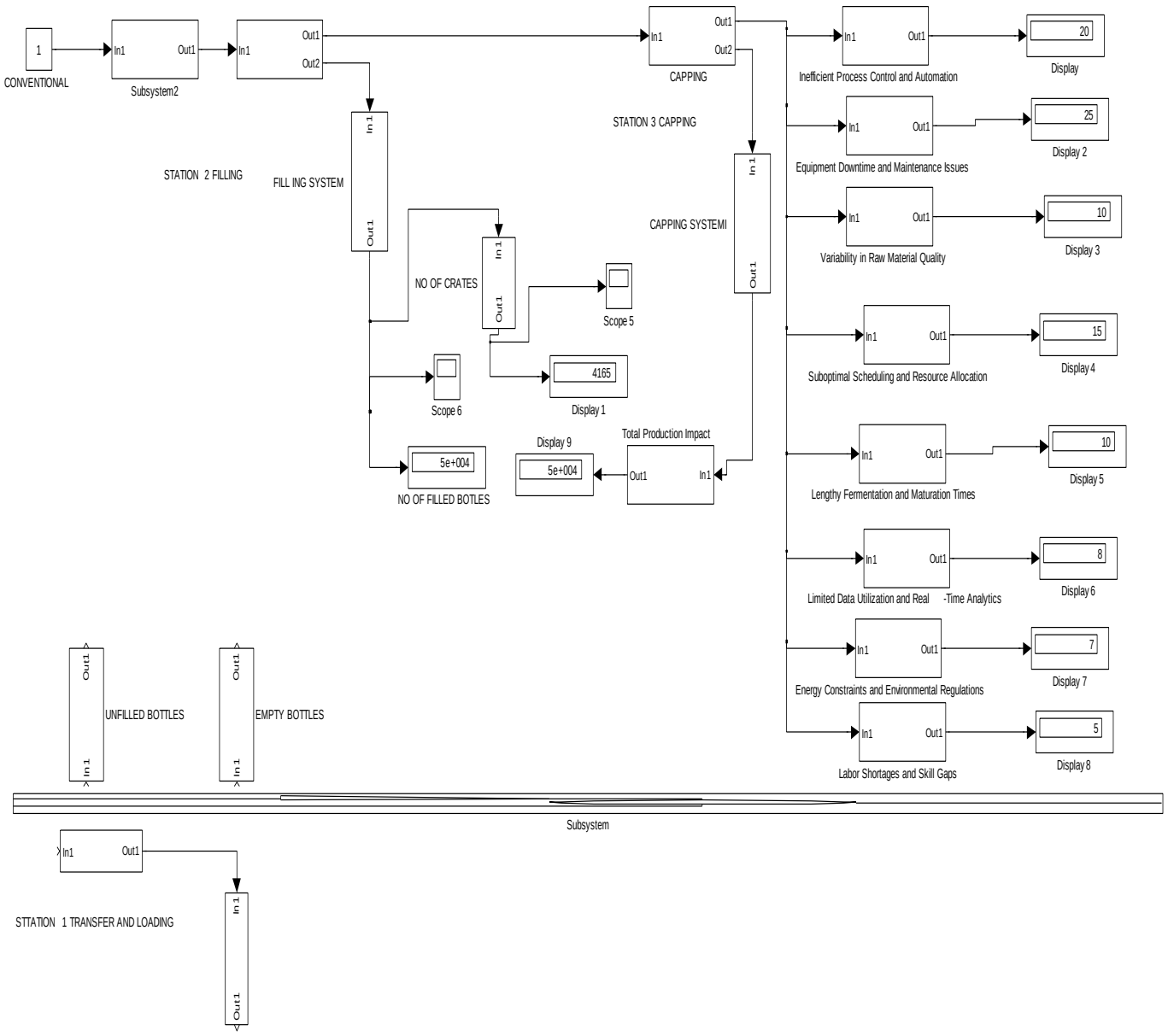

Figure 1.0 Designed conventional SIMULINK model for production processes in the brewery industry

The results obtained were shown in figures 9.0 to 11.0

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To design machine learning rule base that will reduce the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity

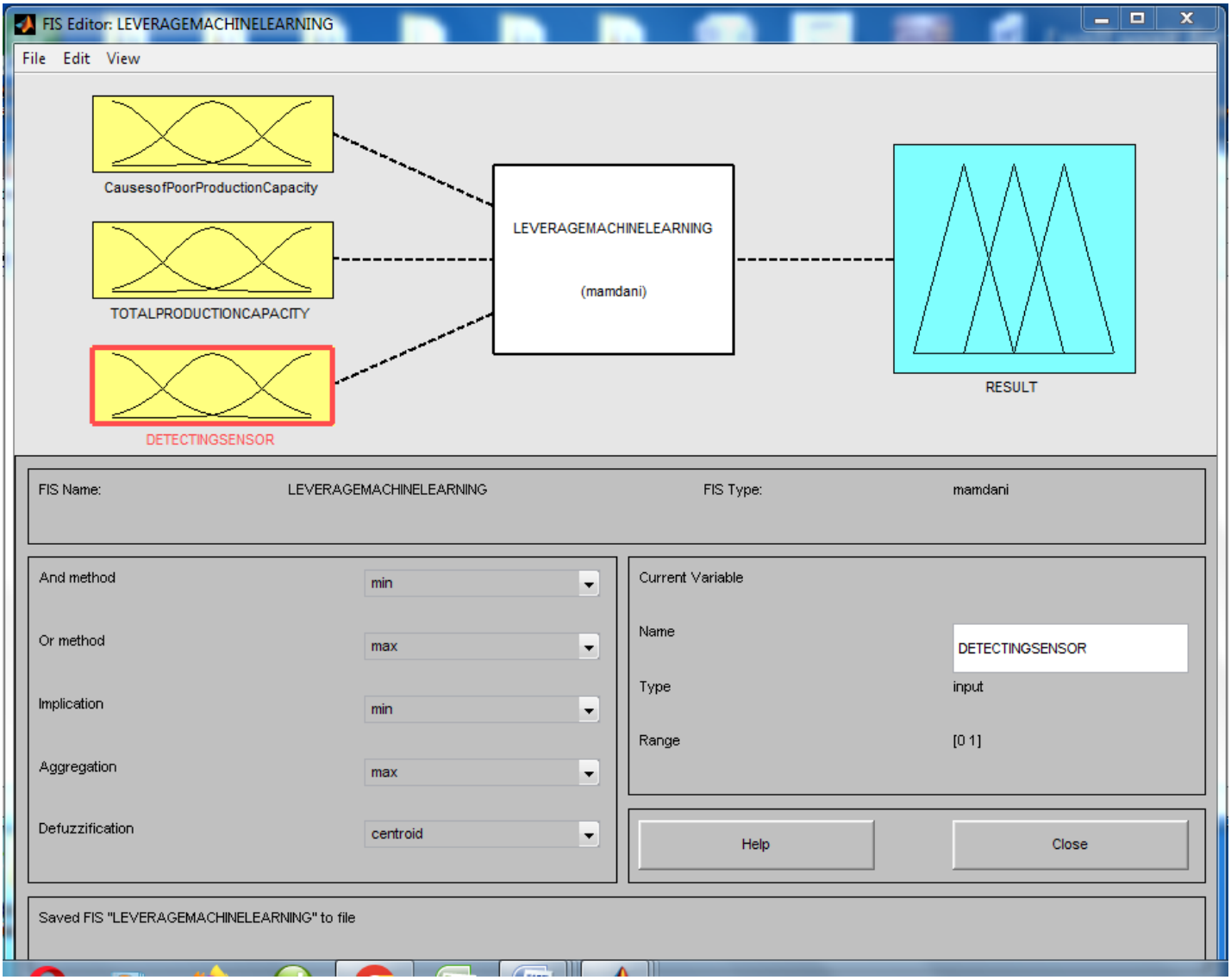

Figure 2.0 Machine learning Fuzzy inference system

Machine learning fuzzy inference system was designed as shown in figure 2.0 to reduce the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity

This has three inputs of causes of poor production capacity, total production capacity and detecting sensor. It also has an output of result.

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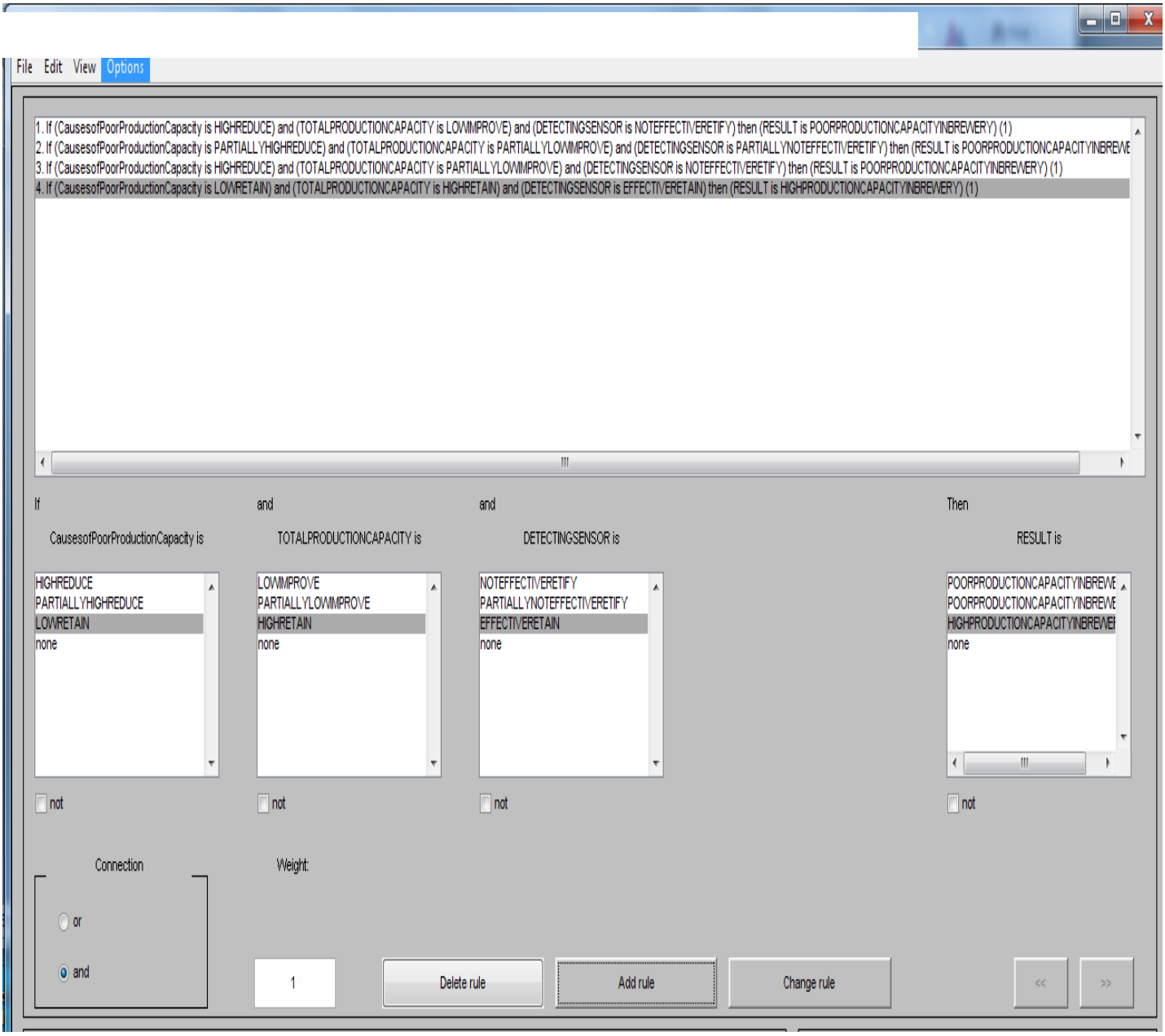

Figure 3.0 Machine learning rule base

Machine learning rule base was also designed to reduce the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity

These rules were extensively elucidated in table 2

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Table 2. 0: Machine learning rule base

The comprehensive rules of designed machine learning rule base, that will reduce the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity is shown in table 2.0

1	IF CAUSES OF POOR PRODUCTION CAPACITY IS HIGH REDUCE	AND TOTAL PRODUCTION CAPACITY IS LOW IMPROVE	AND DETECTING SENSOR IS NOT EFFECTIVE RECTIFY	THEN RESULT IS POOR PRODUCTION CAPACITY IN BREWERY INDUSTRY
2	IF CAUSES OF POOR PRODUCTION CAPACITY IS PARTIALLY HIGH REDUCE	AND TOTAL PRODUCTION CAPACITY IS PARTIALLY LOW IMPROVE	AND DETECTING SENSOR IS PARTIALLY NOT EFFECTIVE RECTIFY	THEN RESULT IS POOR PRODUCTION CAPACITY IN BREWERY INDUSTRY
3	IF CAUSES OF POOR PRODUCTION CAPACITY IS HIGH REDUCE	AND TOTAL PRODUCTION CAPACITY IS PARTIALLY LOW IMPROVE	AND DETECTING SENSOR IS NOT EFFECTIVE RECTIFY	THEN RESULT IS POOR PRODUCTION CAPACITY IN BREWERY INDUSTRY
4	IF CAUSES OF POOR PRODUCTION CAPACITY IS LOW RETAIN	AND TOTAL PRODUCTION CAPACITY IS HIGH RETAIN	AND DETECTING SENSOR IS EFFECTIVE RETAIN	THEN RESULT IS HIGH PRODUCTION CAPACITY IN BREWERY INDUSTRY

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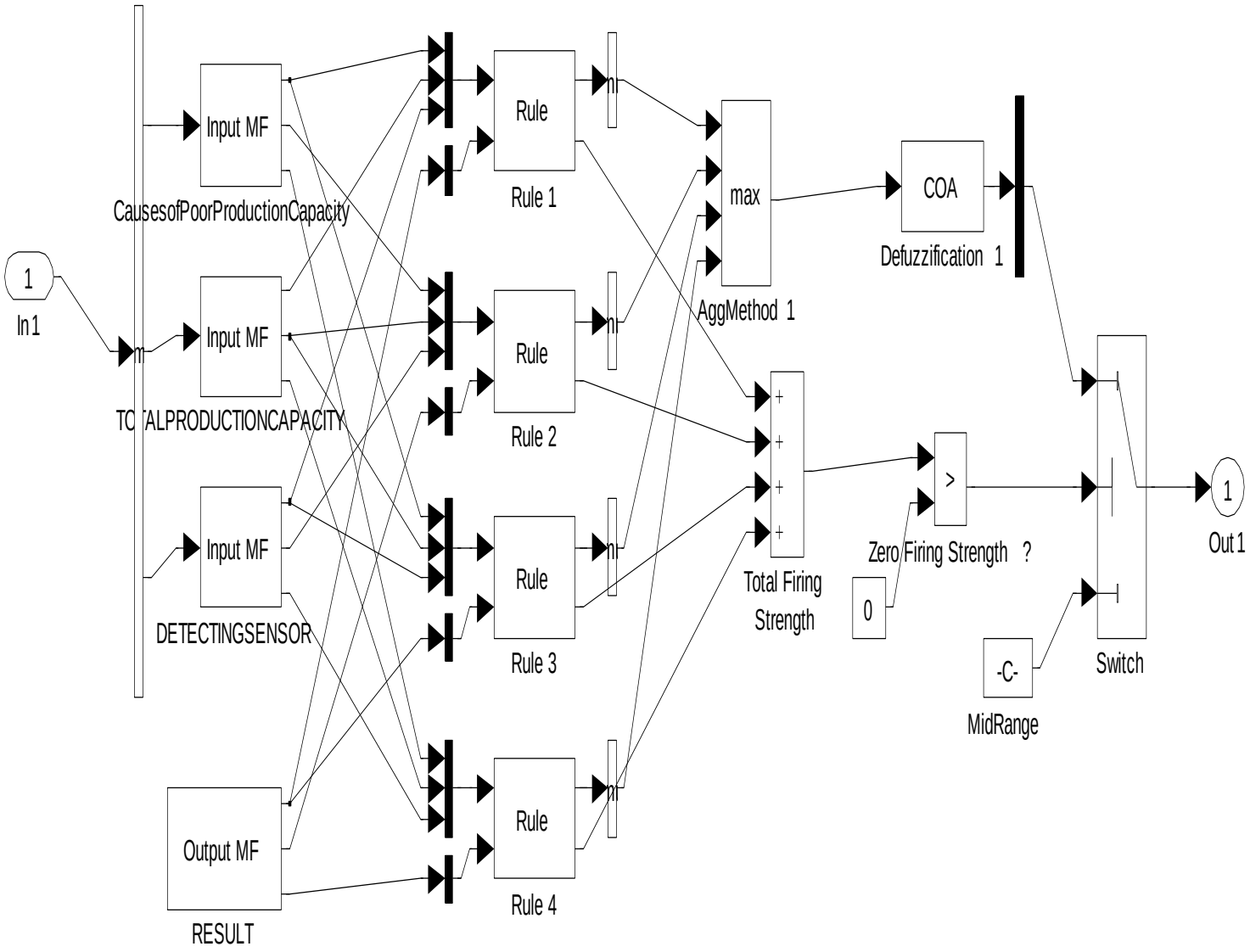

Figure 4.0: Operational application of the four rules

To train ANN in the designed machine learning rule base for effective reduction of the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity, was shown in the operation of the four rules I figure 4.0

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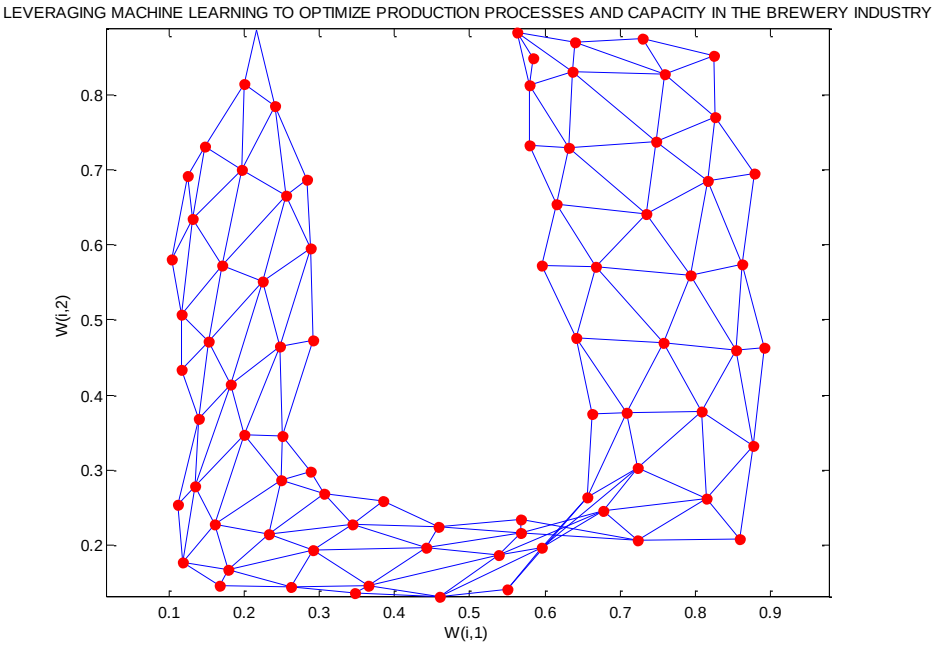

Fig 5 trained ANN in the designed machine learning rule base for effective reduction of the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity
ANN was trained twenty times in four rules 20 x4 = 80 eighty rules that looks identical like human brain.

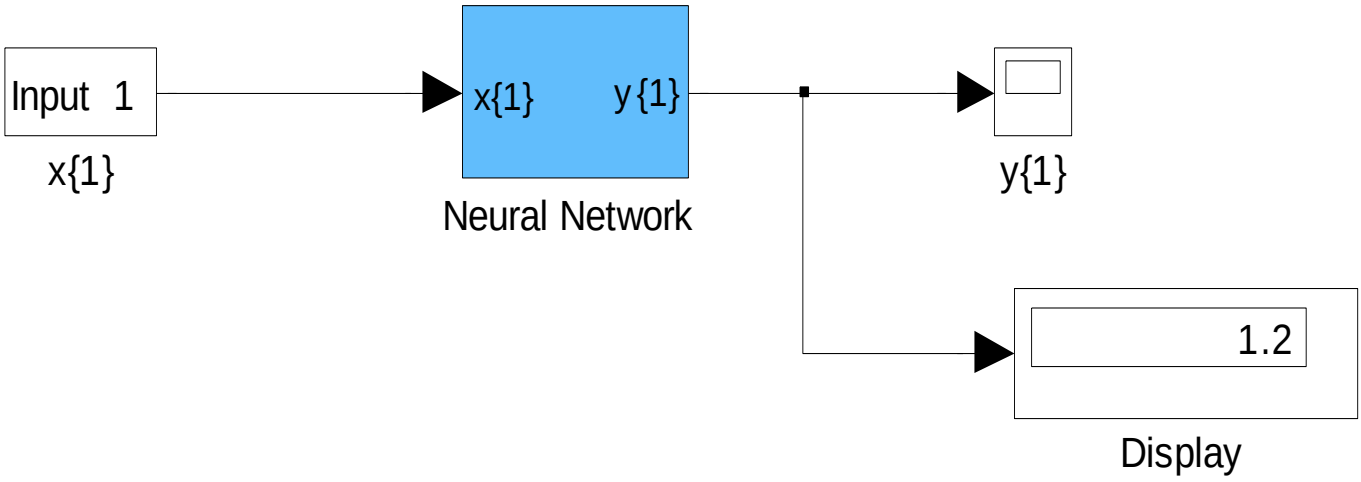

Figure 6.0: Result obtained during the training

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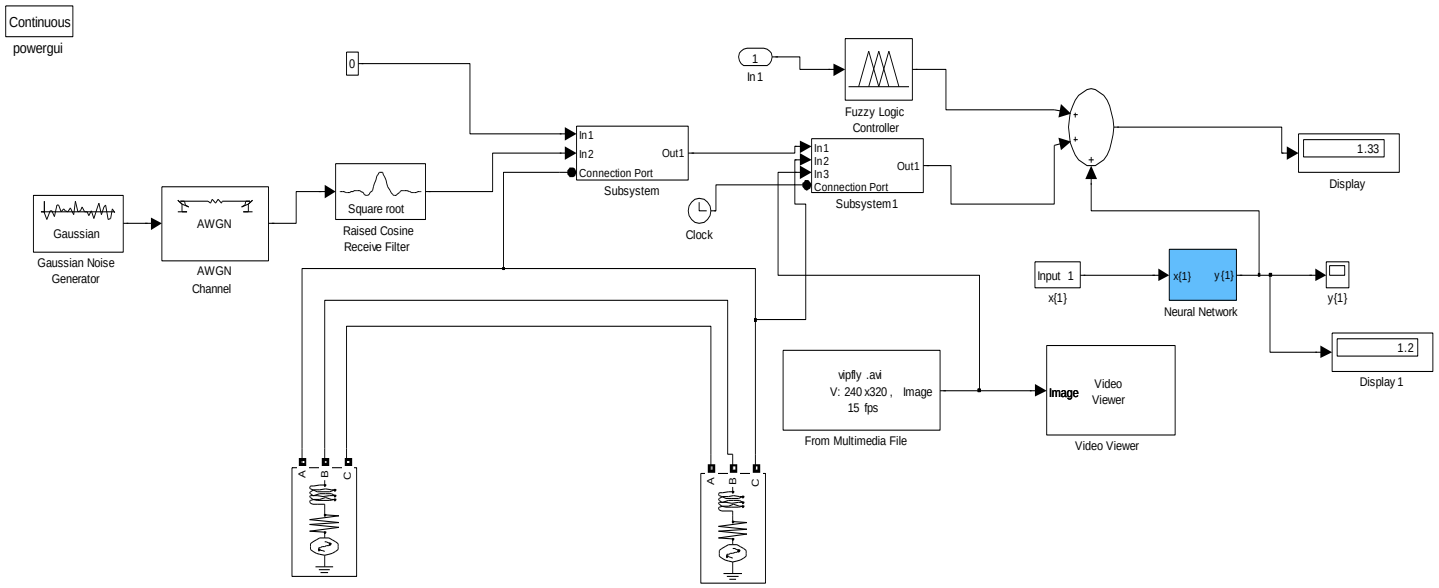

Figure 7.0: Designed SIMULINK model for leverage machine learning

This will be integrated in figure 1.0 to obtain the results shown in figures 9.0 to11.0

To develop an algorithm that will implement the process, we have to go through the following process-

1. Characterize and establish the causes of poor production capacity in a brewery industry.
2. Identify inefficient Process Control and Automation
3. Identify Equipment Downtime and Maintenance Issues
4. Identify Variability in Raw Material Quality
5. Identify Suboptimal Scheduling and Resource Allocation
6. Identify Lengthy Fermentation and Maturation Times
7. Identify Limited Data Utilization and Real-Time Analytics
8. Identify Energy Constraints and Environmental Regulations
9. Identify Labor Shortages and Skill Gaps
10. Identify Total Production Impact
11. Design a conventional SIMULINK model for production processes in the brewery industry and integrate 2 through 10
12. Design leverage machine learning rule base that will reduce the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity.
13. Train ANN in the designed machine learning rule base for effective reduction of the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity
14. Design a SIMULINK model for leverage machine learning

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15. Integrate 12 through 14
16. Integrate 15 in 11
17. Do the causes of poor production capacity in a brewery industry reduce?
18. IF NO go to 16
19. IF YES go to 23
20. Does the production capacity in a brewery industry improve?
21. IF NO go to16
22. IF YES go to 23
23. Optimized production processes and capacity in the brewery industry.
24. Stop
25. End

To design a SIMULINK model for leveraging machine learning to optimize production processes and capacity in the brewery industry.

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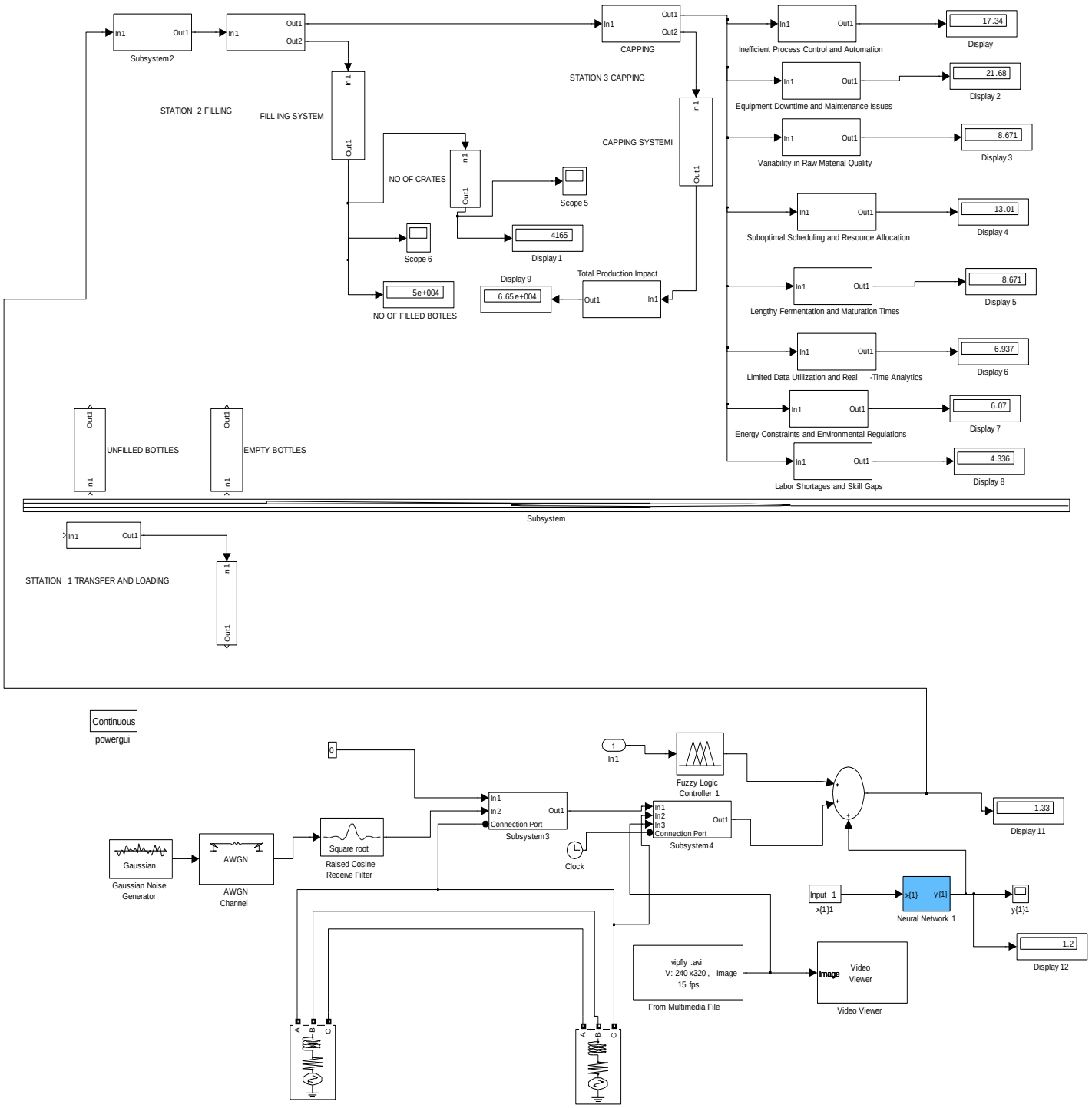

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Fig 8 designed SIMULINK model for leveraging machine learning to optimize production processes and capacity in the brewery industry.

The results obtained were as shown in figure 9.0 to 11.0

To validate and justify the percentage improvement in the production capacity of a brewery industry with and without leveraging machine learning

To find percentage improvement in the reduction of inefficient Process Control and Automation cause of poor production capacity in brewery industry with leveraging machine learning

Conventional inefficient Process Control and Automation =20%

Leveraging machine learning inefficient Process Control and Automation =17.34%

%improvement in the reduction of inefficient Process Control and Automation cause of poor production capacity in brewery industry with leveraging machine learning=

Conventional inefficient Process Control and Automation - Leveraging machine learning inefficient Process Control and Automation

%improvement in the reduction of inefficient Process Control and Automation cause of poor production capacity in brewery industry with leveraging machine learning= 20% - 17.34%

%improvement in the reduction of inefficient Process Control and Automation cause of poor production capacity in brewery industry with leveraging machine learning=2.66%

To find percentage improvement in the reduction of Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry with leveraging machine learning

Conventional Lengthy Fermentation and Maturation Times =10%

Leveraging machine learning Lengthy Fermentation and Maturation Times =8.7%

%improvement in the reduction of Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry with leveraging machine learning=

Conventional Lengthy Fermentation and Maturation Times - Leveraging machine learning Lengthy Fermentation and Maturation Times

%improvement in the reduction of Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry with leveraging machine learning=10% - 8.7%

%improvement in the reduction of Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry with leveraging machine learning=1.3%

To find percentage improvement in the production capacity in brewery industry with leveraging machine learning

Conventional production capacity =50,000bottles

Leveraging machine learning production capacity =6, 6500bottles

%improvement in the production capacity in brewery industry with leveraging machine learning=

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$$\text{Leveraging machine learning production capacity - Conventional production capacity} \times \frac{100\%}{\text{Conventional production capacity}} \quad 1$$

$$\%\text{improvement in the production capacity in brewery industry with leveraging machine learning} = 6, \frac{6500\text{bottles} - 50{,}000\text{bottles}}{50{,}000\text{bottles}} \times \frac{100\%}{1}$$

%improvement in the production capacity in brewery industry with leveraging machine learning=33%

3.0

4.0 Results and Discussions

Table 3 comparison of conventional and leveraging machine learning inefficient Process Control and Automation cause of poor production capacity in brewery industry

Time (days)	Conventional inefficient Process Control and Automation cause of poor production capacity in brewery industry (%)	Leveraging machine learning inefficient Process Control and Automation cause of poor production capacity in brewery industry (%)
1	20	17.34
2	20	17.34
3	20	17.34
4	20	17.34
10	20	17.34

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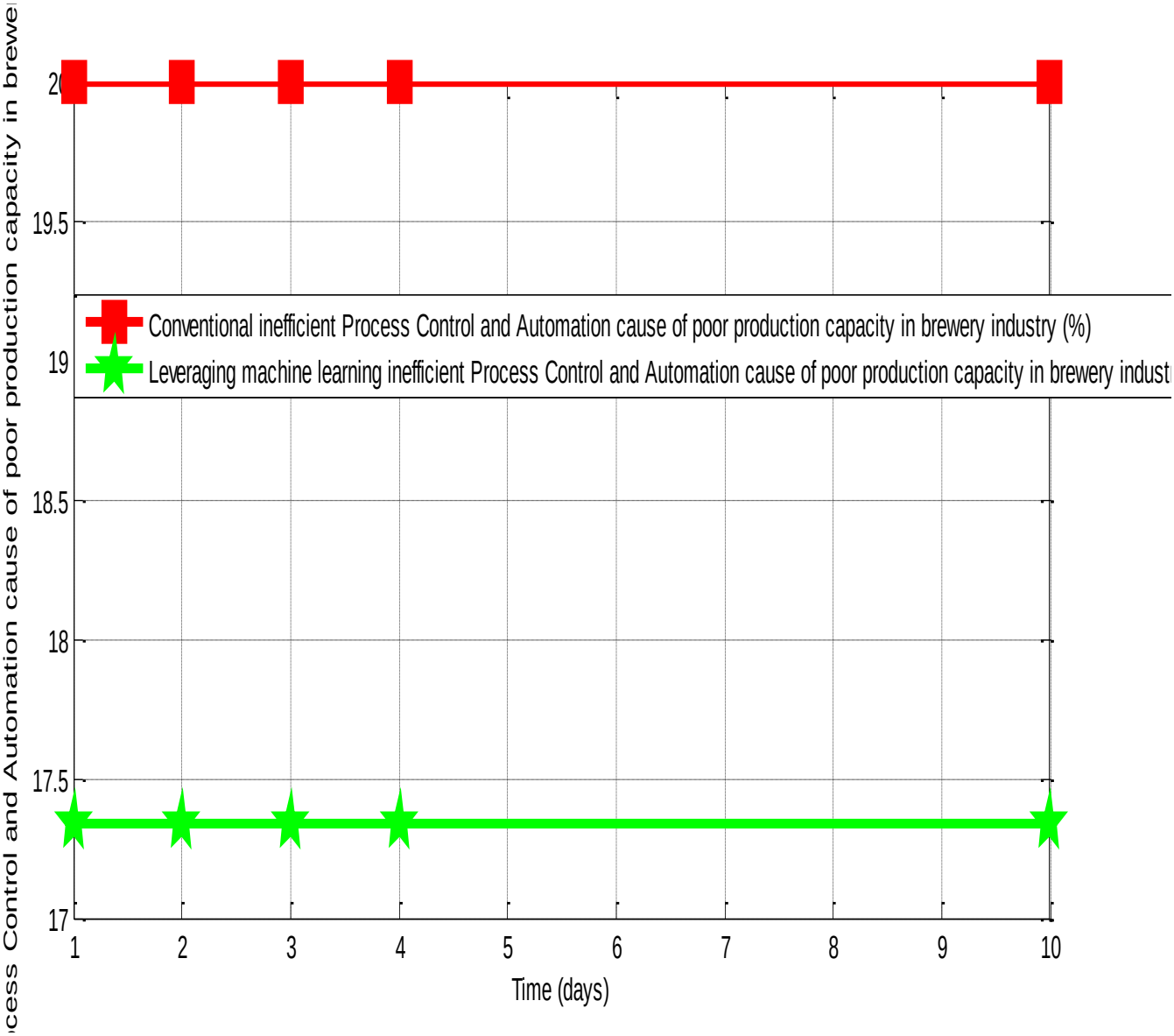

Figure 9.0: Comparison of conventional and leveraging machine learning inefficient Process Control and Automation cause of poor production capacity in brewery industry

The conventional inefficient Process Control and Automation cause of poor production capacity in brewery industry was20%. On the other hand, when leveraging machine learning was introduced in the system, it drastically reduced inefficient Process Control and Automation cause of poor production capacity in brewery industry to17.34% thereby enhancing the production capacity.

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Table 4 comparison of conventional and leveraging machine learning Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry

Time (days)	Conventional Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry (%)	Leveraging machine learning Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry (%)
1	10	8.7
2	10	8.7
3	10	8.7
4	10	8.7
10	10	8.7

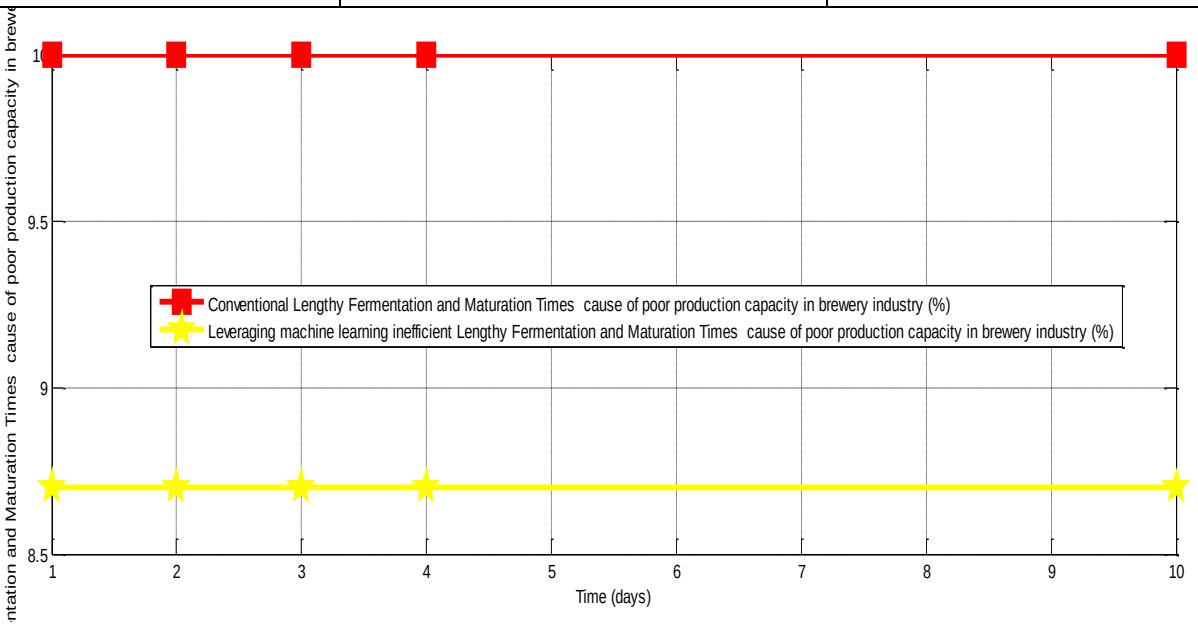

Figure 10.0: comparison of conventional and leveraging machine learning Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry

The conventional Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry was10%. Meanwhile, when leveraging machine learning was incorporated in the system, it decisively

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reduced Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry to 8.7%.

Table 5 comparison of conventional and leveraging machine learning production capacity in brewery industry

Time (days)	Conventional production capacity in brewery industry (bottles)	Leveraging machine learning production capacity in brewery industry (bottles)
1	50000	6 6500
2	50000	6 6,500
3	50000	6 6,500
4	50000	6 6,500
10	50000	6 6,500

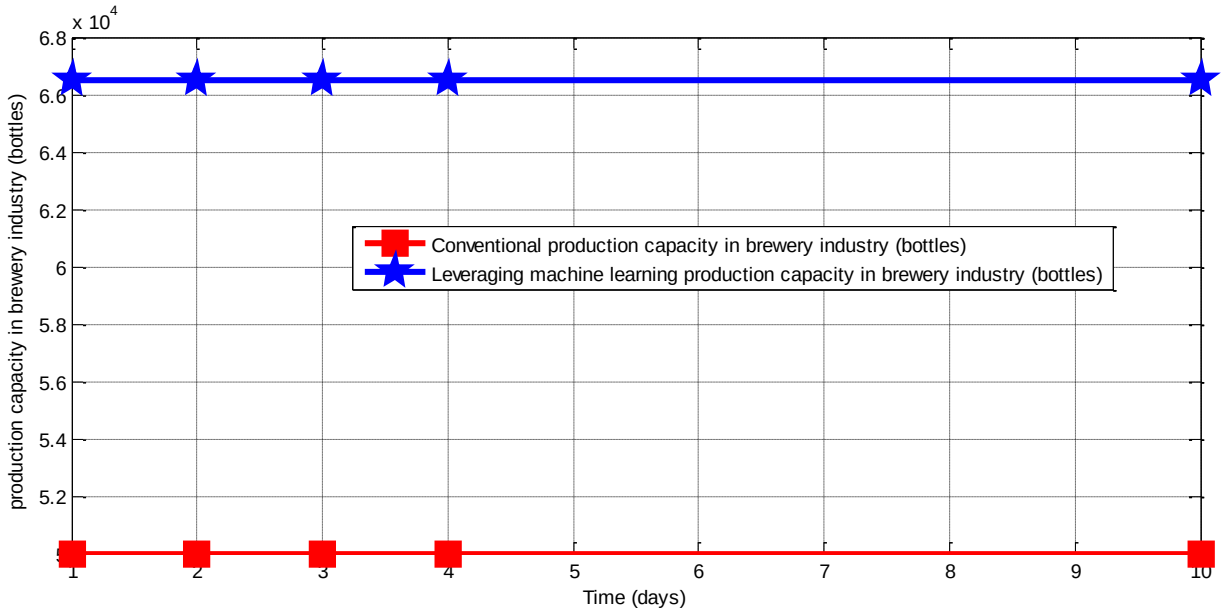

Fig 11 comparison of conventional and leveraging machine learning production capacity in brewery industry

The conventional production capacity in brewery industry was 50000bottles of drink. On the other hand, when leveraging machine learning was inculcated in the system, it simultaneously enhanced the production capacity in a brewery industry to6 6500 bottles of drink. Finally, with these results obtained, it showed that production capacity in a brewery industry was optimized by 33%.

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4.0 Conclusion

The consistent poor production capacity experienced in a brewery industry is anchored on these factors, inefficient Process Control and Automation, Equipment Downtime and Maintenance Issues, Variability in Raw Material Quality, Suboptimal Scheduling and Resource Allocation, Lengthy Fermentation and Maturation Times, Limited Data Utilization and Real-Time Analytics, Energy Constraints and Environmental Regulations, Labor Shortages and Skill Gaps coupled with Total Production Impact. This was overcame by introducing leveraging machine learning to optimize production processes and capacity in the brewery industry, to perfectly achieve this, it was done in the approach, characterizing and establishing the causes of poor production capacity in a brewery industry, designing a conventional SIMULINK model for production processes in the brewery industry, designing leverage machine learning rule base that will reduce the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity, training ANN in the designed machine learning rule base for effective reduction of the causes of poor production capacity in a brewery industry and simultaneously increase the production capacity, designing a SIMULINK model for leverage machine learning, developing an algorithm that will implement the process, designing a SIMULINK model for leveraging machine learning to optimize production processes and capacity in the brewery industry and validating and justifying the percentage improvement in the production capacity of a brewery industry with and without leveraging machine learning. The results obtained were, the conventional inefficient Process Control and Automation cause of poor production capacity in brewery industry was20%. On the other hand, when leveraging machine learning was introduced in the system, it drastically reduced inefficient Process Control and Automation cause of poor production capacity in brewery industry to17.34% thereby enhancing the production capacity, the conventional Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry was10%. Meanwhile, when leveraging machine learning was incorporated in the system, it decisively reduced Lengthy Fermentation and Maturation Times cause of poor production capacity in brewery industry to 8.7% and the conventional production capacity in brewery industry was 50000bottles of drink. On the other hand, when leveraging machine learning was inculcated in the system, it simultaneously enhanced the production capacity in a brewery industry to6 6500 bottles of drink. Finally, with these results obtained, it showed that production capacity in a brewery industry was optimized by 33%.

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