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Enhanced Precision of an Electro-pneumatic Actuator Based Robotic Bottle Capper for an Increased Output Using Fuzzy Controller

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ABSTRACT

The low production capacity of capped bottles of beer in a brewery industry is as a result of low precision experienced in electro pneumatic actuator based robotic bottle capper. This is surmounted by introducing enhanced precision of an electro pneumatic actuator based robotic bottle capper for an increased output using fuzzy controller. It is done in this way, characterizing an electro pneumatic actuator based robotic bottle capper, establishing low precision of an electro pneumatic actuator based robotic bottle capper at a reduced output from the characterized data, developing an electro pneumatic actuator based robotic bottle capper rule base to enhance precision at an increased output from the established data and designing a SIMULINK model for an enhanced precision of an electro pneumatic actuator based robotic bottle capper for an increased output using fuzzy controller. The results obtained are, the highest conventional precision in electro pneumatic actuator based robotic bottle capper is 94.4% while that when fuzzy controller is incorporated in the system is 97.32%. With these results obtained, it shows that the percentage improvement in electro pneumatic actuator based robotic bottle capper precision when fuzzy controller is imbibed in the system is 2.92%, the highest conventional quantity of crates of bottles an electro pneumatic actuator based robotic bottle capper could cap is 27000crates. On the other hand, the highest quantity of crates of bottles an electro pneumatic actuator based robotic bottle capper could cap is 27840crates when fuzzy controller is incorporated in the system. The percentage improvement in production capacity when fuzzy is inculcated in the system over the conventional method is 3.1% and the highest conventional number of bottles capped by electro pneumatic actuator based robotic bottle capper is 324000 bottles while that when fuzzy controller is injected in the system is 333900 bottles. With these results obtained, It shows that the percentage improvement in the production of capped bottles when fuzzy is incorporated in the system is better than the conventional method by 3.1%

Keywords: *Electro Pneumatic Actuator; Robotic Bottle Capper; Fuzzy Controller*

1. Introduction

Servo pneumatic actuators with force control are applied in the following fields: dynamic and static material test systems, spot-welding equipment, vehicle suspensions, manipulator grippers, physiotherapy and assembly robots, paint spraying systems, and others (Chiavervini and Sciavicco, 2012). Force or torque is a function of the load on the actuator. According to Belforte et al (2015), a pressure regulator is commonly used to control the pressure in a circuit and a pneumatic cylinder or motor converts this pressure into a corresponding force or torque. Also, a directional control valve can be used in certain instances. The force or torque can be sensed by a force cell, which is installed between the load and pneumatic cylinder rod (pneumatic motor shaft), or by a pressure transducer that measures the pressure in the actuator working chambers. The feedback signal from the sensor is analyzed by the control system, which controls the pressure regulators or control valves. As with a position and velocity circuit, the regulator or valve is actuated to achieve the desired pressure.

2. Methodology

To characterize an electro pneumatic actuator based robotic bottle capper.

Table 1 To characterize an electro pneumatic actuator system

DIMENSIONS OF A CAP	HEIGHT OF AN APPROPRIATE CAP	HEIGHT OF AN IN APPROPRIATE CAP	DIAMETER OF AN APPROPRIATE CAP	DIAMETER OF AN IN APPROPRIATE CAP
Height of a cap	8.5mm	9mm	26mm	29mm

To evaluate the circumference of an appropriate cap of a bottle
Circumference of a bottle cap = 2pir ----------1
Circumference an electro pneumatic actuator would cover to cork the precise cap of a bottle becomes
Circumference an electro pneumatic actuator would cover to cork the precise cap of a bottle = 2 x 3.142 x 26/2
Circumference an electro pneumatic actuator would cover to cork the precise cap of a bottle = 81.69mm
To evaluate the area an electro pneumatic actuator would cover to cork the precise cap of a bottle
Area an electro pneumatic actuator would cover to cork the precise cap of a bottle = pir^2
Area an electro pneumatic actuator would cover to cork the precise cap of a bottle = 3.142×13^2
Area an electro pneumatic actuator would cover to cork the precise cap of a bottle = 3.142 x 13 x 13
Area an electro pneumatic actuator would cover to cork the precise cap of a bottle = $531mm^2$
To evaluate the circumference of an inappropriate cap of a bottle
Circumference of an inappropriate cap of a bottle = 2pir
Circumference of an inappropriate cap of a bottle = 2 x 3.142 x 29/2
Circumference of an inappropriate cap of a bottle = 2 x 3.142 x 14.5
Circumference of an inappropriate cap of a bottle = 2 x 3.142 x 14.5
Circumference of an inappropriate cap of a bottle = 91.1mm
To evaluate the area an electro pneumatic actuator would cover to cork in appropriate cap of a bottle
The area an electro pneumatic actuator would cover to cork in appropriate cap of a bottle=pir^2----------.2
Area an electro pneumatic actuator would cover to cork in appropriate cap of a bottle = 3.142×14.5^2
Area an electro pneumatic actuator would cover to cork in appropriate cap of a bottle=$660.6mm^2$
To evaluate the percentage of precision in the circumference of corking a cap of a bottle
Circumference of an electro pneumatic actuator that would grip cork to have precise capping of the bottle = 81.69mm
Circumference of an inappropriate gripping the cap of a bottle = 91.1mm
% of precision in the circumference of corking a cap of a bottle =

$$\frac{\text{Circumference of inappropriate corking - Circumference of an appropriate corking}}{\text{Circumference of inappropriate corking}} \times \frac{100\%}{1}$$

$$\% \text{ of precision in the circumference of corking a cap of a bottle} = \frac{91.1mm - 81.69mm}{91.1mm} \times \frac{100\%}{1}$$

% of precision in the circumference of corking a cap of a bottle =

$$\frac{9.41mm}{91.1mm} \times \frac{100\%}{1}$$

% of precision in the circumference of corking a cap of a bottle = 9.9%
To evaluate the percentage of precision in the area of corking a cap of a bottle

Area an electro pneumatic actuator would cover to cork the precise cap of a bottle = 531mm^2
Area an electro pneumatic actuator would cover to cork in appropriate cap of a bottle=660.6mm^2
% of precision in the area of corking a cap of a bottle =

$$\frac{\text{Area of inappropriate corking - Area of appropriate corking}}{\text{Area of inappropriate corking}} \times \frac{100\%}{1}$$

$$\% \text{ of precision in the area of corking a cap of a bottle} = \frac{660.6mm^2 - 531mm^2}{660.6mm^2} \times \frac{100\%}{1}$$

$$\% \text{ of precision in the area of corking a cap of a bottle} = \frac{129.6mm^2}{660.6mm^2} \times \frac{100\%}{1}$$

% of precision in the area of corking a cap of a bottle = 19.6%

To evaluate the percentage of precision in the time of corking a cap of a bottle
1bottle of beer will be conventionally corked at a time of = 0.1333s
1bottle of beer will be corked at an optimized time of = 0.007515s
% of precision in the time of corking a cap of a bottle =

$$\frac{\text{Conventional corked time of a bottle – Optimized corked time of a bottle}}{\text{Conventional corked time of a bottle}} \times \frac{100\%}{1}$$

$$\% \text{ of precision in the time of corking a cap of a bottle} = \frac{0.1333s - 0.007515s}{0.1333s} \times \frac{100\%}{1}$$

% of precision in the time of corking a cap of a bottle = 94.4%

Table 2 Ama brewery beer production capacity data

SPEED REV/PM	NUMBER OF CRATES PRODUCED	TIME OF PRODUCTION (hr)
1350	27000	12

1 crate = 12 bottles
27000crates = 12 x 27000 = 324000 bottles
12hrs = 324000
324000 bottles = 43200seconds
1 bottle = 43200/324000
1bottle = 0.1333s
1000 bottles = 0.1333 x 1000
1000 bottles = 133.3s
1350rpm = 27000 crates = 324000bottles
324000 bottles = 1350rpm
1 bottle = 1350/324000
1 bottle = 0.004167rpm
1000bottles = 0.004167 x1000 = 4.166667rpm

Table 3 To establish low precision of an electro pneumatic actuator based robotic bottle capper at a reduced output from the characterized data.

PRECISION IN CAPPING A BOTTLE	NUMBER OF CRATES CAPPED	NUMBER OF BOTTLES CAPPED
94.4%	27000	324000

To develop an electro pneumatic actuator based robotic bottle capper rule base to enhance precision at an increased output from the established data.

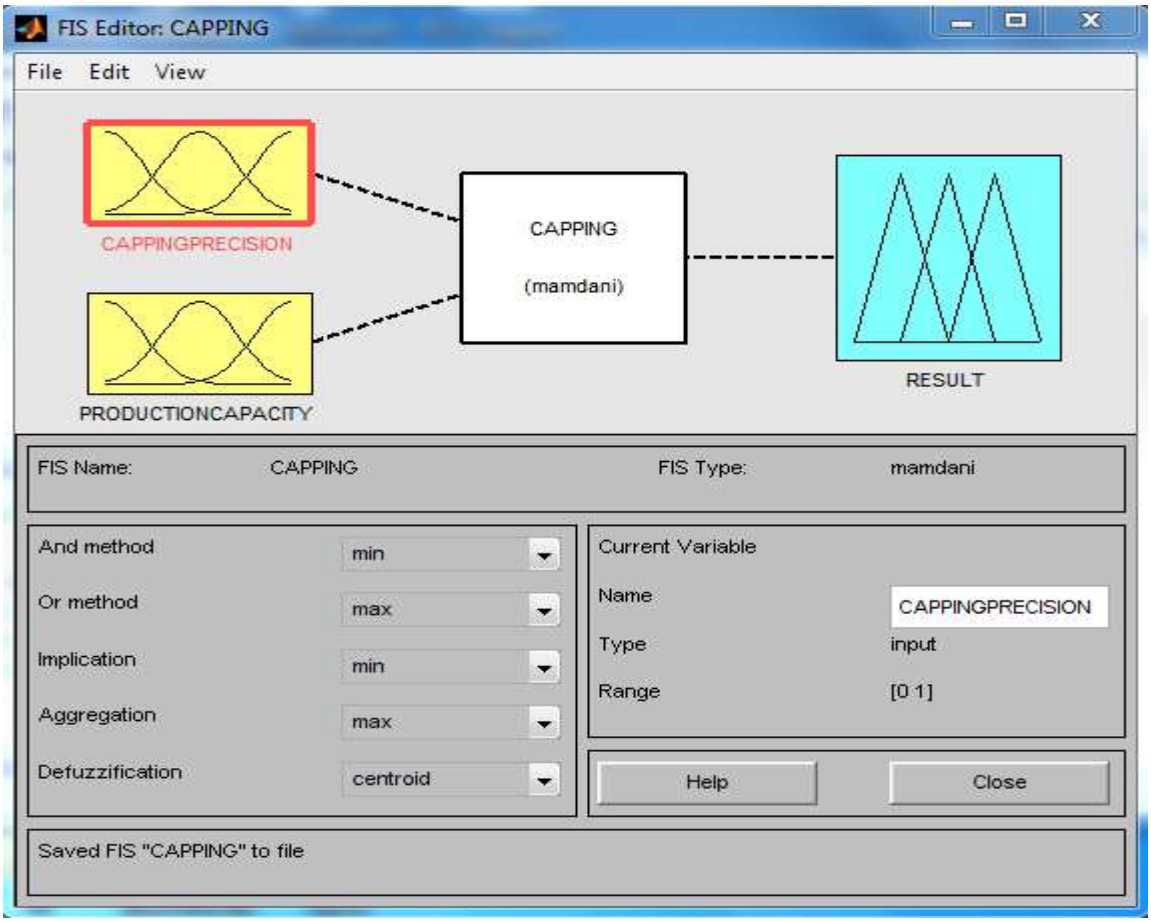

Fig 1 developed model predictive controller fuzzy inference system that will enhance the capping precision mechanism of an electro pneumatic actuator system

Fig 1 shows developed model predictive controller fuzzy inference system that will enhance the capping precision mechanism of an electro pneumatic actuator system. Fig 1 has two inputs of capping precision and production capacity. It also has an output of results.

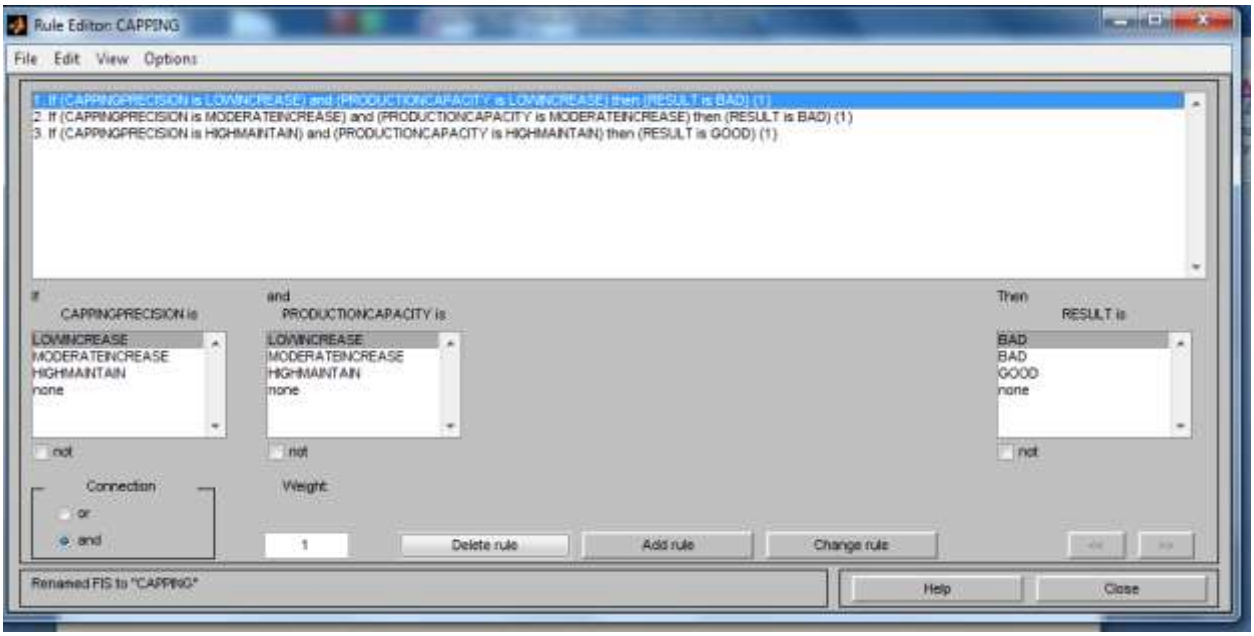

Fig 2 developed model predictive controller rule base that will enhance the capping precision mechanism of an electro pneumatic actuator system

In fig 2 the rules that enhances the efficacy of an electro pneumatic actuator system in its capping mechanism is detailed in table 1

Table 4 Detailed developed model predictive controller rule base that will enhance the capping precision mechanism of an electro pneumatic actuator system

1	**If capping precision is high increase**	**And production capacity is low increase**	**Then, result is bad**
2	If capping precision is moderate increase	And production capacity is moderate increase	Then, result is bad
3	If capping precision is high maintain	And production capacity is high maintain	Then, result is good

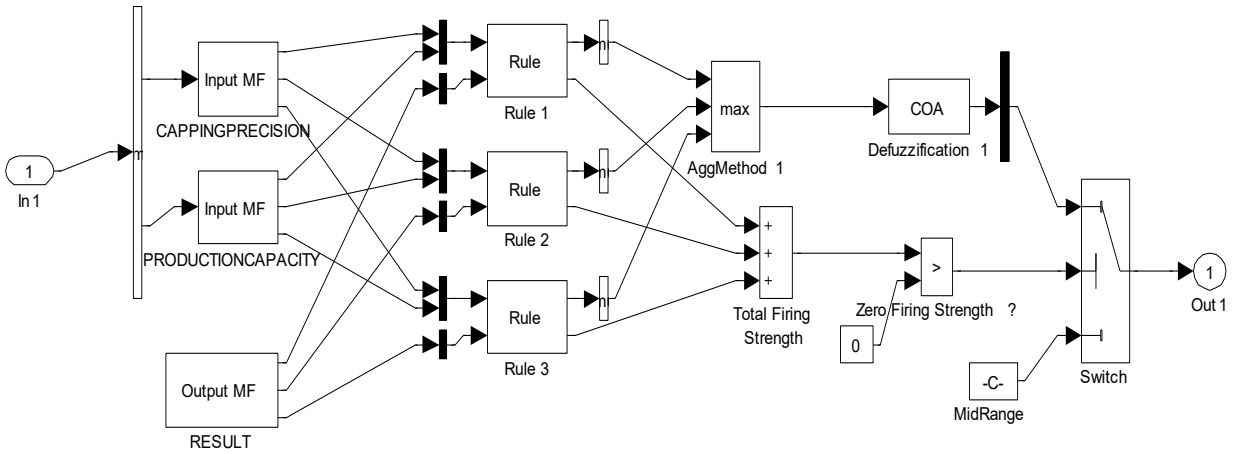

Fig 3 Simulated rule base that enhances the efficacy of the increase in precision of an electro pneumatic actuator based robotic bottle capper for an increased output

To design a SIMULINK model for an enhanced precision of an electro pneumatic actuator based robotic bottle capper for an increased output using fuzzy controller

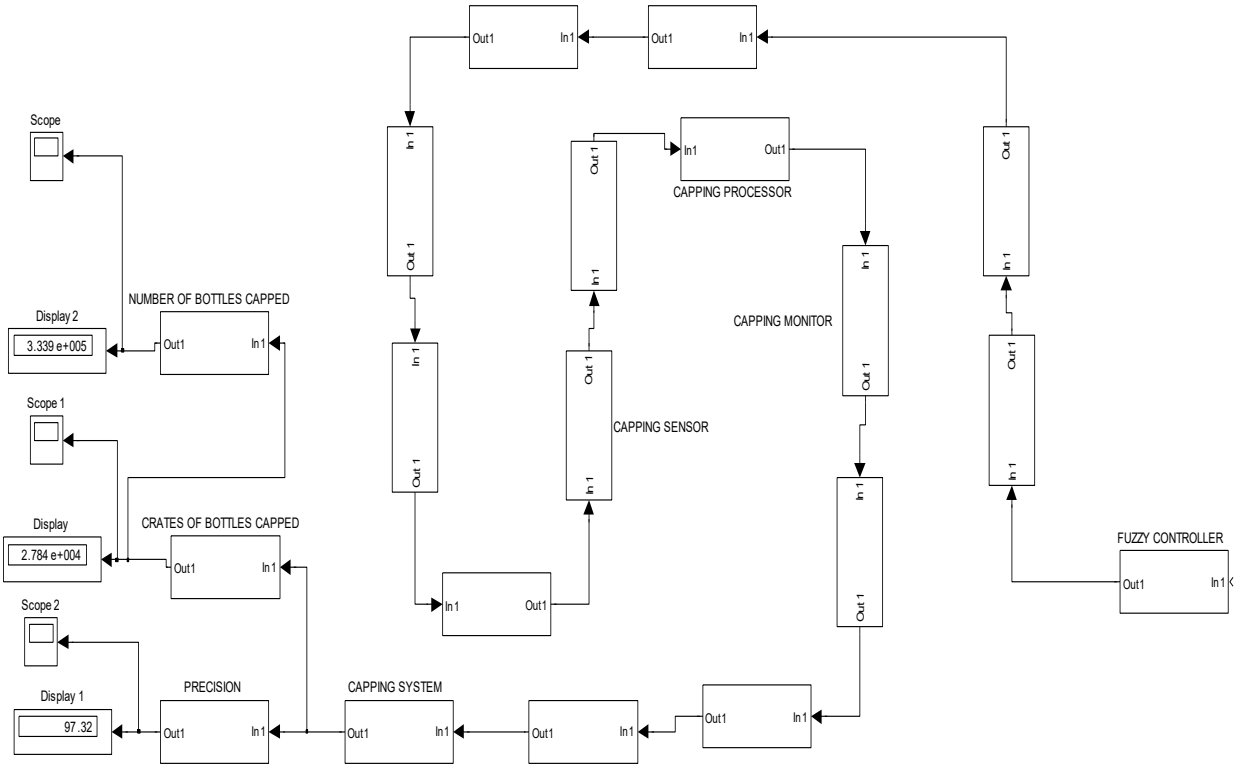

Fig 4 designed SIMULINK model for an enhanced precision of an electro pneumatic actuator based robotic bottle capper for an increased output using fuzzy controller.

The results obtained after simulation are as shown in figures 5, 6 and 7.

2.0 Discussion of Result

Table 5 Comparing conventional and fuzzy controller precision in electro pneumatic actuator based robotic bottle capper

Time (s)	*Conventional precision in electro pneumatic actuator based robotic bottle capper(%)*	*Fuzzy controller precision in electro pneumatic actuator based robotic bottle capper(%)*
0	0	0
1	60	61
2	80	82
3	90	91
4	94.4	97.32
10	94.4	97.32

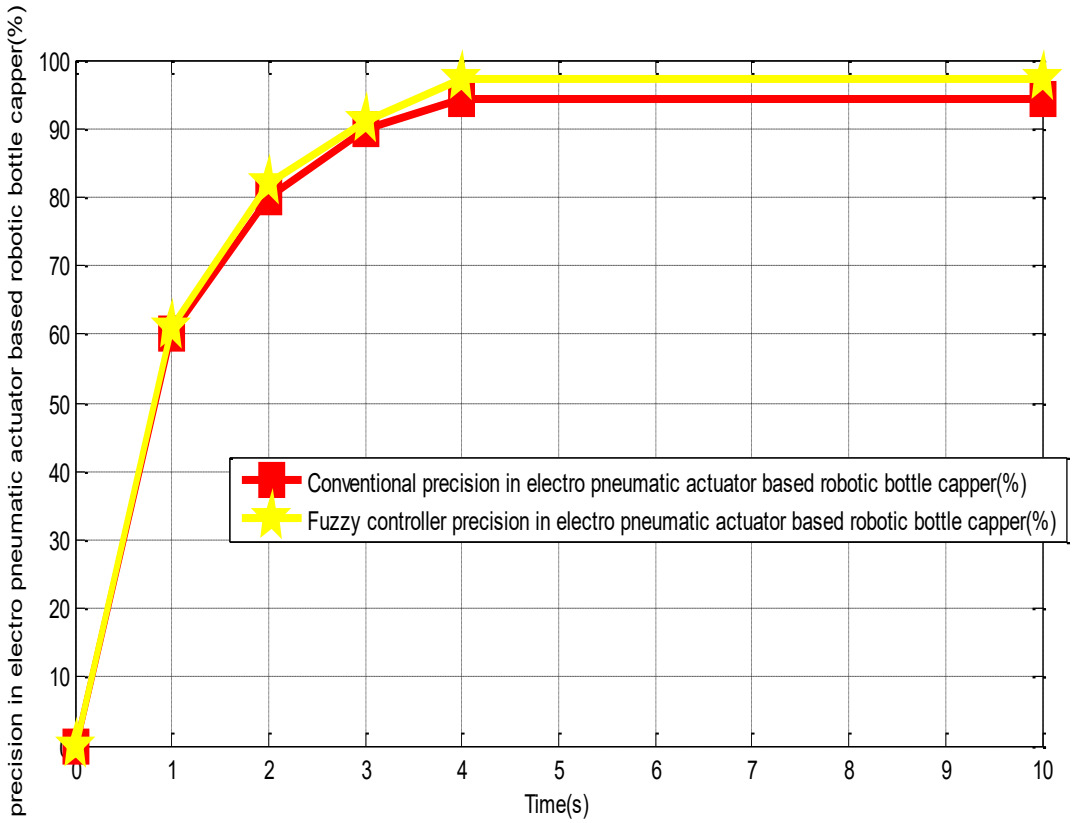

Fig 5 Comparing conventional and fuzzy controller precision in electro pneumatic actuator based robotic bottle capper. The highest conventional precision in electro pneumatic actuator based robotic bottle capper is 94.4% while that when fuzzy controller is incorporated in the system is 97.32%. With these results obtained, it shows that the percentage improvement in electro pneumatic actuator based robotic bottle capper precision when fuzzy controller is imbibed in the system is 2.92%

Table 6 Comparing conventional and fuzzy controller number of crates capped by electro pneumatic actuator based robotic bottle capper

Time (s)	*Conventional number of crates capped by electro pneumatic actuator based robotic bottle capper(Number)*	*Fuzzy controller number of crates capped by electro pneumatic actuator based robotic bottle capper(Number)*
0	0	0
1	17000	18000
2	23000	24000
3	26000	27000
4	27000	27840
10	27000	27840

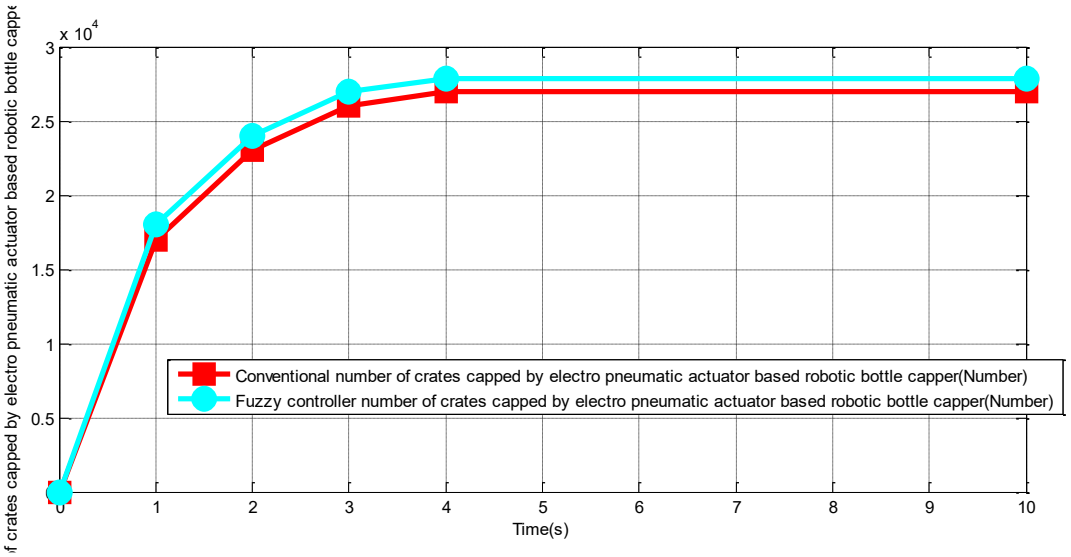

Fig 6 Comparing conventional and fuzzy controller number of crates capped by electro pneumatic actuator based robotic bottle capper

In figure 6 the highest conventional quantity of crates of bottles an electro pneumatic actuator based robotic bottle capper could cap is 27000crates. On the other hand, the highest quantity of crates of bottles an electro pneumatic actuator based robotic bottle capper could cap is 27840crates when fuzzy controller is incorporated in the system. The percentage improvement in production capacity when fuzzy is inculcated in the system over the conventional method is 3.1%

Table 7 Comparing conventional and fuzzy controller number of bottles capped by electro pneumatic actuator based robotic bottle capper

Time (s)	*Conventional number of bottles capped by electro pneumatic actuator based robotic bottle capper (Number)*	*Fuzzy controller number of bottles capped by electro pneumatic actuator based robotic bottle capper (Number)*
0	0	0
1	80000	100000
2	180000	200000
3	260000	260000
4	324000	333900
10	324000	333900

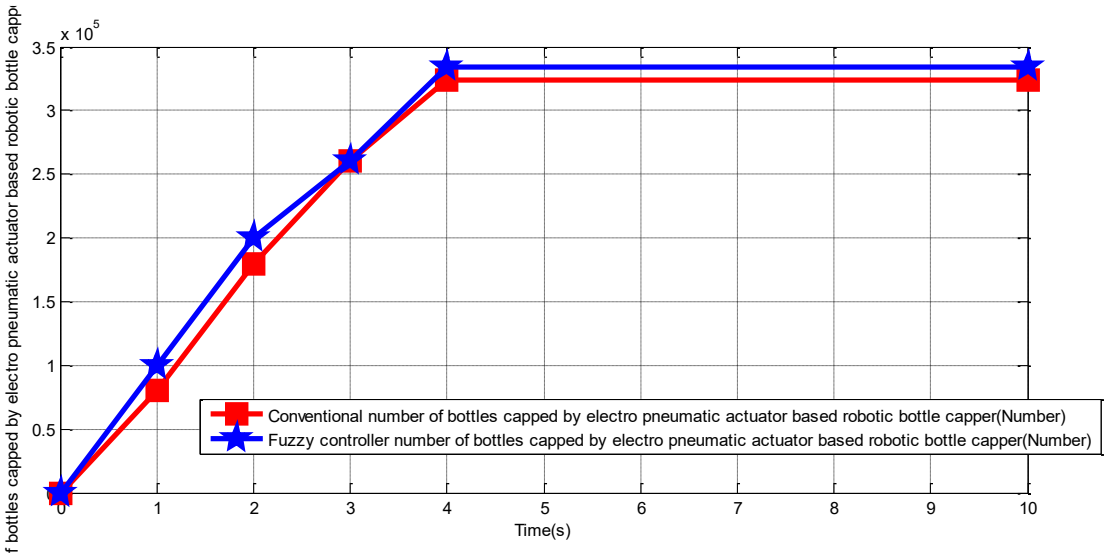

Fig 7 Comparing conventional and fuzzy controller number of bottles capped by electro pneumatic actuator based robotic bottle capper.

In fig 7 the highest conventional number of bottles capped by electro pneumatic actuator based robotic bottle capper is 324000 bottles while that when fuzzy controller is injected in the system is 333900 bottles. With these results obtained, it shows that the percentage improvement in the production of capped bottles when fuzzy is incorporated in the system is better than the conventional method by 3.1%

4.0 Conclusion

The low production capacity of capped bottles of drinks in the brewery industry is as a result of low precision of an electro pneumatic actuator based robotic bottle capper. This is resolved by introducing enhanced precision of an electro pneumatic actuator based robotic bottle capper for an increased output using fuzzy controller. To achieve this, it is done in this procedure, characterizing an electro pneumatic actuator based robotic bottle capper, establishing low precision of an electro pneumatic actuator based robotic bottle capper at a reduced output from the characterized data, developing an electro pneumatic actuator based robotic bottle capper rule base to enhance precision at an increased output from the 1 3.1% and the highest conventional number of bottles capped by electro pneumatic actuator based robotic bottle capper is 324000 bottles while that when fuzzy controller is injected in the system is 333900 bottles. With these results obtained, it shows that the percentage improvement in the production of capped bottles when fuzzy is incorporated in the system is better than the conventional method by 3.1%

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