A NEW APPROACH OF SYRUP MANUFACTURING USING FUZZY TIME CONTROL DISCRETE EVENT SYSTEM

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ABSTRACT

Pharmaceutical industries of the world are manufacturing their most of the goods in syrup form. The proposed study relates with the designing of medicated syrup manufacturing, using the fuzzy time control discrete event system. The system is designed with three inputs; viscosity, specific gravity, and chemical selection. And eight outputs temperature, temperature time, mixing speed, mixing time, valve, valve opening time, PH at current liquid temperature, and PH time. System is controlled by controlling the four parameters; valve selection, temperature monitoring unit, mixing motor, and PH control unit. System takes feed back from four sensors and time control rules are formulated and simulated using MATLAB tool box..

KEYWORDS: *Fuzzy time control, Discrete event, Syrup manufacturing, MATLAB simulaiton*

1. INTRODUCTION

Syrup is the aqueous pharmaceutical preparation having the concentrated sugar solution with active and non-active ingredients. These preparations are manufactured by pharmaceutical industries following the standards of British and European pharmacopoeias in the whole world. The syrup solutions are characterized by parameters temperature, specific gravity, pH, and viscous consistency. [1-4] the proposed syrup manufacturing model is designed by using fuzzy time control discrete event system in which output variables are time dependent and discussed with non probabilistic uncertainty issues [5] and controller work on heuristic knowledge [6] controller operate the plant ON or OFF for a specific period of time. Design system has flexibility to easily adjust the input and output parameters according to the mixture requirement.

2. COMPARISION OF FUZZY LOGIC CONTROL WITH FUZZY TIME CONTROL DISCRETE EVENT SYSTEM

Numerous systems are designed using “fuzzy logic controls” (FLC) these systems are much better than conventional control system due to their simplicity in calculations and better performance. Fuzzy logic controls systems are based on heuristic knowledge, these systems takes numeric input and gives numeric output but the controller work on words. FLC are superior in their design and performance but did not take time into account. Time independency is their draw back.

It is desired to design a system which discusses the time control issues of the digital control system for which the output states are used to activate the plant ON or OFF for a specific period of time. The new designed fuzzy time control discrete event system fulfill the local and distributive requirements which is

modified form of fuzzy logic controls system. Fuzzy time control discrete event system is the combination of the fuzzy time control system and discrete event system and discusses the nonprobabilistic uncertainty issues [2].

Fig.1. Block diagram of fuzzy logic control system

This system contains a Fuzzifier, inference engine; rule of them, defuzzifiers, and discrete event system

Fig.2. block diagram of fuzzy time control discrete event system

Three inputs; viscosity, specific gravity, and chemical selection are used for the designed syrup manufacturing system.

Three numeric input values are given to three Fuzzifiers. After receiving numeric values of inputs these Fuzzifiers convert them into linguistic variables. These linguistic variables are then given to inference engine where the max-min composition is applied and gives eight values of R's. Knowledge base provides eight singleton values according to the fuzzy rules designed for the proposed syrup manufacturing system after getting the crisp values. Defuzzifiers get eight values from inference engine and eight from knowledge base at its input and give the eight crisp values at its output. Here eight defuzzifiers are used, four for output variable; temperature, mixing speed, PH, valve selection and four for output time; temperature time, mixing time valve opening time, and PH time [7]. The values of out variables are converted into binary codes using analog to digital converter (ADC) and decoder and crisp values of output time; temperature time, mixing time valve opening time, and PH time are provided to the pulse strobe units which provides the time pulses. These time pulses allow the binary codes to pass for a specific period of time. Then these binary codes are used to make active discrete event system under time constrain [8].

Fig.3. Syrup manufacturing fuzzy time control discrete event system.

3. DESIGN ALGROTHEM

The syrup manufacturing system is designed with three inputs viscosity specific gravity and chemical selection and eight outputs temperature, temperature time, valve, valve opening time, PH at current liquid temperature, PH time, mixing speed, mixing time, each input plot contains six membership functions and five regions the name of membership functions And their ranges are shown in Table 1.

TABLE-1 INPUT MF AND THEIR RANGES

NO	Membership Function	Viscosity dyn-s/cm ²	Specific Gravity Mg/ml	Chemical selection
1	Very small	0-1	0-1	0-10
2	Small	0-2	0-2	0-20
3	Medium	1-3	1-3	10-30
4	Above medium	2-4	2-4	20-40
5	High	3-5	3-5	30-50
6	Very high	4-5	4-5	40-50

In response of chemical selection valve are open, installed at the feed lines for material constituents flow. Plot of input membership functions (MF). For viscosity is shown in the figure-4 there are six membership functions F1[1], F1[2], F1[3], F1[4], F1[5], F1[6] and five regions.

Plot of input MF viscosity contains six MF, s F2[1], F2[2], F2[3], F2[4], F2[5], F2[6] and five regions input numeric value of viscosity lies in any one of the five region.

Plot of input MF chemical selection contains six MF,s F3[1] F3[2], F3[3], F3[4], F3[5], F3[6] and five regions.

Plot of output MF are shown in figure-7 for the convenience in calculation the range values of output membership function for mixing speed, mixing time, valve selection, valve opening time, PH at given temperature, PH time, Temperature, Temperature time are

taken same, plot contains five output MF's and four regions.

Fig.4. Input MF function specific gravity plot

Fig.5. Input MF plot for viscosity

Figure 6 Input MF plot of chemical selection

Fig.7. Output MF plot

Output membership functions and their ranges are listed in the table-2.

To verify the design model of syrup manufacturing the input fuzzy variable value are taken; viscosity=1.4, specific gravity=1.7 and chemical selection=16 this value of viscosity lies in the first half of second region and maps with the fuzzy variable medium and small, medium is taken as F1[3] and small is taken as F1[2] the value of specific gravity lies in the second half of the second region and maps with the fuzzy variable medium and small, medium is taken as F2[3], F2[2]. Selected value of chemical selection lies in the

send half of second region and maps with the fuzzy variable medium and small, medium is taken as F3[3], F3[2]. Fuzzifier result for this model are shown in table-3. Inference engine take values from the Fuzzifier and apply min-max composition and gives the eight values; R1, R2, R3, R4, R5, R6, R7, and R8.

$$\begin{aligned} R1 &= F1[3] \wedge F2[3] \wedge F3[3] = 0.4 \wedge 0.3 \wedge 0.4 = 0.3 \\ R2 &= F1[2] \wedge F2[3] \wedge F3[3] = 0.6 \wedge 0.3 \wedge 0.4 = 0.3 \\ R3 &= F1[3] \wedge F2[2] \wedge F3[3] = 0.4 \wedge 0.7 \wedge 0.4 = 0.4 \\ R4 &= F1[2] \wedge F2[2] \wedge F3[3] = 0.6 \wedge 0.7 \wedge 0.4 = 0.4 \\ R5 &= F1[3] \wedge F2[3] \wedge F3[2] = 0.4 \wedge 0.3 \wedge 0.6 = 0.3 \\ R6 &= F1[2] \wedge F2[3] \wedge F3[2] = 0.6 \wedge 0.3 \wedge 0.6 = 0.3 \end{aligned}$$

$$R7 = F1[3] \wedge F2[2] \wedge F3[2] = 0.4 \wedge 0.7 \wedge 0.6 = 0.4$$

$$R8 = F1[2] \wedge F2[2] \wedge F3[2] = 0.6 \wedge 0.7 \wedge 0.6 = 0.6$$

In the output MF plot there are two overlapping regions and system takes three inputs so there are eight rules are design for this system [9] which are listed in the table-4, these rules were designed by collecting the data from different syrup manufacturing industries. Singleton values obtained from knowledge base for applied rule are listed in table-5, which are basically the normalised values obtained from the output membership function plot.

TABLE 2: OUTPUT MEMBERSHIP FUNCTIONS AND THEIR RANGES.

Membership Function	Range	Temperature	Temperature Time	PH	PH time	value	Valve Opening time	Mixing speed	Mixing Time
MF1	0-5	Off	None	Small	None	None	None	Stop	None
MF2	0-40	Low	Small	Normal	Small	Few	Small	Slow	Small
MF3	40-60	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
MF4	60-80	High	Long	High	Long	Large	Long	Fast	Long
MF5	80-100	Very-high	Very-long	Very High	Very-long	Very large	Very-long	Very fest	Very-long

TABLE 3: RESULT OF FUZZIFIER CALCULATION

Input Variable	Value of input	Region	Fuzzy set Calculation
Viscosity	1.4	2 nd	$F_1[3]=0.4$ $F_1[2]=1-F_1[3]$ $=0.6$
Specific Gravity	1.7	2 nd	$F_2[3]=0.3$ $F_2[2]=1-F_2[3]$ $=0.7$
Chemical Selection	17	2 nd	$F_3[3]=0.4$ $F_3[2]=1-F_3[3]$ $=0.6$

TABLE 4: DESIGN RULES FOR SYSTEM

no	viscosity	specific gravity	chemical selected	tem.	tem. time	mixing speed	mixing time	valve	valve opening time	ph	ph time
1	small	small	medium	low	long	fast	long	few	long	medium	long
2	medium	small	medium	low	medium	fast	medium	few	medium	normal	medium
3	small	medium	medium	medium	long	very fast	long	few	long	medium	long
4	memium	medium	medium	medium	medium	very fast	medium	few	medium	normal	medium
5	small	small	small	low	long	fast	long	medium	long	medium	long
6	medium	small	small	low	medium	fast	medium	medium	medium	normal	medium
7	small	medium	small	medium	long	very fast	long	medium	long	medium	long
8	medium	medium	small	medium	medium	very fast	medium	medium	medium	normal	medium

TABLE 5: SINGLETON VALUES

Singleton Value	Tem.	Tem. Time	Mixing speed	Mixing Time	PH	PH time	valve	Valve Opening Time
S ₁	0.3	0.7	0.7	0.7	0.5	0.7	0.3	0.7
S ₂	0.3	0.5	0.7	0.5	0.3	0.5	0.3	0.5
S ₃	0.5	0.7	1	0.7	0.5	0.7	0.3	0.7
S ₄	0.5	0.5	1	0.5	0.3	0.5	0.3	0.5
S ₅	0.3	0.7	0.7	0.7	0.5	0.7	0.5	0.7
S ₆	0.3	0.5	0.7	0.5	0.3	0.5	0.5	0.5
S ₇	0.5	0.7	1	0.7	0.5	0.7	0.5	0.7
S ₈	0.5	0.5	1	0.5	0.3	0.5	0.5	0.5

Rule base block for the design model of syrup manufacturing system contains lookup table, it consists of rules which are design for model. Three comparators, three detectors and three decoders, these detectors and decoders tell about the region maps by the input variable and response of fuzzy set to these variable. Comparator takes information's from detectors and decoders and gives the singleton values. As shown in figure-3.18

Fig.8. Arrangement of rule base to get singleton values for syrup manufacturing system.

Output crisp values are obtained by defuzzification. There are many methods used for defuzzification e.g. (MOM) mean of maximum. (SOM) smallest of maximum. (LOM) left of maximum etc.

The method use in this paper for defuzzification is (COA) center of average. Whose mathematical form is

$$\sum_i S_i * R_i / \sum_i R_i$$

Where $i = 1, 2, 3, 4, 5, 6, 7, 8$

This system takes sixteen inputs to each defuzzifier eight from inference engine i.e. R1, R2, R3, R4, R5, R6, R7, R8 and eight from the rule base i.e. S1, S2, S3, S4, S5, S6, S7, S8 and gives the crisp value of outputs. MATLAB simulation result for this system are shown in the figure-9 below:

Fig.9. MATLAB simulation rule viewer

Table-6 shows the output defuzzified values for temperature, temperature time, mixing speed, mixing time, valve, valve opening time, PH at current liquid temperature, and PH time.

From MATLAB simulation and also the defuzzified values from manual calculation corresponding to the input variable viscosity=1.4, specific gravity=1.7 and chemical selected =16.

TABLE 6: MATLAB SIMULATION RESULTS

	Tem.	Tem.Time	MixingSpeed	MixingTime	PH	PHTime	Valve	Valve Opening Time
MATLAB Simulation	40.3	61.4	84.4	61.4	34	61.4	31.1	61.4
Manual Calculated Values	42	59.8	86	59.8	36	59.8	34	59.8

4. RESULTS AND DISCUSSION

MATLAB simulation results for the proposed syrup manufacturing model are shown in figure 10. Figure 10 (a) Shows that temperature depends on viscosity and does not depend on specific gravity.

Fig.10. (a) Plot between specific gravity viscosity and temperature

Figure 10 (b) shows that cooling/ heating time does not depend on specific gravity it depend on the viscosity.

Fig.10. (b) plot between specific gravity, viscosity and temperature time

Figure 10 (c) Shows that mixing speed does not depend on viscosity depends on specific gravity.

Fig.10. (c) Plot between specific gravity, viscosity and mixing speed

Figure 10 (d) Shows that rotating time depend on viscosity it does not depend on specific gravity.

Fig.10. (d) Plot between specific gravity, viscosity and mixing time

Figure 10 (e) Shows that valve opening does not depend on the viscosity of the syrup it depends on specific gravity.

Fig.10. (e) Plot between specific gravity, viscosity and valve opening

Figure 10 (f) Shows that PH does not depend on viscosity it depends on specific gravity.

Fig.10. (f) plot between specific gravity, viscosity and the syrup PH

Figure 10 (g) shows that the temperature does not depend on the viscosity and chemical selection.

Fig.10. (g) Plot between viscosity chemical selection and temperature

Figure 10 (h) Shows that mixing speed depends on the specific gravity of the liquid.

Fig.10. (h) Plot between chemical selection, specific gravity and mixing speed

Figure 10 (i) Shows that PH of syrup depends on specific gravity it does not depend on chemical selection.

Fig.10. (i) Plot between chemical selection, specific gravity and PH

5. CONCLUSION

Proposed syrup manufacturing model is an industrial application of fuzzy time control discrete event system. Design model is very efficient and simple in their performance and has flexibility to adjust the input and output parameters easily according to the syrup requirement. Design model provides the satisfactory defuzzified values from MATLAB simulation. Proposed syrup manufacturing model provides stable state of syrup in small interval of time.

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طريقة جديدة لتصنيع أدوية الشرب باستخدام نظام التحكم المبهم في الوقت ذو مرات الحدوث المحددة

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الملخص:

تقوم صناعة الدواء في العالم بتصنيع معظم أدويتها على هيئة دواء شرب. الدراسة المقترحة تتعلق بتصميم تصنيع شراب دوائي باستخدام نظام التحكم المبهم في الوقت ذو مرات الحدوث المحددة. تم تصميم النظام بثلاث مدخلات وهي اللزوجة، الجاذبية النوعية والنوع الكيميائي، والنظام له ثمانية مخرجات وهي: درجة الحرارة، زمن درجة الحرارة، سرعة الخلط، زمن الخلط، الصمام، زمن فتح الصمام، زمن الـ PH وقيمة الـ PH عند درجة حرارة السائل الحالية. يتم التحكم في النظام من خلال التحكم في الاربعة التالية: اختيار الصمام، وحدة مراقبة درجة الحرارة، موتور الخلط، ووحدة التحكم في نسبة الـ PH. يتم تغذية النظام عكسياً من خلال اربعة مستشعرات وقاعدة التحكم في الزمن، وتم استخدام برمجيات MATLAB في عمل محاكاة لهذا النظام.