A Fuzzy logic Approach for Continuous Co-polymerization Reactor Control Problem

Lalit G. Patil[1*]& Dr.Jagrut Gadit[2]

[1] *Teaching Assistant, Department of Electrical Engineering, The Maharaja Sayajirao University of Baroda, Gujarat, India*

[2] *Associate Professor, Department of Electrical Engineering, The Maharaja Sayajirao University of Baroda, Gujarat, India*

*[*2] lalit.gecgnr@gmail.com*

Abstract:

Most industrial applications of modelling and control relay on intuition, sound engineering judgment and past experience, and heuristic procedures. Here i have discussed the problem in modelling and control of polymerization reactors. There are considerable difficulties in modelling of emulsion polymerization reactors and non-availability of robust online measurement techniques for critical properties of the product. Quality control is interpreted as proper recipe formulation, optimal initial conditions selection, and adhoc operation based on experience.

Temperature, Pressures and flow rates of the process are considered as controlled variables for closed loop control system design. Vague control and measurement objectives, difficult sampling, discrete sensor output, large dead times and sampling difficulty in controlling polymerization reactors. An operator of polymerization reactors is able to control the processes based on his/her experience, without a mathematical model. Hence, one way to handle the control problem is to develop a controller based on operator knowledge. The process operator thinks and acts according to linguistic quantities like 'high', 'medium', 'low' etc. The theory of fuzzy sets developed helps in enable us to mathematically describe and handle these linguistic expressions. A FLC based on fuzzy logic provides a mean of converting a linguistic control strategy based on an operation knowledge into an automatic control strategy.

For Referring this Paper:

Lalit G. PatilandDr. Jagrut Gadit(2014), A Fuzzy Logic Approach for Continuous Co-polymerization Reactor Control Problem, *International Journal of Research (IJR*), Volume-1, Issue-4. Page757-762. ISSN 2348-6848.

Keywords:

Fuzzy Logic Controller; Fuzzy Rules; Crisp; Control Problem; Fuzzification; MATLAB

Introduction

There are the five stages in designing a FLC is shown at below with continuous co-polymerization reactor control problem. Associated with each input is a linguistic variable. Each linguistic variable may take a number of possible values. Each value is represented by a fuzzy set. In continuous stirred tank co-polymerization reactor, we have to control the mole fraction of monomer in the co-polymer(c) and reactor temperature (T) using the flow rate of feed monomer (F). The ranges are assumed to be

0.56-0.64 for C and 76-80 for T and 16-20kg/h for F respectively. We have taken the labels 'CLow', 'CMedium' and 'CLarge' associated with the linguistic variable (C) and the fuzzy set 'TLow', 'TMedium' and 'THigh' associated with the linguistic variable temperature and the fuzzy set 'FLow', 'FMedium' and 'FHigh' with the flow rate of active monomer.

Proposed Algorithm

A standard form of function for all the relevant numbers can be chosen from the programming point of view. A triangular membership function is widely used membership function. The fuzzy numbers associated with this type of functions are referred to as triangular fuzzy numbers. The main advantage of this type of fuzzy numbers is that it can be completely defined by three values (a,b,c). 'a' represents the extreme left of the fuzzy number range while its grade of membership is zero. Value c represents the extreme right of the range and its grade of membership is again zero. Point b is apex in the triangular membership where the grade of membership is unity.

All the points in ranges a-b and b-c have grades of membership (ϒ) defined by the relations:

ϒ = 0 ;x ≤ a

ϒ = (x-a) / (b-c) ;a ≤ x ≤ b

ϒ = (c-x) / (c-b) ;b ≤ x ≤ c

ϒ = 0 ;x ≥ c

Where x is a non-fuzzy numerical value and **ϒ**is the grade of membership of the fuzzy set.

Triangular membership function for each fuzzy set is assumed here. The values of a, b and c of the membership for each fuzzy set is assumed to be as follows.

For composition

CLOW : [0.56 0.58 0.60]

CMEDIUM : [0.58 0.60 0.62]

CHIGH : [0.60 0.62 0.64]

For Temperature

TLOW : [76 77 78]

TMEDIUM : [77 78 79]

THIGH : [78 79 80]

For Composition

FLOW : [16 17 18]

FMEDIUM : [17 18 19]

FHIGH : [18 19 20]

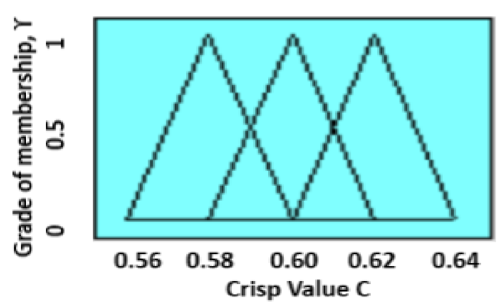

Fig. 1 Fuzzy relation for composition C

The fuzzy controller design procedure consists of the following steps:

1. Specify the ranges of manipulated and controlled variables.

2. Deducing the linguistic labels that can be used to describe these variables and specifying the appropriate ranges of applicability of each label, along with the fuzzy sets.

3.Selecting the type of membership function and the parameter in that function for the manipulated variables and the output variables.

4. Determining the rules that will relate the linguistic labels of controlled variables to that of the manipulated variables. The execution of these rules gives the fuzzy output.

5.Selecting a suitable defuzzification algorithm to calculate the non-fuzzy value for the manipulated variables to be implemented in the process.

Input acquisition:

Let the input for the composition C and temperature T are read from the sensors as

Composition C = 0.584

Temperature T = 81.5C

Irrespective of the inference and defuzzification method sued, the first stage evaluates the grade of membership for each of the terms, using the corresponding values of a,b and c, we get the grade of membership for the composition C

ϒ CLow(0.584) = 0.70

ϒCMedium(0.584) = 0.20

ϒCHigh(0.584) = 0.0

Similarly,We get the grade of membership for the temperature T as

ϒ TLow(81.5) = 0.0

ϒTMedium(81.5) = 0.75

ϒTHigh(81.5) = 0.25

Rule evaluation :

Let we make seven rules, and the result of each rule gives the grade of membership for output F and the corresponding fuzzy set. We execute these rules,

Rule 1: If (C is CLow) and (T is TLow) then (F is FHigh)

ϒFHigh is given by min{0.7,0.0} = 0.0

Rule 2: If (C is CLow) and (T is TMedium) then (F is FMedium)

ϒFMedium is given by min{0.70,0.75} = 0.70

Rule 3: If (C is CLow) and (T is THigh) then (F is FMedium)

ϒFMedium is given by min{0.7,0.25} = 0.25

Rule 4: If (C is CMedium) and (T is TLow) then (F is FMedium)

ϒFMedium is given by min{0.20,0.0} = 0.0

Rule 5: If (C is CMedium) and (T is TMedium) then (F is FMedium)

ϒFMedium is given by min{0.20,0.75} = 0.20

Rule 6: If (C is CMedium) and (T is THigh) then (F is FLow)

ϒFLow is given by min{0.20,0.25} = 0.20

Rule 7: If (C is CHigh) and (T is THigh) then (F is FLow)

ϒFLow is given by min{0.0,0.25} = 0.25

A quick review of the rule membership reveal that Rule No.2 has the highest membership grade (0.7) and Rules No. 1 and 4 have the lowest membership grade (0.0).

MATLAB Implementation

The following shows the fuzzy rules, relating fuzzy sets C and T to fuzzy set F.

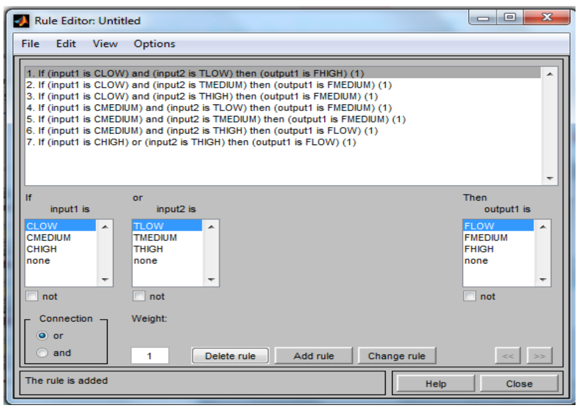

Fig. 2 Fuzzy rules for control problem

Inference and Defuzzification

In this two Rule No. 6 and 7, prescribe the 'FLow' output. There are four Rule No.2,3,4 and 5, which prescribe the output to be 'Medium' and the only Rule No. 1 which prescribes the output to be 'High'. Since the rules are considered to be combined in the rule base by OR operation, the membership grade associated with each output term obtained by identifying the rule which prescribes that output term with maximum membership grade. The membership grade for each output term is computed as below:

Output term	Rules (Ri)	Membership grade for (F)
Low	6,7	max{0.2,0.25} = 0.25
Medium	2,3,4,5	max{0.7,0.25,0.0,0.2}= 0.7
High	1	0

Table. 1 Inference of fuzzy rules

Results

The Defuzzified output for F is obtained by using fuzzy mean method as

$$\text{Crisp output of F} = \frac{\sum[(F)i\ \Upsilon i]}{\sum \Upsilon i}$$

Where (F)I = [(a+c)/2]

{'a' and 'c'} of that particular fuzzy set given in table and Ϋi is the grade of membership given in table.

Defuzzifiedoutput

$$\mathbf{F} = \frac{\left(0.25\left[\frac{(16+18)}{2}\right] + 0.70\left[\frac{(17+19)}{2}\right] + 0.0\left[\frac{(18+20)}{2}\right]\right)}{(0.0 + 0.70 + 0.25)}$$

F = 37.74

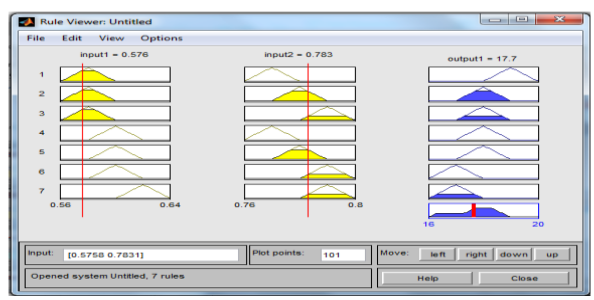

Fig. 3 Fuzzy rule viewer for Control problem

Conclusion

From the above mentioned problem and using MATLAB we can conclude that we observed the Increased robustness for polymerization reactors. Few rule are encompassing great complexity. FLC is rule oriented, the order of rules is arbitrary that is the important advantage due to uncertainty of inputs. FLC is tolerant to redundant or contradictory rules. This method can be easily extended to multi-input multi-output systems for the same problem of reactors.

REFERENCES

1. V.G.Nyttle, M.Chidambaram, Fuzzy logic control of a fed-batch fermentor with significant measurement delay, May 1994, Volume 10, Issue 5-6, pp 225-228

2. M.Chidambaram, Computer control of processes, 2002, pp247-277

3. Nádson M. N. Lima, Lamia Zuñiga Liñan, Flavio Manenti, Rubens Maciel Filho,Marcelo Embiruçu, Eugénio C. Ferreira, Maria R. Wolf Maciela, Multivariable Nonlinear Advanced Control of Copolymerization Processes, 20th European Symposium on Computer Aided Process Engineering, Elsevier, 2010

4. M.Alipoor, M.Zeinali, and H.Sadoghi Yazdi, Fuzzy Temperature Control in a Batch Polymerization Reactor Using ANFIS Method, International Journal of Engineering and Technology Vol.1, No.1, April, 2009

5. B.Roffel and P.A.Chin, APPLICATION OF FUZZY LOGIC IN THE CONTROL OFPOLYMERIZATION REACTORS, Vol.1, No.2, pp.267-272, 1993

About Authors

Lalit G. Patil was born on June 20, 1990. Hereceived the B.E degree inElectronics and Communication Engineering from Gujarat University and M.E Degree in Electrical Engineering from The M.S.University of Baroda, India. He is currently Working as a Teaching Assistant at The M.S.University of Baroda, India. His Current interest is Control applications, Pattern Recognitions and Robotic applications.

Dr. Jagrut J. Gaditwas born on September 17, 1964 inIndia. He received the M.E degree in Electrical Engineering with Specialization in Intelligent Control Systems. He works as a Associate faculty member in the Department of Electrical Engineering, The M.S.University of Baroda, India. His current interest is Digital Control, Intelligent systems etc.