Experiment-1.1

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Subject Name: Soft Computing Lab **Subject Code: 23CSH-653**

Aim of the Experiment :

a) Implementation of Fuzzy controller (Washing Machine)

b) Implementation of Fuzzy controller of Automatic Braking System

c) Implementation of Fuzzy controller of Fast Charging System

Theory :

Control System:

Any system whose outputs are controlled by some inputs to the system is called control system.

Fuzzy Controller:

A fuzzy controller is a type of control system that uses fuzzy logic to control a dynamic system. Unlike traditional control systems that rely on precise mathematical models, fuzzy controllers handle uncertainty and imprecision by using linguistic variables and fuzzy rules. Fuzzy logic allows the system to work with approximate reasoning and make decisions based on vague or ambiguous information.

A fuzzy controller typically consists of three main components:

a) **Fuzzification:** This process involves converting crisp input values into fuzzy sets. Fuzzy sets represent the degree of membership of an input in a particular linguistic term. For example, if the input is "temperature," fuzzy sets might include "low," "medium," and "high."

b) **Inference Engine:** The inference engine applies fuzzy logic rules to the fuzzy sets obtained from fuzzification to determine the fuzzy output sets. These rules are typically expressed in the form of "if-then" statements, where the "if" part corresponds to certain conditions and the "then" part to the resulting action.

c) **Defuzzification:** The fuzzy output sets obtained from the inference engine are converted back into crisp values for the system's output. This process involves aggregating the fuzzy sets and finding a single, crisp output value.

Fuzzy Sets:

Fuzzy sets are used to represent linguistic variables, which are qualitative terms that describe the state of system. For example, in a temperature control system, linguistic variables could be like "hot," "cold," or "warm."

Fuzzy Output:

Fuzzy output refers to the result or decision produced by a fuzzy logic controller. In a fuzzy logic system, the output is often expressed in terms of linguistic variables and fuzzy sets, reflecting the imprecision and uncertainty inherent in the system.

A) <u>IMPLEMENTATION OF FUZZY CONTROLLER (WASHING MACHINE):</u>

Design a controller to determine the wash time of a domestic washing machine. Assume the input is “Dirtness” and “Dirtness Type” on clothes. Use three descriptors for input variables and five descriptors for controller action and defuzzification.

Steps to Solve:

1) Identify input and output variables and decide descriptor for the experiment.

Inputs are “Dirtness” and “Dirtness Type”. Assume they are in percentage.

Output is “Wash Time” measured in a minutes.

Descriptor for input variable

Dirtness	**Dirtness Type**
SD: Small Dirt	NG: No Grease
MD: Medium Dirt	MG: Medium Grease
LD: Large Dirt	LG: Large Grease
{SD, MD, LD}	{NG, MG, LG}

Descriptor for the output variable

Wash Time
VS: Very Short
S: Short
M: Medium
L: Large
VL: Very Large
{VS, S, M, L, VL}

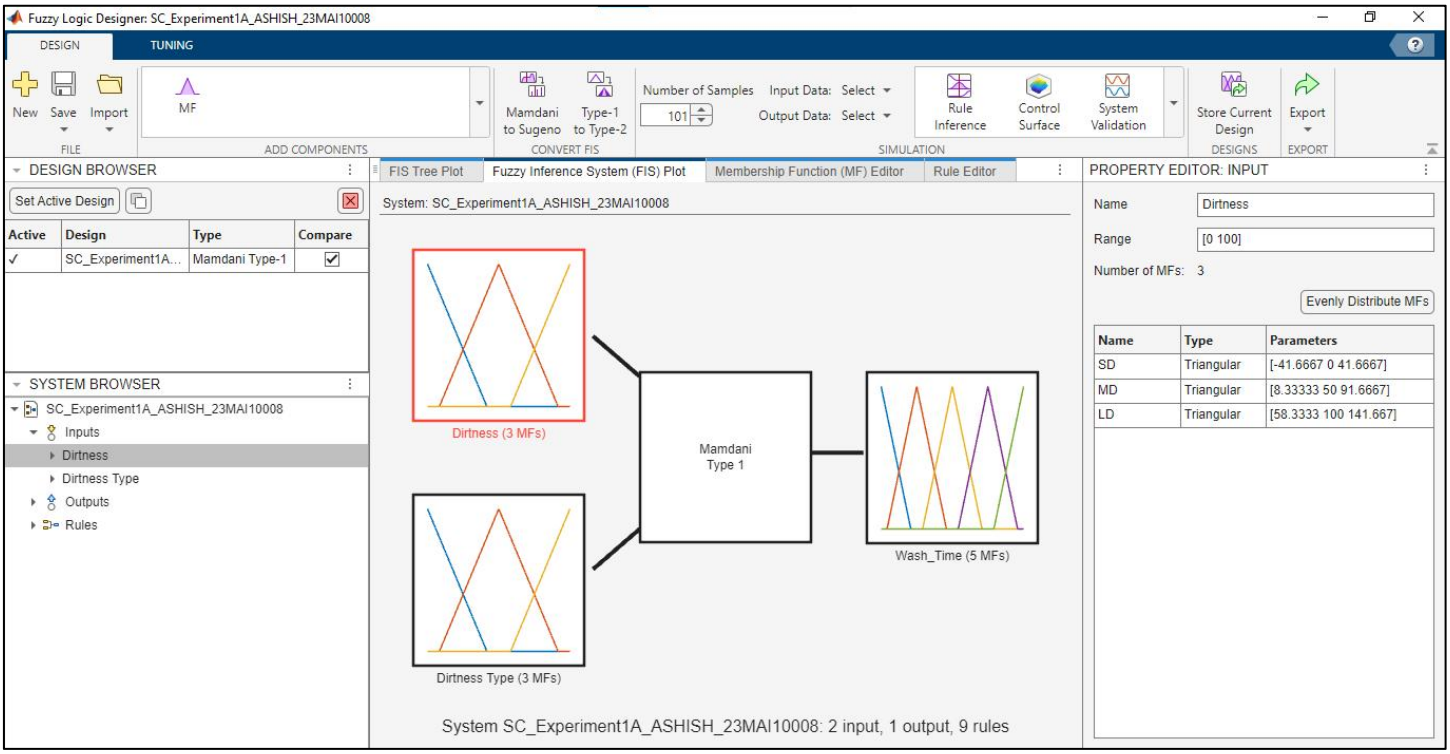
2) Define the membership function for each input and output variable.

3) Form a rule base.

4) Defuzzification or Final Result.

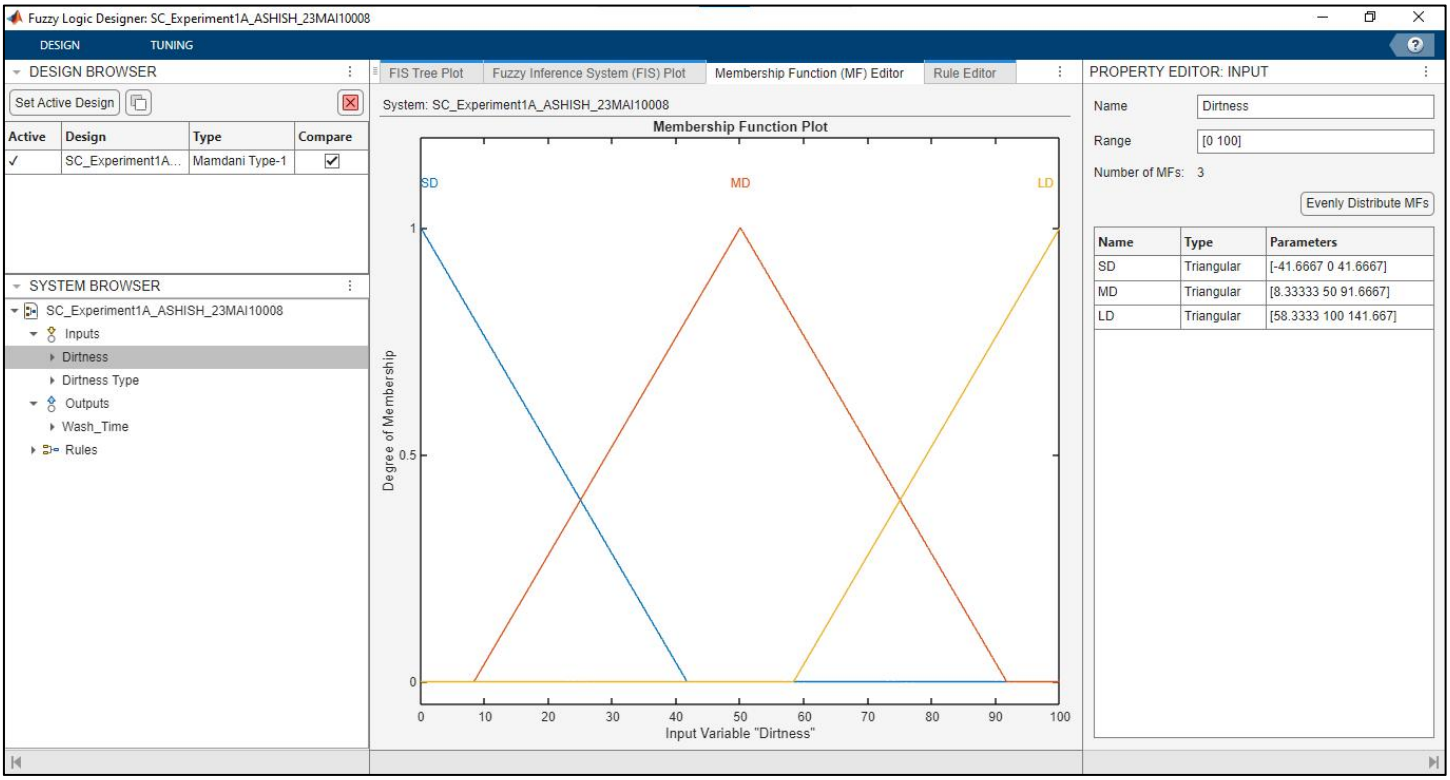
Procedure:

1) Inputs and Outputs :

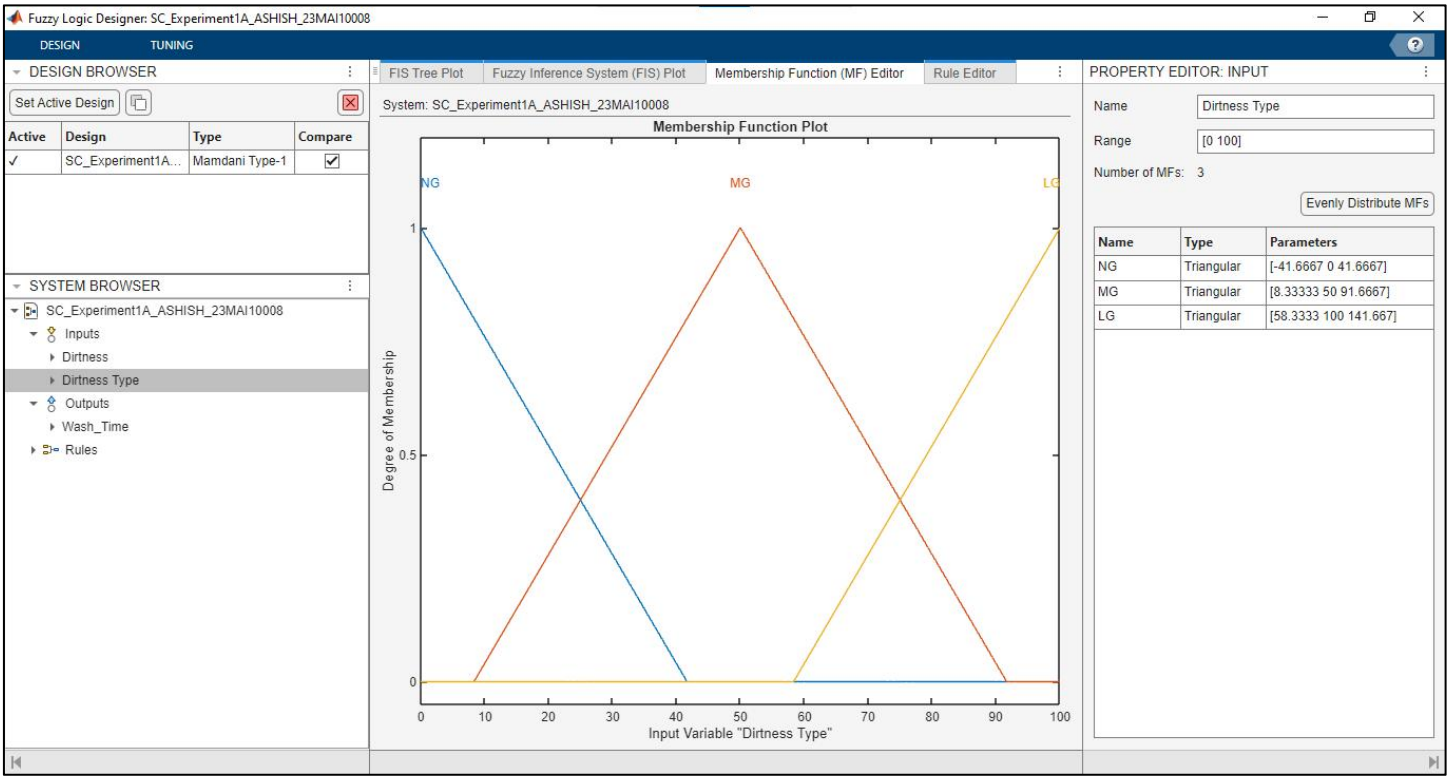


2) Membership Function for each Input and Output :

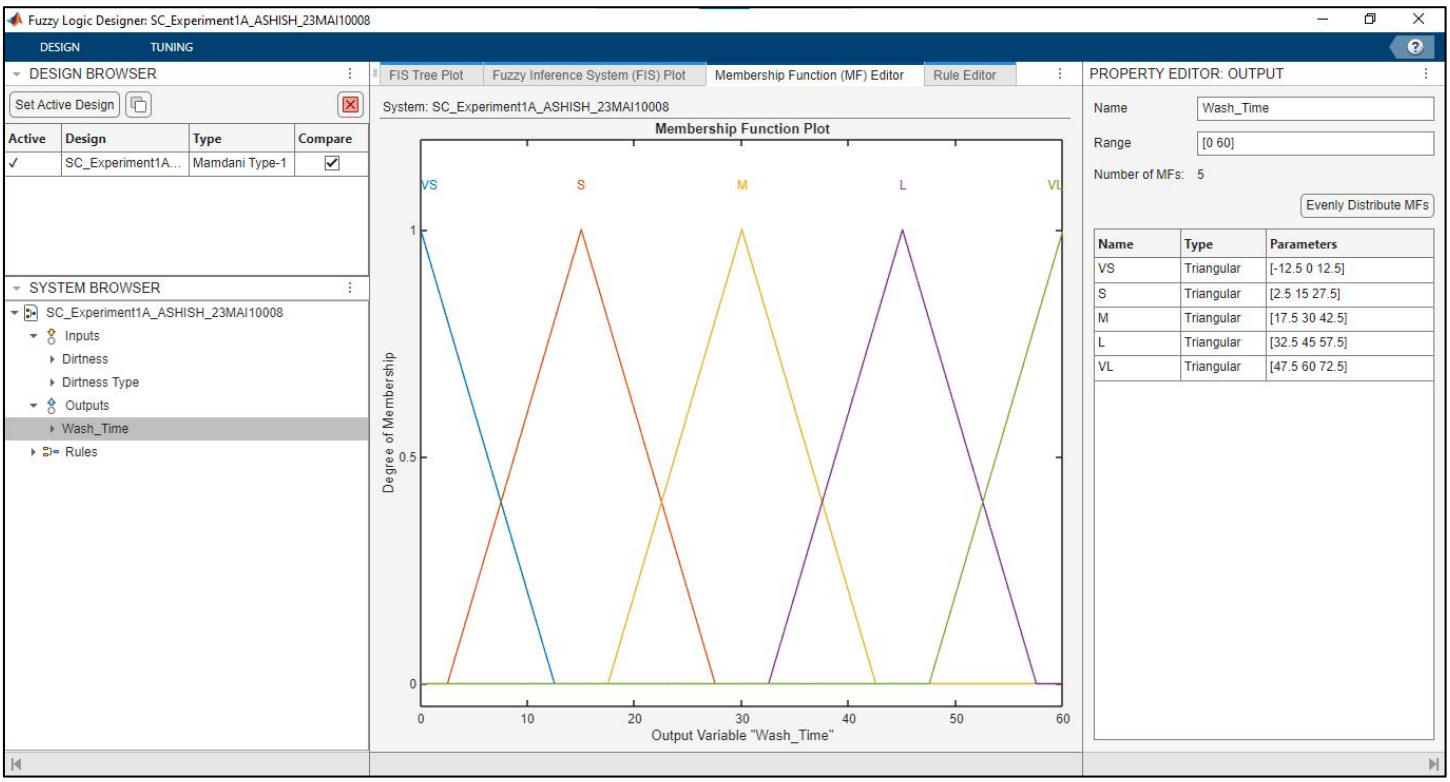
<u>MF for Dirtness:</u>



MF for Dirtness Type :



MF for Wash Time :



3) Forming Rule Base :

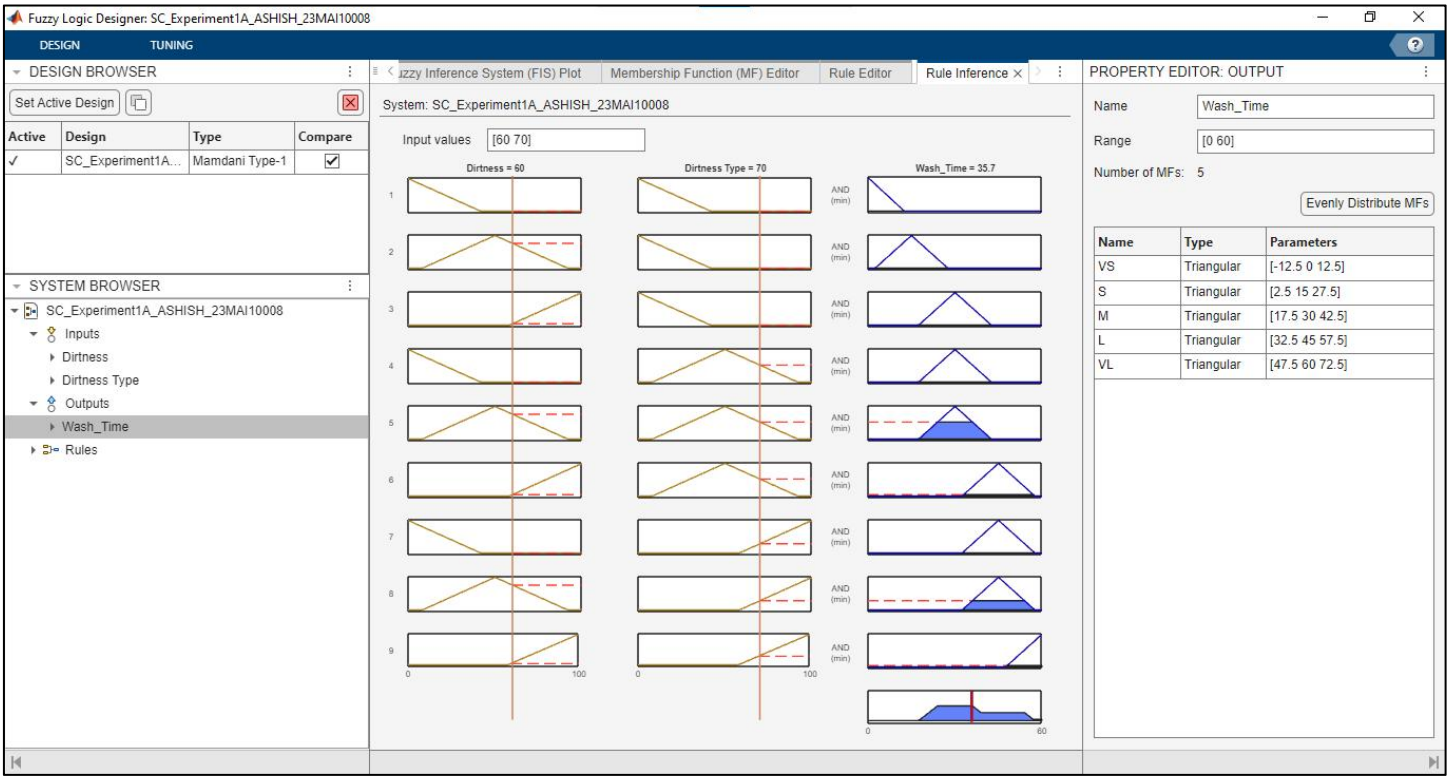
	SD	MD	LD
NG	VS	S	M
MG	M	M	L
LG	L	L	VL

System: SC_Experiment1A_ASHISH_23MAI10008

Add All Possible Rules | Clear All Rules

	Rule	Weight	Name
1	If Dirtness is SD and Dirtness Type is NG then Wash_Time is VS	1	rule1
2	If Dirtness is MD and Dirtness Type is NG then Wash_Time is S	1	rule2
3	If Dirtness is LD and Dirtness Type is NG then Wash_Time is M	1	rule3
4	If Dirtness is SD and Dirtness Type is MG then Wash_Time is M	1	rule4
5	If Dirtness is MD and Dirtness Type is MG then Wash_Time is M	1	rule5
6	If Dirtness is LD and Dirtness Type is MG then Wash_Time is L	1	rule6
7	If Dirtness is SD and Dirtness Type is LG then Wash_Time is L	1	rule7
8	If Dirtness is MD and Dirtness Type is LG then Wash_Time is L	1	rule8
9	If Dirtness is LD and Dirtness Type is LG then Wash_Time is VL	1	rule9

4) Evaluation at Dirt is 60% and Type is 70% :



B) IMPLEMENTATION OF FUZZY CONTROLLER OF AUTOMATIC BRAKING SYSTEM:

An Automatic Brake Control System. The speed and distance are inputs to a controller which outputs a control force to adjust the brake applied.

Depending upon the speed and distance, the brake is applied automatically. Fuzzy controller works in shades of gray where the speed and distance are treated as a series of overlapping ranges. The controller is programmed with simple if-then rules that tell the controller how hard the brake is applied. As a result, when the speed or distance changes, the brake will continuously adjust.

Steps to Solve:

1) Identify input and output variables and decide descriptor for the experiment.

Inputs are "Speed" and "Distance".

Output is "Brake".

Descriptor for input variable

Speed	**(Km/hr)**	**Distance**	**(Feet)**
DSL	0-40	ECL	0-30
VSL	20-60	VCL	20-40
SL	40-80	CL	30-50
MSL	60-100	MD	40-60
FST	80-120	FAR	50-70
VFS	100-140	VFAR	60-80
EFS	120-160	EFAR	70-100
{DSL,VSL, SL,MSL, FST,VFS, EFS}		{ECL,VCL, CL,MD, FAR,VFAR, EFAR}	

Descriptor for output variable

Brake
Release
VLP
LP
MP
HP
VHP
EHP
{Release, VLP, LP, MP, HP, VHP, EHP }

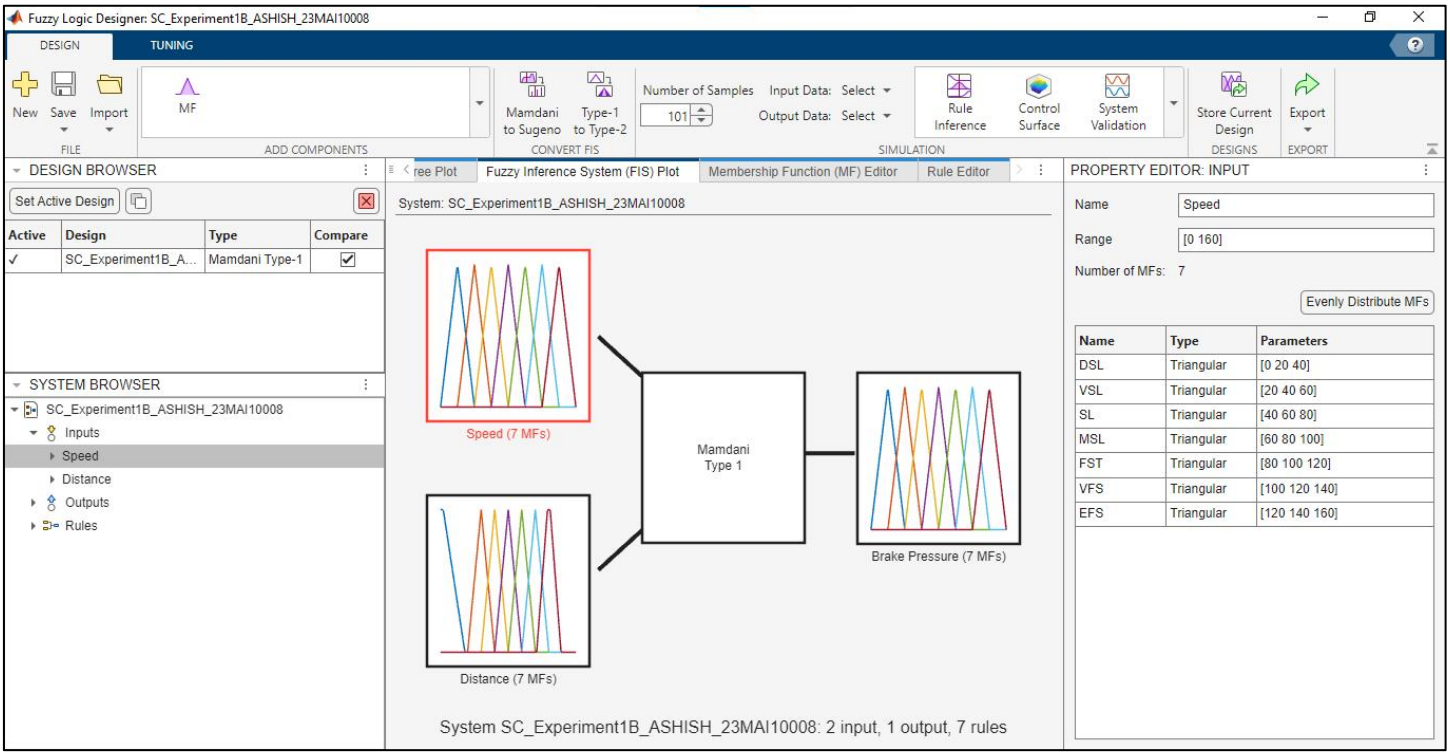
2) Define the membership function for each input and output variable.

3) Form a rule base.

4) Defuzzification or Final Result.

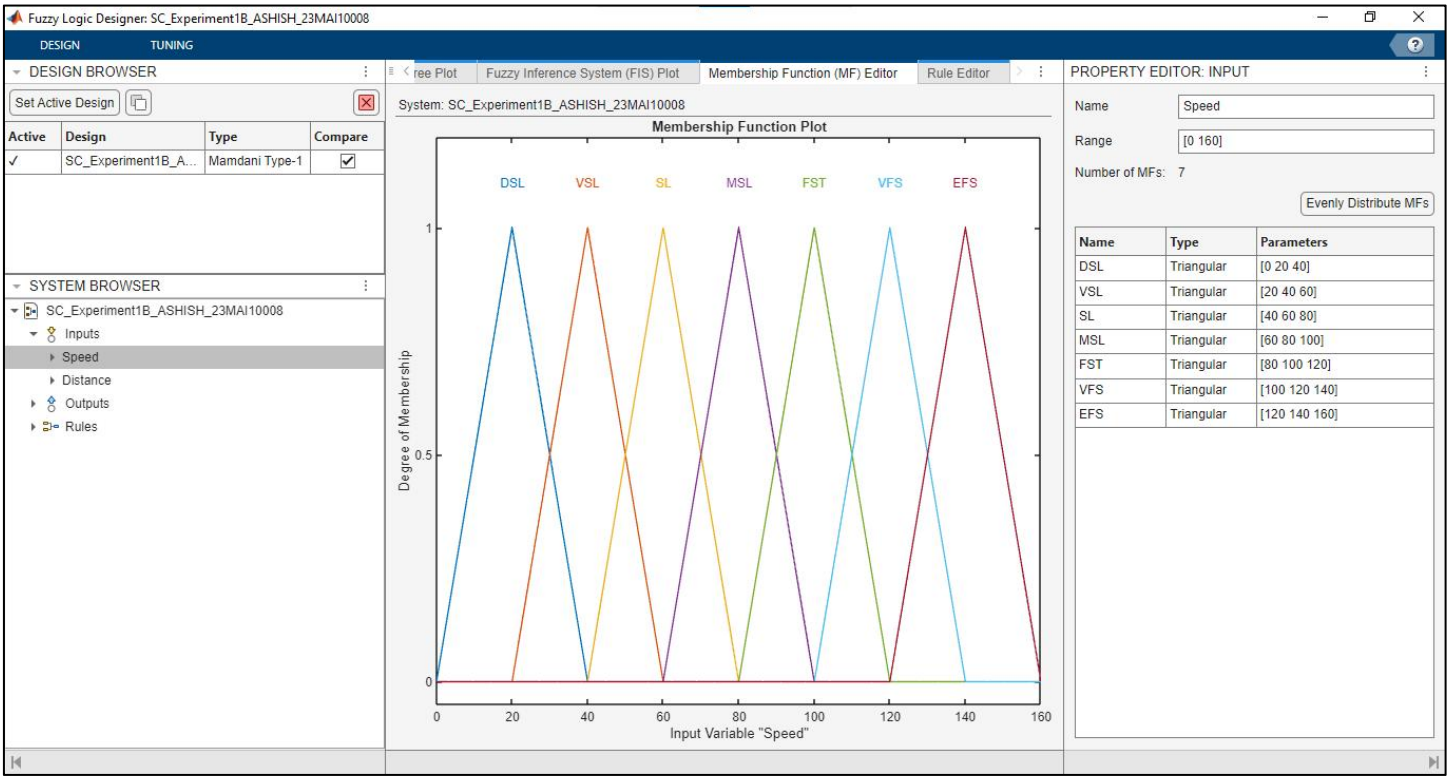
Procedure:

1) Inputs and Outputs :

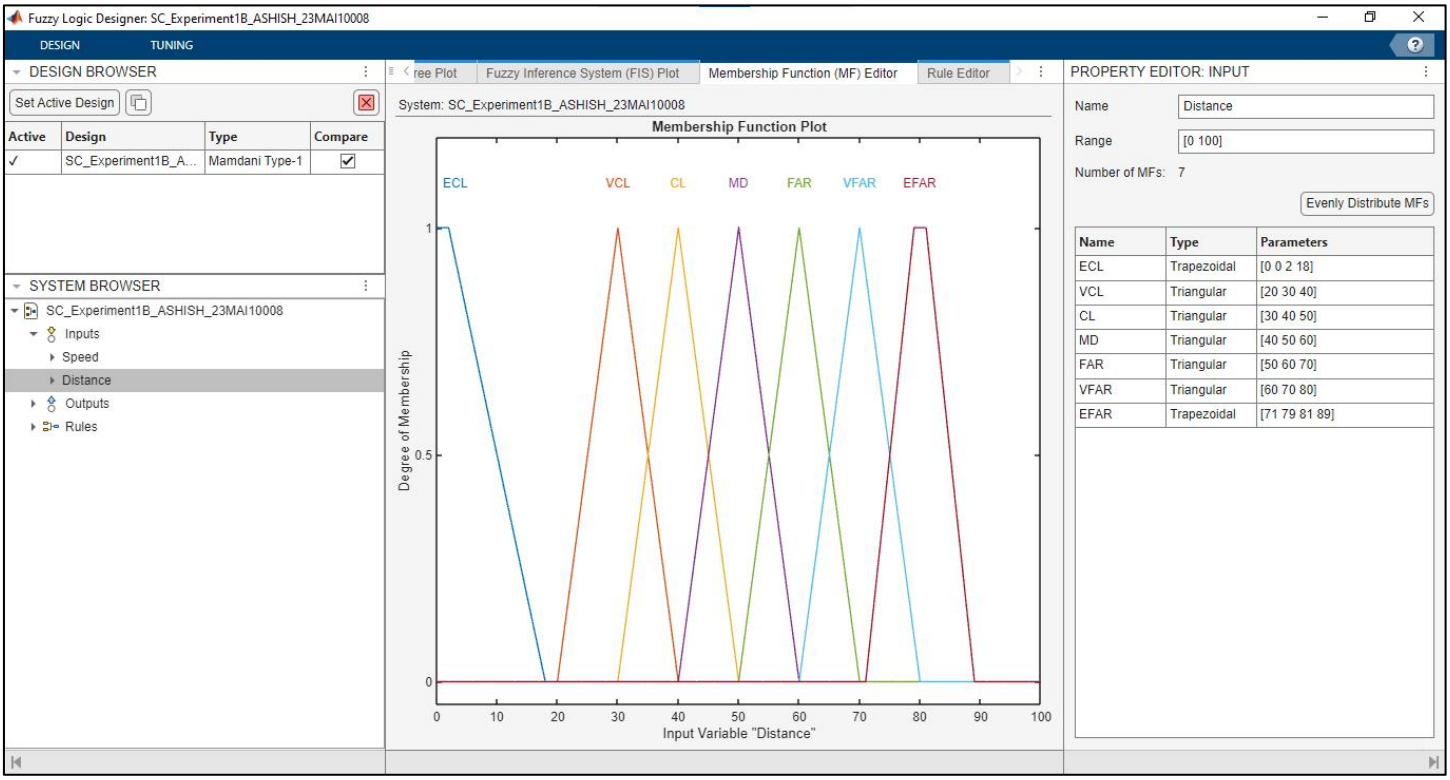


2) Membership Function for each Input and Output:

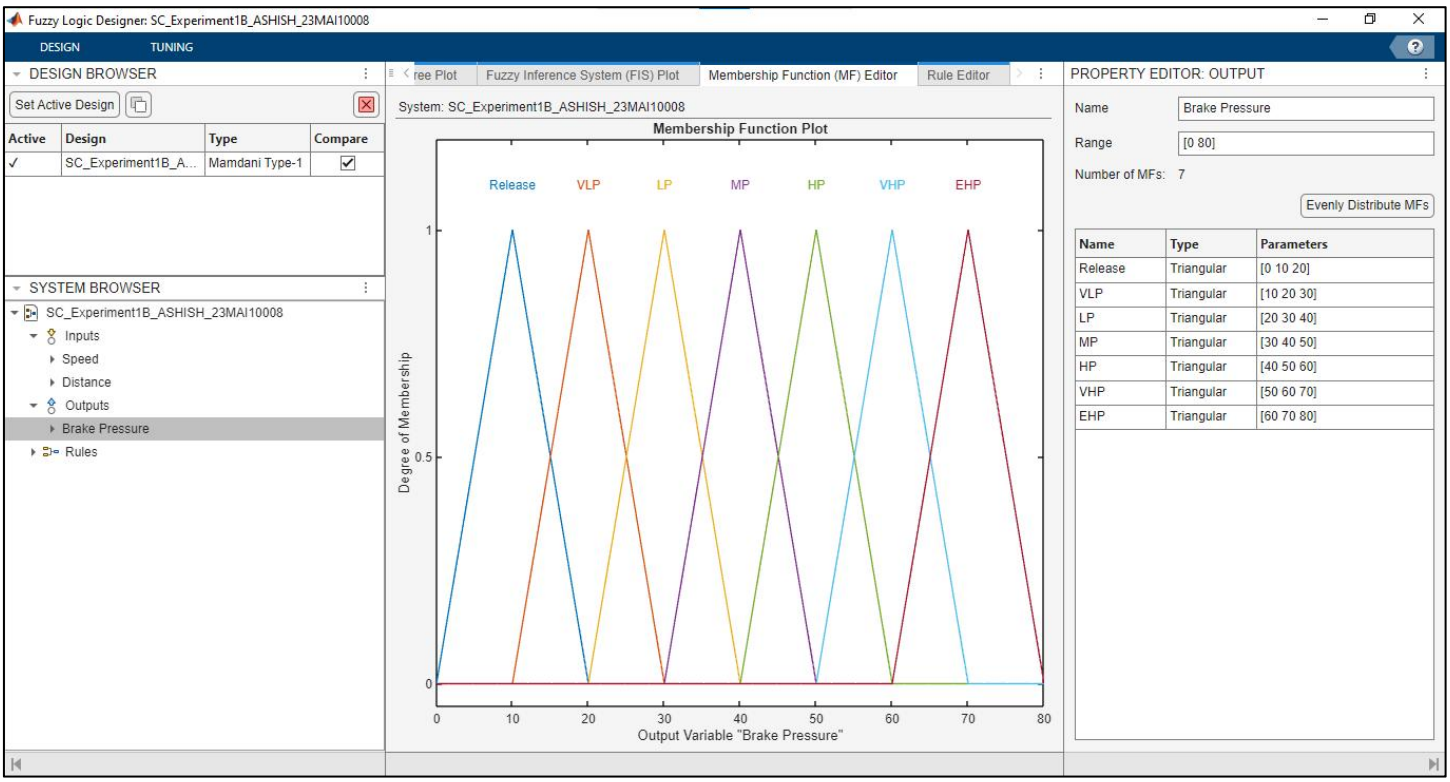
MF for Speed :



MF for Distance :



MF for Break Pressure :



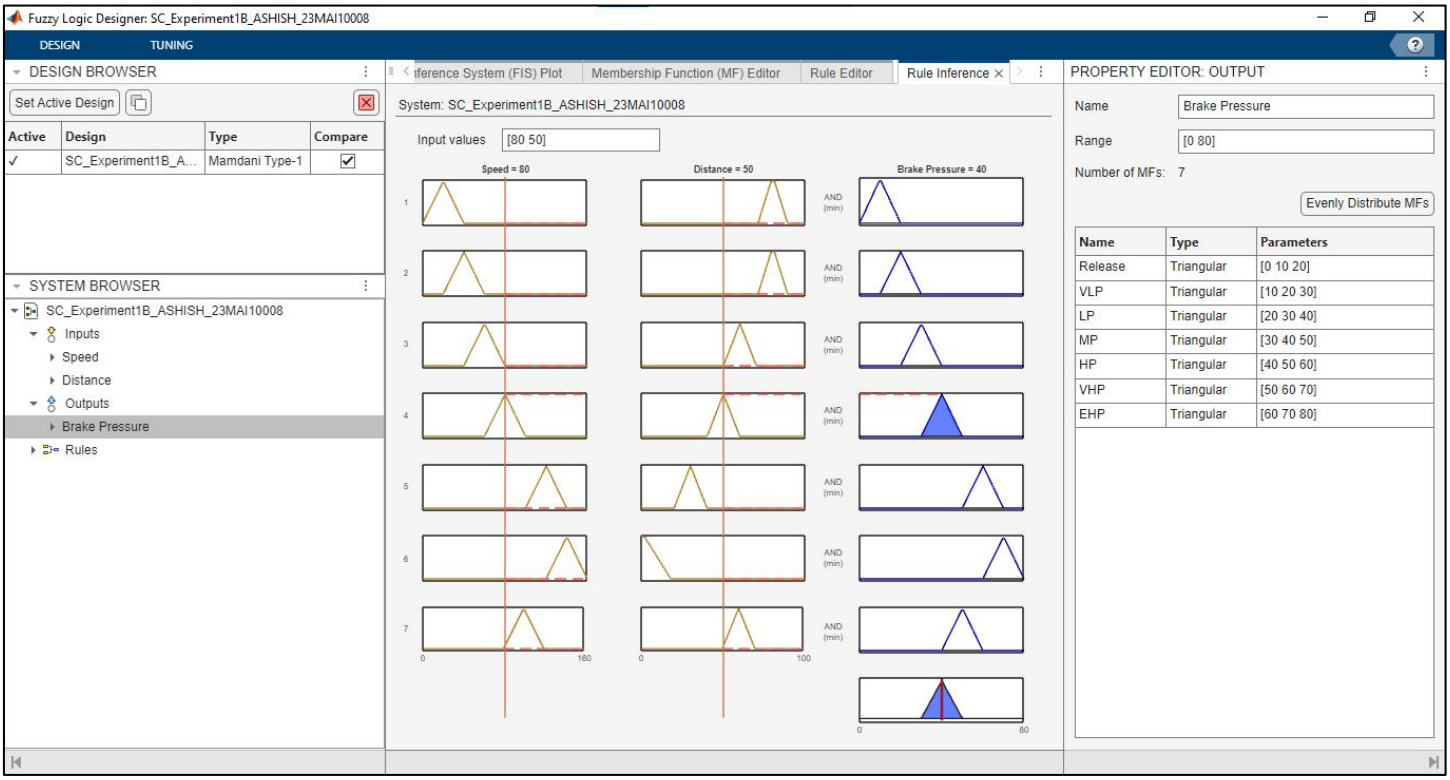
3) Forming Rule Base:

System: SC_Experiment1B_ASHISH_23MAI10008

Add All Possible Rules | Clear All Rules

	Rule	Weight	Name
1	If Speed is DSL and Distance is EFAR then Brake Pressure is Release	1	rule1
2	If Speed is VSL and Distance is EFAR then Brake Pressure is VLP	1	rule2
3	If Speed is SL and Distance is FAR then Brake Pressure is LP	1	rule3
4	If Speed is MSL and Distance is MD then Brake Pressure is MP	1	rule4
5	If Speed is VFS and Distance is VCL then Brake Pressure is VHP	1	rule5
6	If Speed is EFS and Distance is ECL then Brake Pressure is EHP	1	rule6
7	If Speed is FST and Distance is FAR then Brake Pressure is HP	1	rule7

4) Evaluation at Speed is 80 and Distance is 50 :



C) IMPLEMENTATION OF FUZZY CONTROLLER OF FAST CHARGING SYSTEM:

An Automatic Charging Time Calculation System, The battery level, temperature and charging current are inputs to a controller which outputs the calculation of the time taken by battery to be fully charged.

Depending upon the battery level, temperature and charging current, the time taken is calculated automatically. Fuzzy controller works in shades of gray where the battery level, temperature and charging current are treated as a series of overlapping ranges. The controller is programmed with simple if-then rules that tell the controller how much time is taken to charge a full battery which is measured in hours. As a result when the battery level, temperature and charging current changes the time will continuously change.

Steps to Solve:

1) Identify input and output variables and decide descriptor for the experiment.

Inputs are “Battery Level”, “Temperature” and “Charging Current”.

Output is “Charging Time”.

Descriptor for variables:

Battery level (%) :

Low	0-30%
Medium	20-70%
High	60-100%

Charging Current (A) :

Low	0-5
Medium	3-10
High	8-15

Temperature (^{0}C) :

Low	0-25
Medium	20-40
High	30-60

Charging Time (H) :

Low	0-2
Medium	1-4
High	3-6

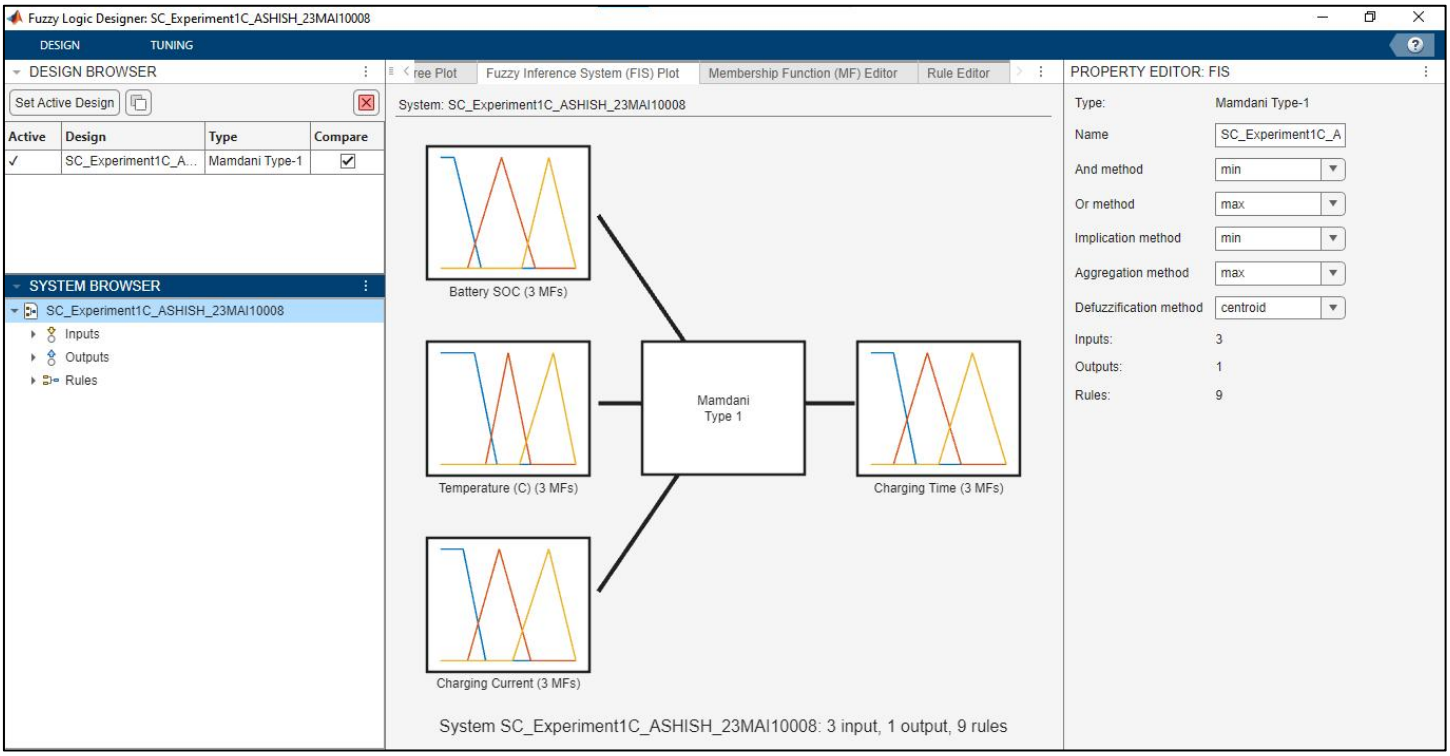
2) Define the membership function for each input and output variable.

3) Form a rule base.

4) Defuzzification or Final Result.

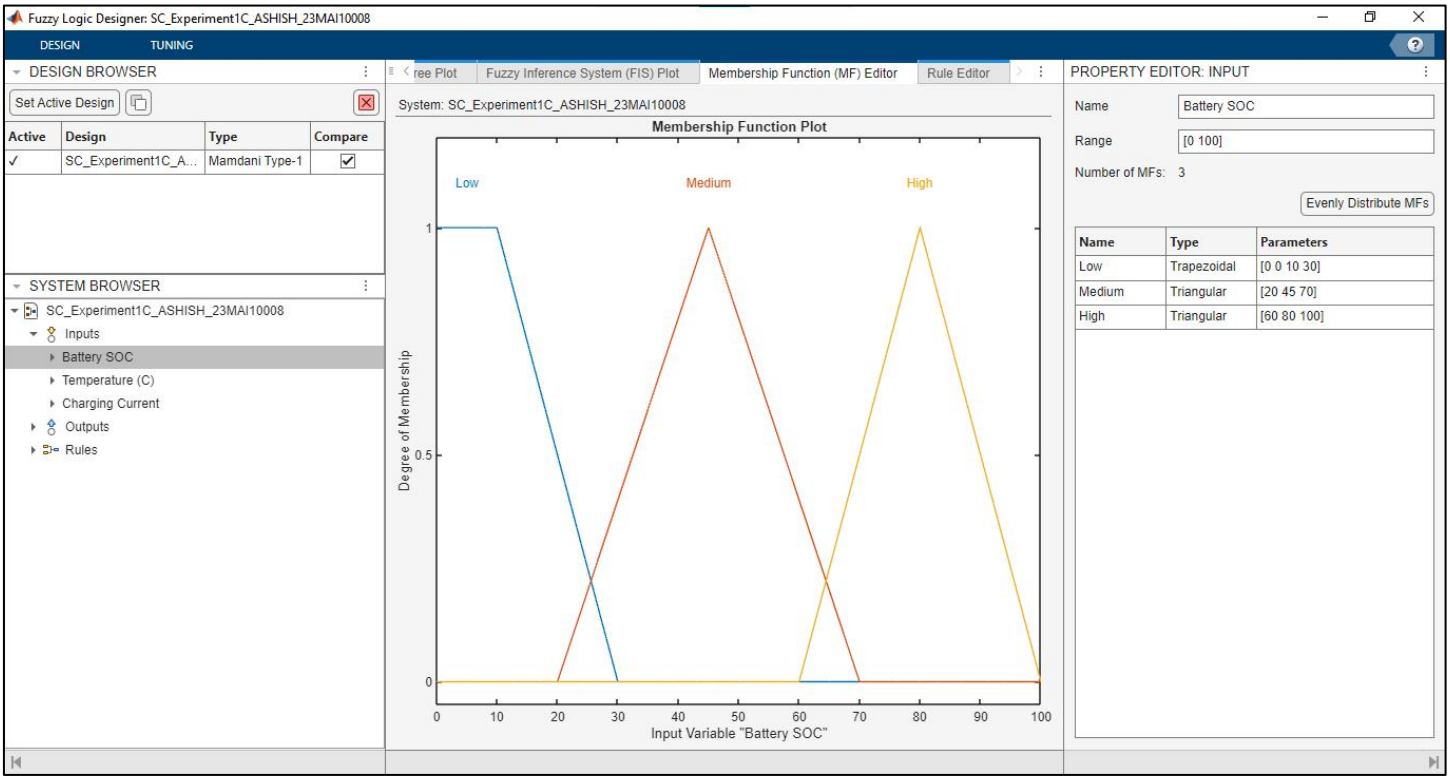
Procedure:

1) Inputs and Outputs :

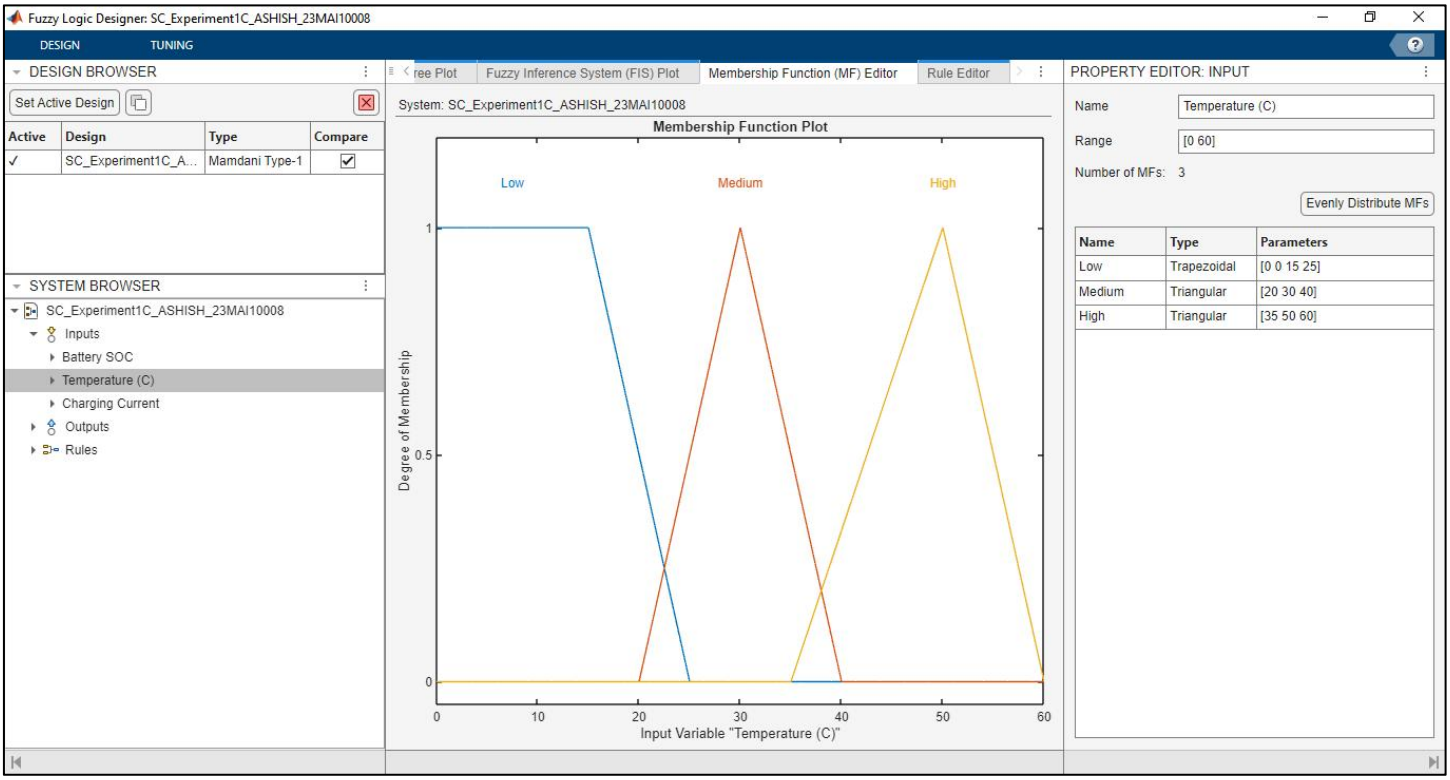


2) Membership Function for each Input and Output:

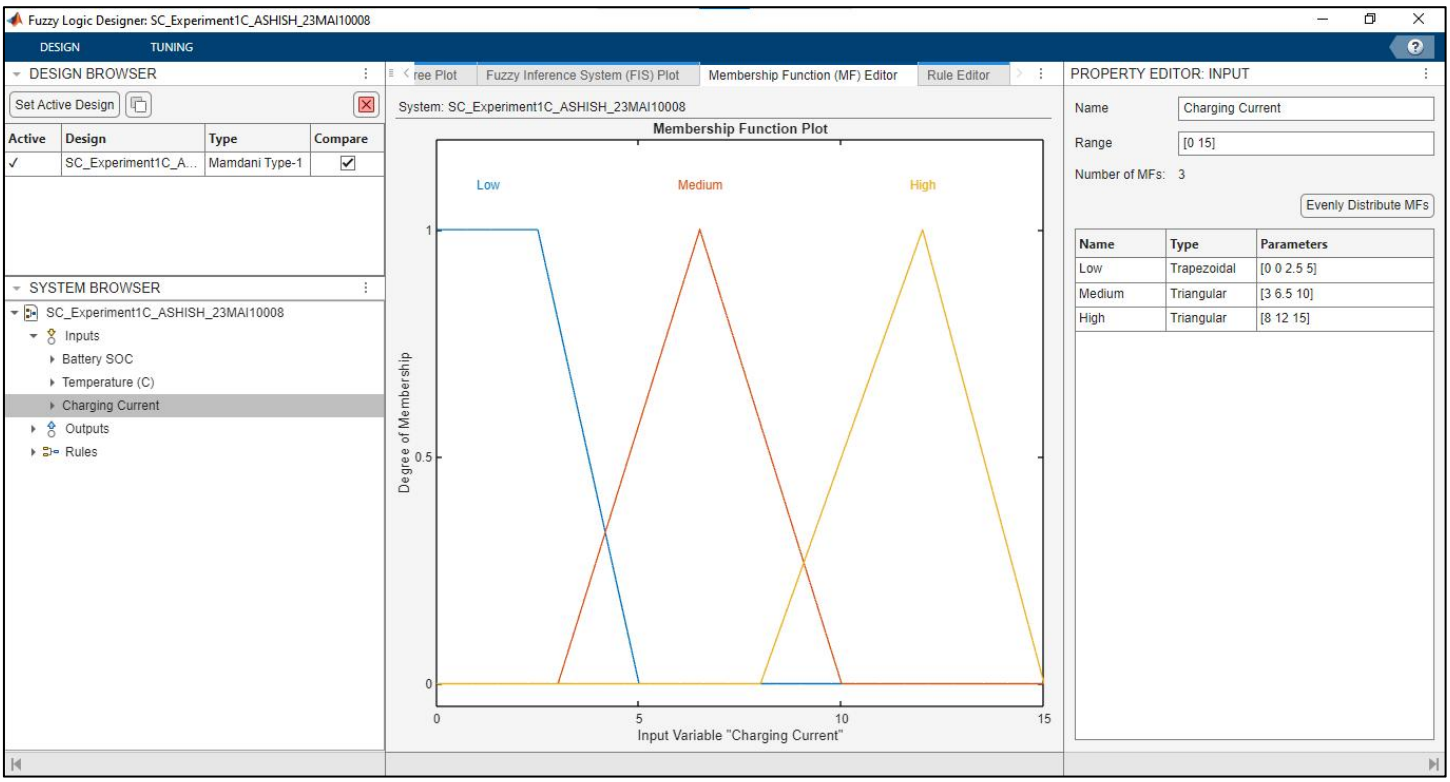
MF for Battery SOC :



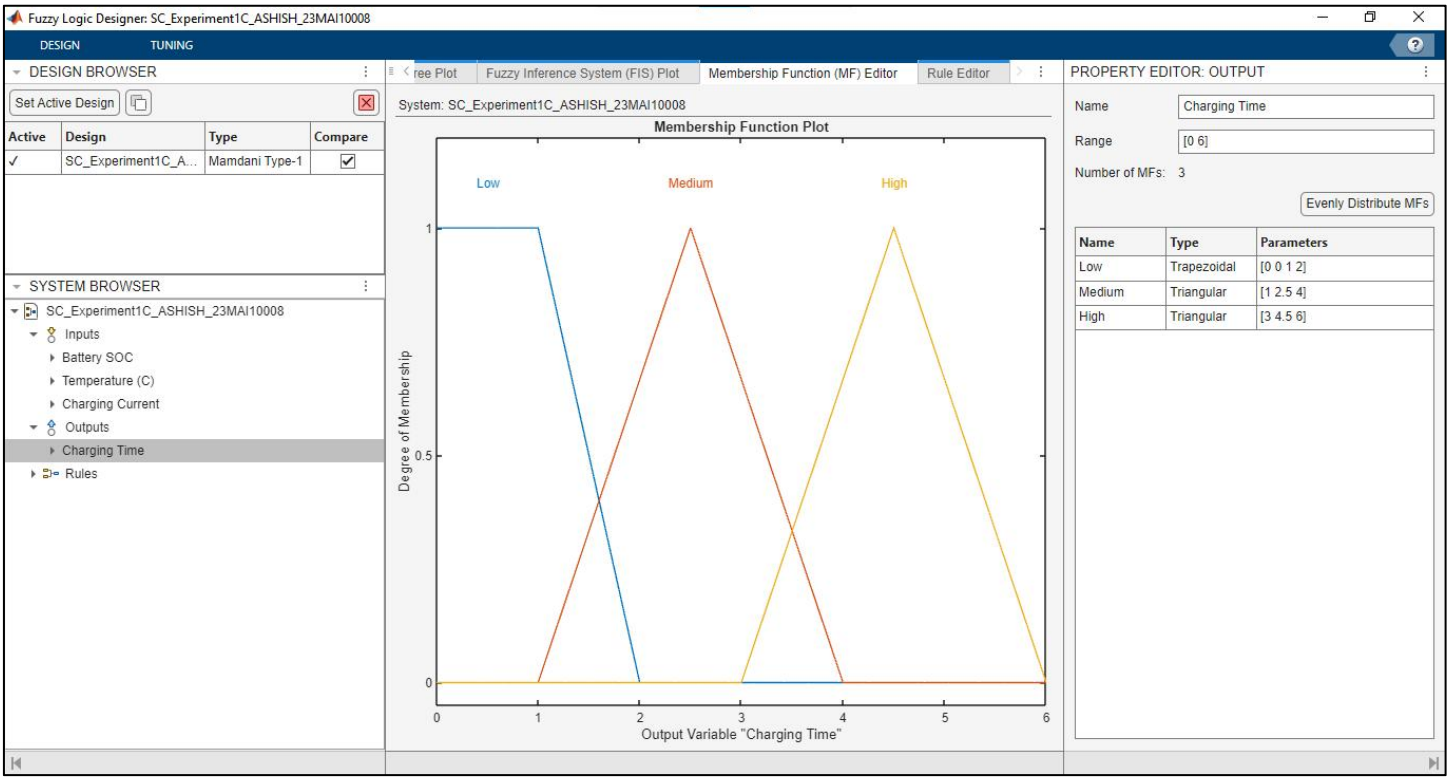
MF for Temperature (^{0}C) :



MF for Charging Current (A) :



MF for Charging Time :



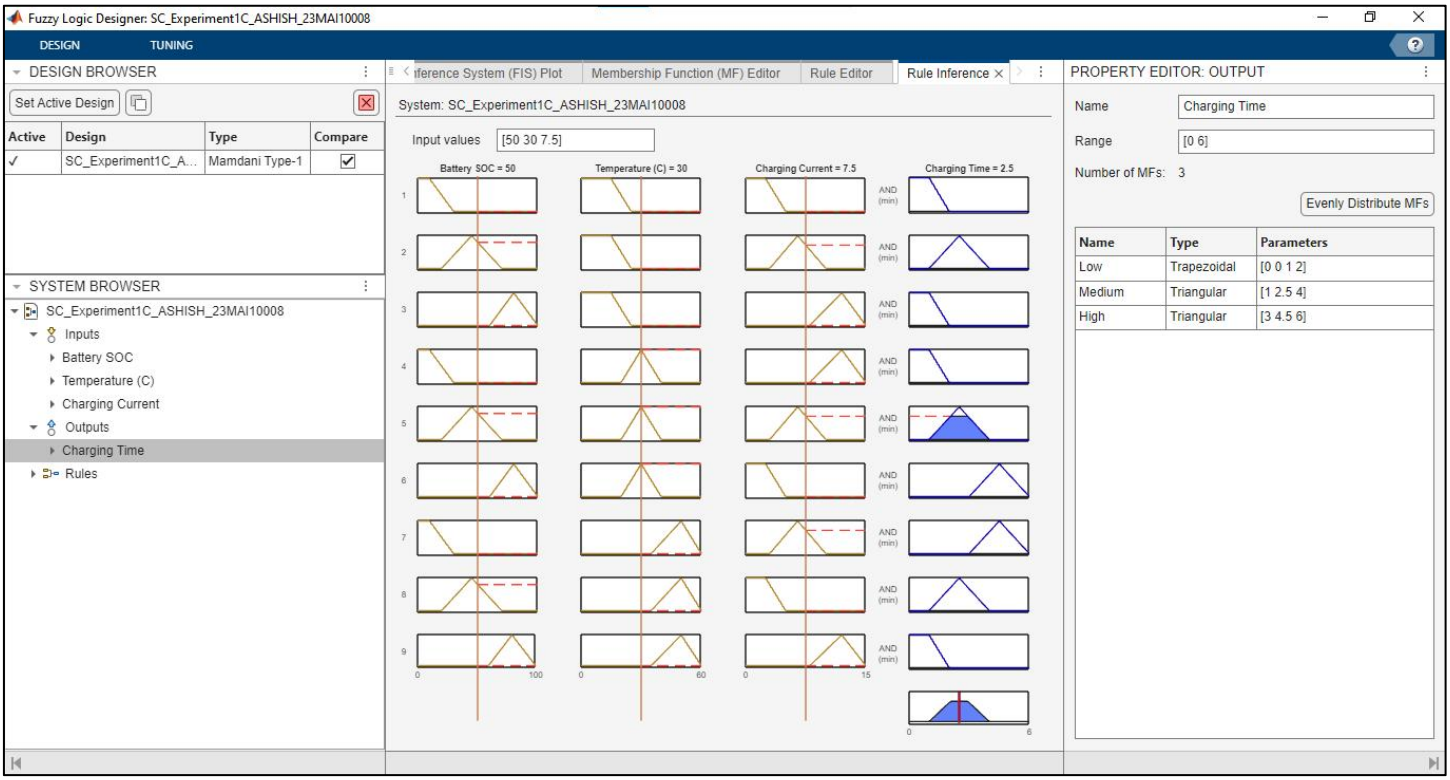
3) Forming Rule Base :

System: SC_Experiment1C_ASHISH_23MAI10008

Add All Possible Rules | Clear All Rules

	Rule	Weight	Name
1	If Battery SOC is Low and Temperature (C) is Low and Charging Current is Low then Charging Time is Low	1	rule1
2	If Battery SOC is Medium and Temperature (C) is Low and Charging Current is Medium then Charging Time is Medium	1	rule2
3	If Battery SOC is High and Temperature (C) is Low and Charging Current is High then Charging Time is Low	1	rule3
4	If Battery SOC is Low and Temperature (C) is Medium and Charging Current is High then Charging Time is Low	1	rule4
5	If Battery SOC is Medium and Temperature (C) is Medium and Charging Current is Medium then Charging Time is Medium	1	rule5
6	If Battery SOC is High and Temperature (C) is Medium and Charging Current is Low then Charging Time is High	1	rule6
7	If Battery SOC is Low and Temperature (C) is High and Charging Current is Medium then Charging Time is High	1	rule7
8	If Battery SOC is Medium and Temperature (C) is High and Charging Current is Low then Charging Time is Medium	1	rule8
9	If Battery SOC is High and Temperature (C) is High and Charging Current is High then Charging Time is Low	1	rule9

4) Evaluation at Battery 50, Temperature 30 and Charging Current is 7.5 :



Learning outcomes (What I have learnt):

1. I learnt about the fuzzy inference systems used in matlab.
2. I learnt about the working of fuzzy controller.
3. I learnt about the basics of fuzzy logic concepts.
4. I learnt about the basics of conditional fuzzy propositions.
5. I learnt about how to develop intelligent system using fuzzy logic.