CLASS: **SUBJECT: SC**

EXPT. NO: **DATE:**

TITLE : Mamdani Fuzzy Model

OBJECTIVES: To study and implement Mamdani Fuzzy Model in MATLAB using various membership functions.

THEORY:

- The Mamdani fuzzy inference system was proposed as the first attempt to control a steam engine and boiler combination by a set of linguistic control rules obtained from experienced human operators.
- As an illustration of this model we would consider an example in which two input linguistic variables, Temperature (T) and Pressure (P) are considered with following membership functions:
- The Mamdani fuzzy inference system was proposed as the first attempt to control a steam engine and boiler combination by a set of linguistic control rules obtained from experienced human operators.
- As an illustration of this model we would consider an example in which two input linguistic variables, Temperature (T) and Pressure (P) are considered with following membership functions:

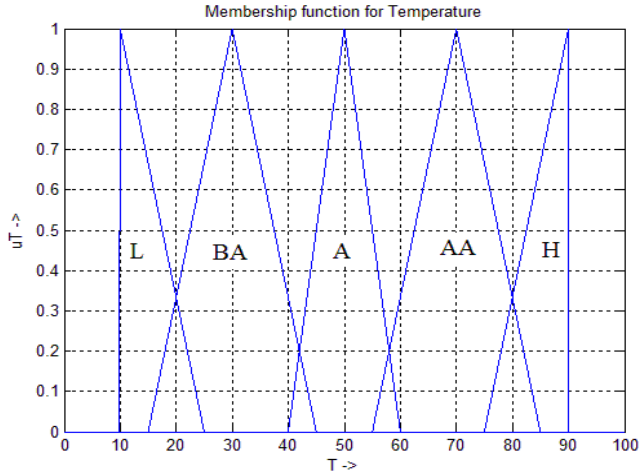

Figure 1: Temperature MF.

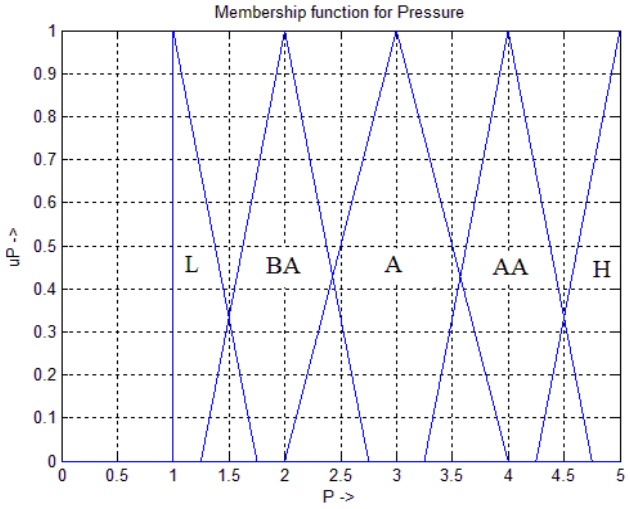

Figure 2: Pressure MF.

Legend: L: Low, BA: Below Average, A: Average, AA: Above Average, H: High.

The output linguistic variable is Heater Power (HP) whose membership functions are given as follows:

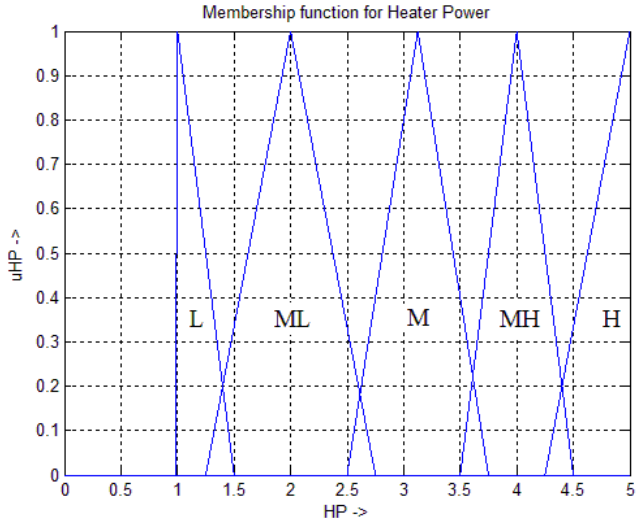

Figure 3: Heater Power MF

Legend: L: Low, ML: Medium Low, M: Medium, MH: Medium High, H: High.

Let us consider only **two rules from the Rule Base**:

R1: If the Temperature is BELOW AVERAGE and Pressure is BELOW AVERAGE, then Heater Power is MEDIUM HIGH.

R2: If the Temperature is LOW and Pressure is LOW then Heater Power is HIGH.

Note: There exist 25 such rules in the Rule Base corresponding to:
5 (Ranges of Temperature) X 5 (Ranges of Pressure).

Now, let us consider a **fact** that is given as input to the fuzzy inference system:
T = 22.5^{o} C (T falls in two ranges, L and BA).
P = 1.5 atm (P falls in two ranges, L and BA).
For this input **Mamdani fuzzy inference** system will work as follows:

Rule 1 Inference:

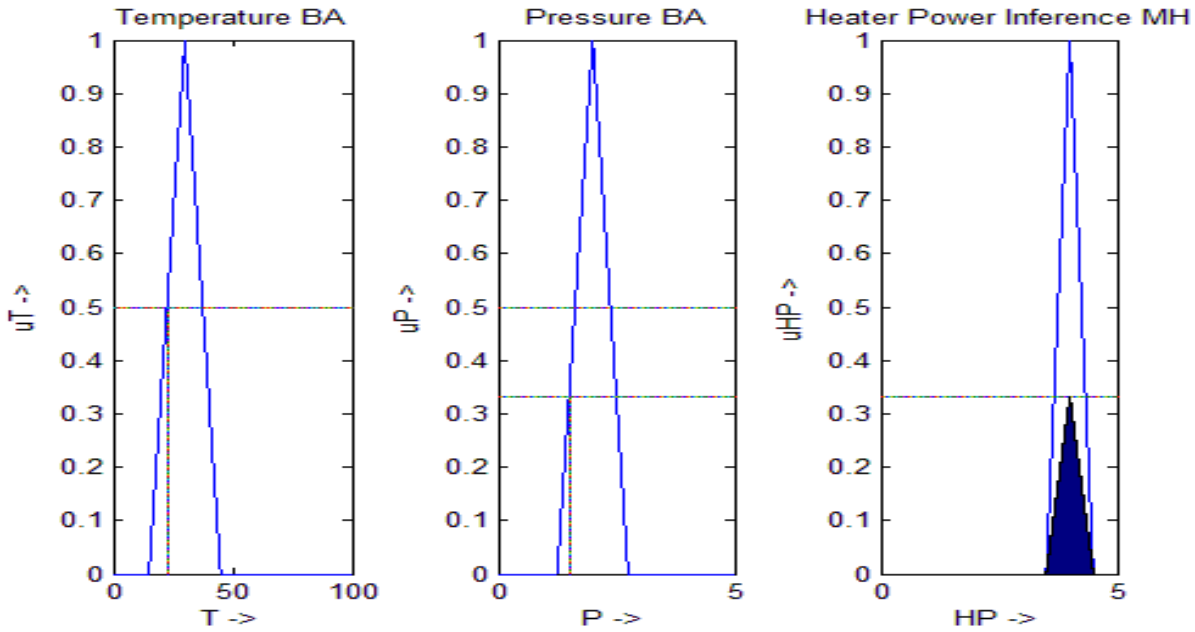

Figure 4.

u^{T}_{BA} (22.5) = 0.5

u^{P}_{BA} (1.5) = 0.3333

min (0.5, 0.3333) = 0.3333

➔Inference MF(shaded)
= u^{HP}_{MH} (new)
= 0.3333 x u^{HP}_{MH}

Rule 2 Inference:

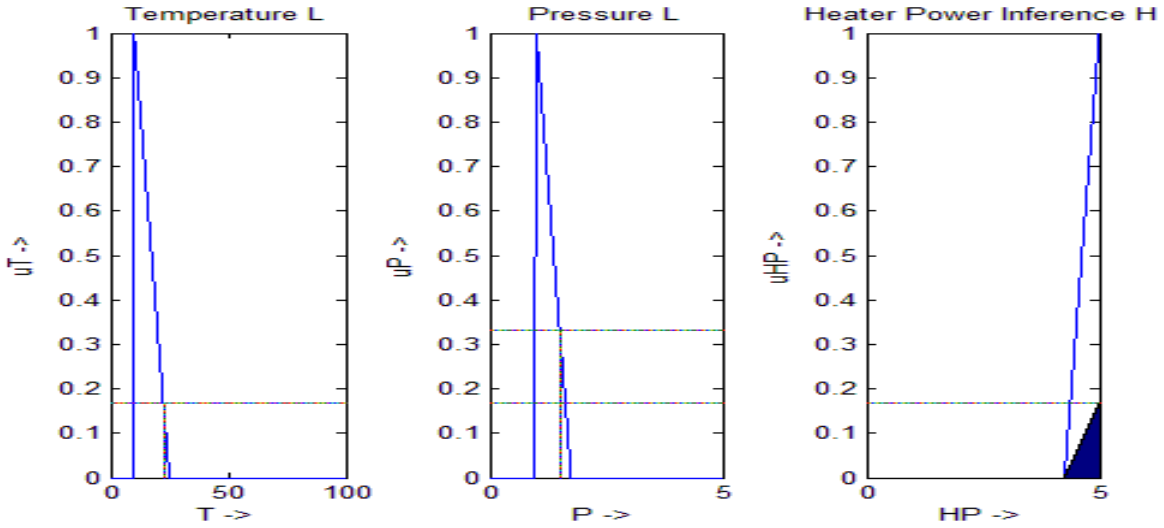

Figure 5.

u^{T}_{L} (22.5) = 0.16667 u^{P}_{L} (1.5) = 0.3333 ➔Inference MF (shaded) = u^{HP}_{H} (new)
= 0.1667 x u^{HP}_{H}

min (0.1667, 0.3333) = 0.1667

Resultant Fuzzy reasoning:

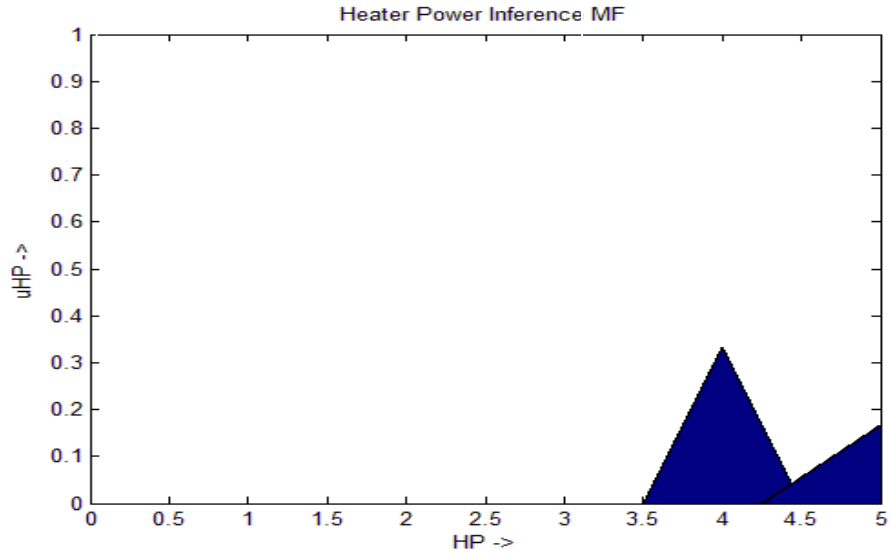

Figure 6.

Defuzzification Step:

Area (u^{HP}_{MH}) = ½ x 1 x 1 = 0.5

Area (u^{HP}_{H}) = (½ x 0.75 x 1) = 0.375

Centre (u^{HP}_{MH}) = 4

Centre (u^{HP}_{H}) = 5

u^{HP}_{MH} (new) = 0.3333

u^{HP}_{H} (new) = 0.1667

Centroid =

$$\frac{[\,u^{HP}_{MH}\text{ (new) x Area }(u^{HP}_{MH})\text{ x Centre }(u^{HP}_{MH}) \;+\; u^{HP}_{H}\text{ (new) x Area }(u^{HP}_{H})\text{ x Centre }(u^{HP}_{H})\,]}{[u^{HP}_{MH}\text{ (new) x Area }(u^{HP}_{MH}) \;+\; u^{HP}_{H}\text{ (new) x Area }(u^{HP}_{H})\,]} =$$

$$\frac{[\,0.3333 \text{ x } 0.5 \text{ x } 4 \;+\; 0.1667 \text{ x } 0.375 \text{ x } 5\,]}{[\,0.3333 \text{ x } 0.5 \;+\; 0.1667 \text{ x } 0.375\,]} = \textbf{4.2728 W}$$

Thus, we have derived a **heater power** required to maintain the temperature and pressure is **4.2728 W** when the temperature reading of the boiler is 22.5^{o} C and pressure reading is 1.5 atm.

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CONCLUSION