CHAPTER 8

COMPARATIVE ANALYSIS OF THE DESIGNED CONTROLLERS

Comparative analysis of any developed work plays a very important role in the design & development of real time power electronic drive systems. In the research work considered & developed in the previous chapters, speed of the induction motors is taken as the main parameter for comparative analysis purposes. Simulink models for the speed control of IM's using 4 types of controllers, viz, PI, Mamdani based FLC, Takagi Sugeno based FLC & using the ANFIS control scheme were developed in Matlab simulink environment. The developed four different control strategies with SVPWM are used to control the firing angle of the inverter. This, in turn, controls the speed of the IM.

The performance of the designed controllers has been analyzed by performing the simulations of the developed controllers in Simulink for a period of 3 second & observing the various performance characteristics (say, speed, torque, flux, current, etc).

Control of speed of IM using PI control strategy was dealt with in chapter number 4. In chapter number 5, speed control of IM's using Mamdani based SVPWM-FLC was presented **[76]**. Speed control of IM using Takagi-Sugeno based FLC strategy was presented in chapter number 6 **[84]**, **[90]**. Adaptive neuro fuzzy control of speed was presented in chapter number 7 **[91]**, **[92]**. In this chapter, a brief

comparison of all the developed control strategies in the chapters 4-7 is presented along with a comparative speed analysis. Also, the proposed methods are compared with the research work done by other researchers in this context here.

The comparison of speed curves for PI control method, Mamdani based FLC control scheme, TS based fuzzy control scheme & using the **proposed ANFIS** control strategy presented in this thesis is graphically shown in the form of simulation result in the Fig. 8.1.

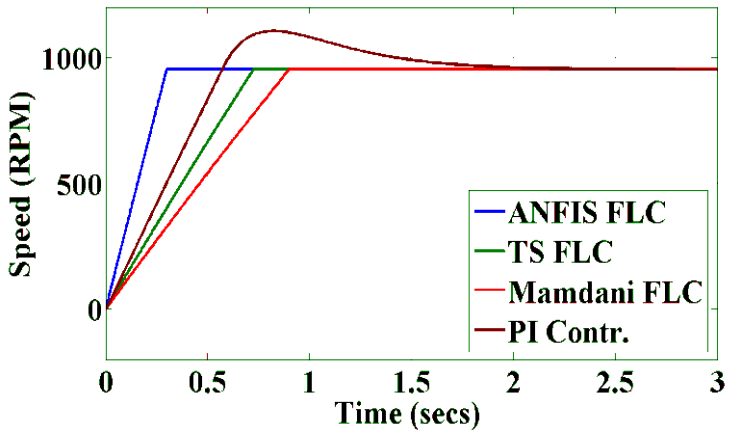

Fig. 8.1: Comparison of speed curves for ANFIS, TS, M-FLC & with PI control

The quantitative analysis of the settling times of the speed curves using different control strategies carried out in this thesis is also presented in the table 8.1. From the speed comparative curve shown in the Fig. 8.1 & from the table 8.1, it can be concluded that due to the incorporation of the proposed ANFIS controller in loop with the

plant (IM), it was observed that the motor reaches the set speed (100 rad/second) very quickly in a lesser time compared to the other 3 methods viz., PI method, Mamdani method **[76]** & the TS method **[84]**. Collectively the simulation results shows that the ANFIS controller provides faster settling times (**0.3 second**), has very good dynamic response & good stabilization compared to the PI method, Mamdani method **[76]**, the TS method **[84]**.

Further, it is noted that in the PI method, it took **2 second** & in the mamdani method, it took **0.9 second**, in the TS scheme, it took only **0.7 second** to reach the set speed.

Table 8.1: Quantitative results of comparison of settling time of speed curve

No.	Type of controller	Set speed (r/s)	Settling speed (s)
1	PI	100	2.0
2	Mamdani-FLC	100	0.9
3	TS-FLC	100	0.7
4	**ANFIS**	**100**	**0.3**

This shows the effectiveness of the developed hybrid control method viz., the adaptive neuro fuzzy inference strategy along with an excellent performance measure of the speed dynamics. Collectively, the numerical results presented in the table 8.1 & from the Fig. 8.1, it is concluded that the proposed ANFIS controller is the best suited method for speed control of IM's. In all the works presented by various authors in table 8.2 & in the references **[31]**, **[51]**, **[35]**, **[63]**, **[20]**,

[47], **[94]**, **[8]**, **[60]**, **[93]**, **[49]**, it can be observed that the settling time of the speed curve is greater than 0.4 second, whereas in this case, using the proposed ANFIS controller, the speed settles at **0.3 second** itself.

Table 8.2: Comparison of settling time of speed curve for proposed ANFIS method compared with references.

Sl. No.	Ref. No. (Bibliography)	Type of controller used	Settling time of speed curve (second)
1.	**Proposed method**	**ANFIS**	**0.3**
2.	[31]	Fuzzy-SMC-PI	0.4
3.	[51]	ANN	0.5
4.	[35]	Fuzzy-SMC-PI	0.5
5.	**[63]**	**ANFIS (150 rad/s)**	**0.52**
6.	[20]	SMC_H_∞_DTC	0.55
7.	[47]	ANN	0.65
8.	**[94]**	**DT-ANFIS (110 r/s)**	**1**
9.	[8]	Min_FOC	1.2
10.	[60]	Fuzzy-NN 1500 rpm	1.4
11.	[93]	ANN Genetic Algo	2
12.	[49]	SELP_T_NN	2

Also, it is observed that the PI method took **2 second**, the Mamdani method took **0.9 second** and the TS scheme took **0.7 second** to reach the set speed, whereas the ANFIS scheme took only **0.3 second** to reach the set speed.

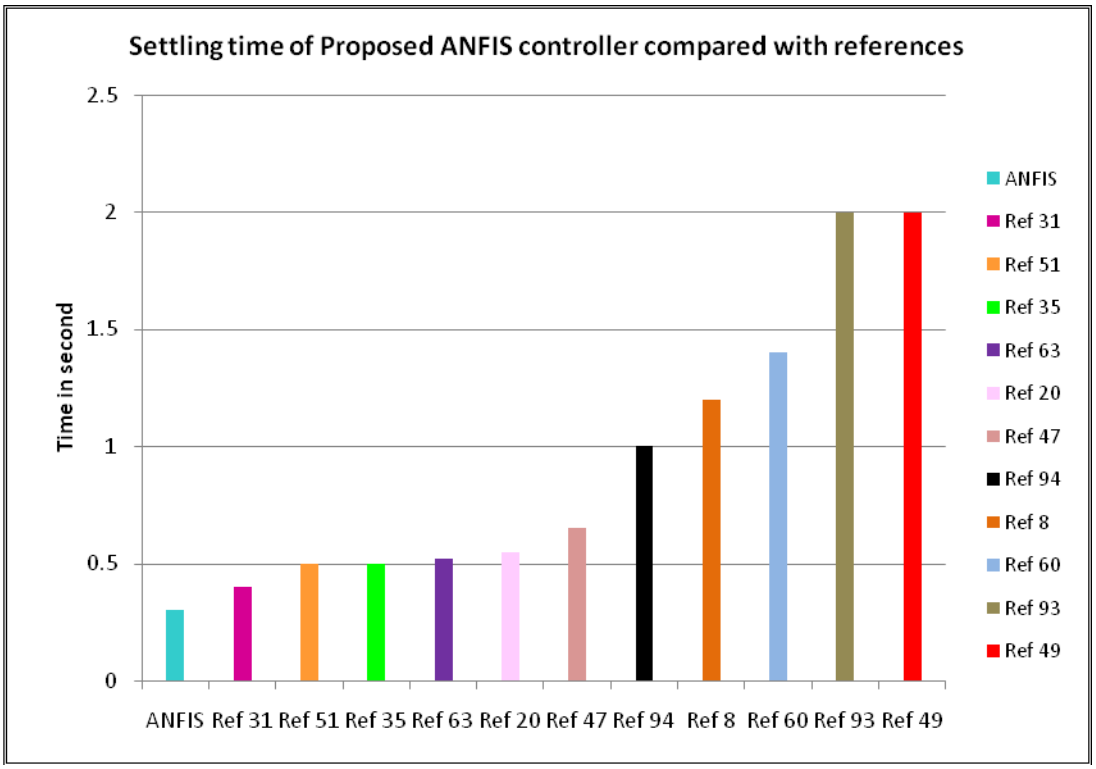

Fig 8.2: Bar chart of the proposed ANFIS method compared with references.

Further, the proposed control methods using various types of controllers presented in this thesis is being compared with the work done by various researchers till date, which is mentioned in the references / bibliography, as shown in Fig. 8.2. Many researchers had worked on the speed control of induction machines using different types of controllers. Some of them being genetic algorithms, sliding mode control, H_∞ control, artificial neural networks, PI control, direct torque control, field oriented control, etc., and combination of some of the previously mentioned controllers. This shows that the designed controller is more dynamic with the speed of response being faster compared to the other methods