Chapter-III

SUMMARY AND CONCLUSIONS

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3.0 INTRODUCTION :

The entire work on Fuzzy Approach to Chokes and coils Designing has been presented in simplified and easy-to-read form under following Three chapters –

I. **Fuzzy Logic And World Around**

II. **Fuzzy Design Methodology**

III. **Summary and Conclusions**

The ***chapter-I*** takes brief account of philosophical development of Fuzzy Sets and Fuzzy Logic, and workers involved in the pioneering work in Fuzzy. It also surveys the relevant literature concerning the Fuzzy Sets in general sense and applications of Fuzzy Logic in particular to the area of design simulations on computer.

Classification right from Aristotelian Two-Valued Logic to Fuzzy Logic has been given. The paradigm shift from Crisp Sets to Fuzzy Sets and then to Fuzzy Logic has been discussed. The very ideas of Prof. Zadeh to tolerate imprecision and model uncertainty in the information and perception of concepts have been given prime place in the introduction. An attempt to highlight the obvious plus points of Fuzzy Sets and Fuzzy Logic in conjunction with Approximate Reasoning is made.

A number of definitions of fuzzy logic given by various researchers have been included.

Good number of fuzzy based and fuzzy supporting tools exists today, such as 'Fuzzy TECH',MATLAB and many other have been given with mention of usage of programming languages like C/C^{++} in developing software intended specifically for application of interest.

Comprehensive account of up to date survey of applications is taken, including sample applications from Engineering and Scientific fields.

We have used Matlab in preparing FIS (Fuzzy inferance System) for design routes fot chokes and coils.

World-wide Research Work on applicability of Fuzzy Sets and Fuzzy Logic in Electrical and Electronics fall to one of the following category –

1. *Fuzzy Expert System (FES)*
2. *Fuzzy Logic Control (FLC)*
3. *Fuzzy Sensor (FS)*
4. *Fuzzy Logic Design (FLD)*

Brief discussion and literature survey of each category has been given. Fuzzy Sensors and Fuzzy Logic Design are the latest developments emerging in the area Fuzzy Applications. Fuzzy based chokes and coils designing belongs to Fuzzy Logic Design.

3.1 ORIENTATION OF RESEARCH WORK :

To dilute and resolve the drawbacks of past design practices, we did developed a (FIS) for designing a Chokes and coils based on conventional design algorithms. However, the methodology remained founded heavily on mathematical models, and failed to accommodate and transcribe the vital human knowledge, intuition and experience in the design process.

We took up the investigation of new methodology of a chokes and coils designing to be founded on the promising concepts of Fuzzy Set Theory and Fuzzy Logic.

4.1.1 Why Fuzzy Logic for Chokes and coils Designing?

Information of chokes and coils designing exists in two forms-

1.Numerical data about input specification like current, frequency etc.

2.Tips for good-design are generally expressed in the linguistic form, such as-

"Size reduction is best achieved by keeping the losses minimum".

- Fuzzy Logic helps in interfacing numerical data with symbolic labels. It allows integrating traditional technique with domain information available in the linguistic form, and helps to improve quality of design.
- Common source of fuzziness is the complexity of dependencies amongst various parameters. This is one of most important and critical part of chokes and coils designing.
- Lack of proper communication and language between the customer, casual experimenter and chokes and coils designer; end up with opposing views on many design specifications.

- Fuzzy Logic has ability to model system involving multiple experts and to find priority by including multiple criteria in the selection process and connecting them by fuzzy logic rules.

Even in its simplest form chokes and coils designing goes through following three phases -

I. Furnishing the correct specifications - [Operating frequency, Current etc.]

II.Calculation of design-parameters -[Core-area, Wire-size,Window-space etc.]

These phases of chokes and coils designing directly or indirectly involve the human factors that ultimately make the design problem of chokes and coils a good target for Fuzzy Logic.

3.2 MODELING AND METHODOLOGY :

The ***chapter-II*** is devoted to fuzzy based design methodology. The fuzzy Design methodology has been developed for the chokes and coils on the platform of Fuzzy Logic.

In the first half of this chapter, classification of Fuzzy System models has been covered. The standing of our problem in the classification tree has been highlighted, which gives better view of significance of employing Fuzzy Logic in the design process of a chokes and coils.

Various design styles of chokes and coils designing have been listed and it is pointed out how the conventional design practices fail to transcribe the human knowledge pertaining to the design tactics and design solutions expressed in the verbal forms, like –

"Turns per volt figure need to be increased"

Such and other colloquial terms are well manageable by human being, but for computers these tasks are disaster and fail to stipulate any reliable results. Fuzzy Logic has ability to model the human knowledge and work with imprecise, vague, incomplete and inconsistent data/information using the apparatus of approximate reasoning. This makes the problem of chokes and coils designing a good target problem for Fuzzy Set Theory and Fuzzy Logic.

3.3 OVERALL REVIEW OF RESEARCH WORK :

Recent fascinating developments and increasing applications of Fuzzy Logic in India infatuated us and immediately we undertook investigation work to examine the possible use of Fuzzy Logic to over come some of the difficulties coming across in the process of chokes and coils designing, or at least dilute them. With this aim we started working on a new methodology of chokes and coils designing to be founded on under lying principles of Fuzzy Sets and Fuzzy Logic.

Methods employed in the chokes and coils designing are legion, but there is no agreed upon one standard approach. One of the reasons could be the uncertain overlapping space existing between conventional mathematical design tool and 'trade-off' exercised during the building of a practical chokes and coils designing.

We exploited the Fuzzy Logic within the framework of 'approximate reasoning' in modeling the 'trade-off' solutions. Designing of chokes and coils

involves Electrical data computations based on the standard ingredients available followed by the mechanical placing of winding tight into the core window. A fuzzy module called fuzzy logic choke design algorithm **[FLCDA].**

3.3.1 FUZZY LOGIC CHOKES AND COILS DESIGN ALGORITHM [FLCDA] :

The very aim of **FLCDA** – the first phase of fuzzy based chokes and coils design is to accommodate human designer's perceptions of looking at the specifications. And then assign situation based fuzzy number to few specifications needed to stimulate the design problem and optimize them through compromised decisions as illustrated in the design examples.In case of Fuzzy Coil Design a sample design has been worked out and results have been given.

Module FLCDA performs the following tasks –

- Accept the initial specifications from the customer
- Add further specifications either from the designer or on fuzzy mode infers them based on fuzzy reasoning
- Compute the data on core and make the proper selection of core. The data on core include-
    1. Core cross sectional area
    2. Core window area
    3. Type and dimensions of selected EI-core
    4. Core grade and quality of EI-stampings

- Compute the data on winding and make the suitable selection of wires. The data on wires include –

    1. Number of turns
    2. Diameters (Size)
    3. Standard Wire Gauge (SWG)

At the end it displays the results of chokes and coils designing. FLCDA establishes the fuzzy mapping between Core Area and Turns per Volt.

The fuzzy approach on computation of electrical data of chokes and coils permits the designer to assign guess-figures, approximations and imprecise values for specifications at the beginning and adjust them in iterations to yield better and optimal results.

It is observed that the FLCDA facilitates easy incorporation of experience and thumb rules exercised by expert designers and chokes and coils builders. Specifications plugged into mathematical equations generally end with non-satisfactory results. This is mainly due to disparity between computed data and available dimensions of standard ingredients of chokes and coils, such as core with specific area, window space and grade, winding wire in standard SWGs. Under such situations, FLCDA is programmed to foresee the consequences and take anticipated qualitative decisions in the initial stages itself, to ease the further design consolidations.

For instance, in the event calculated core area is smaller than that actually available for selected EI-core, then FLCDA as human designer do, goes for increased 'turns per volt' ratio to maintain the flux density. Such tactics have been also followed for efficiency foreseen through current density (losses) and wire sizes through satisfactory degrees of selection of SWG.

On investigation level only essential data has been referred to, which can be widen as a next step of enriching the fuzzy based chokes and coils designing.

The unique features of FLCDA are –

1. First time use of Fuzzy Logic in chokes and coils designing.

2. The user has option either to choose the design data on core and wire from his own judgements or in case of flustering situation he has an option to avail module's knowledge in selecting the design data fuzzy logically.

3. It has flexibility to modulate new data on core and wires, as the data-base is kept independent of main program.

4. It has rule-tuning facility through reshuffling of domains of fuzzy subsets on UoD and modulating the scaling factors.

The potentiality of FLCDA however lies in defining the membership-functions and derive '*If-Then*' rules that exactly reflects the designer's reasoning process.

At this stage of infancy of FLCDA only required minimum data have been referred to and only preliminary results have been successfully implemented.

3.4 EXPERIMENTAL RESULTS

The simulated results are shown in table 3.0 for the input specification shown in table 2.1. Results are in good agreement with past design practices. Design of a Choke/coil invokes the knowledge of an experienced Choke/coil designer. Even in case of simple low frequency filter Choke, many design steps, good amount of decisions and number of iterations are involved. In the initial phase of Choke designing its electrical performance receives prime consideration followed by the mechanical requirements that ultimately determines size, shape, weight, cost and reliability of operation. The Choke/coil designing is largely a cut-and-try procedure, which starts with selection of core size and wire dimension made as first approximation based on the equations, past experience and thumb rules. Upon achievement of satisfactory electrical performance the next step would be checking the mechanical fit of windings into the core-window space.

Trial design problems have been worked out using FLCDA and quite satisfactory preliminary results obtained, have been compared with conventional algorithm.The FLCDA computes the figures for various variables of choke and coil during thedesigning.

3.4.1 Sample Design Problem: High Voltage Medium Current Choke

Specifications:1.AC (input) Voltage= 230 VAC, 50Hz, Sine Waveform

2.Current = 0.5 A.

From the computed figure for core area and tongue width, the good choice as per Indian Standard the EI-core selected is

Type No. : 30 , Grade : C.R.G.O., Squarish core area, a = 1.0 Sq. cm.

Parameter	Conventional Technique	FLCDA Techniques
Core-cross section Area	8.740 Sq. cm.	8.89 Sq. cm.
Turns per Volt ratio	4.69	4.83

Table 3.0 Comparative results of sample design

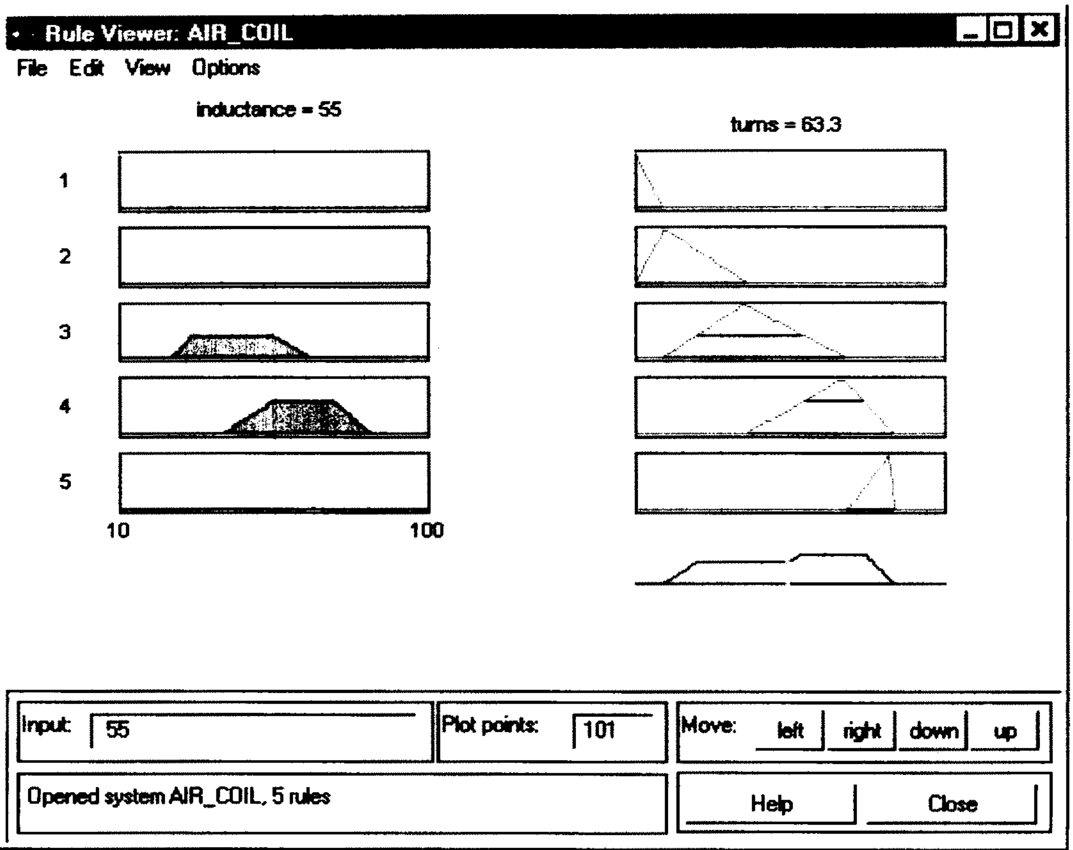
3.4.2 Sample Design Problem: general purpose coil

Specifications: Inductance = 50 μH

Physical dimensions: Radius = 1 cm, Length = 2 cm

Output Result:Number of Turns

Conventional Technique = 61, FLCDA Techniques =60



3.5 FUTURE DEVELOPMENTS AND REFINEMENTS :

We have taken sincere efforts to bring up the wonderful ideas of Fuzzy Sets and Fuzzy Logic in the process of chokes and coils designing. We have exercised

and practiced the use of approximate reasoning while dealing with ambiguous decisions needs to be taken over imprecise data.

Fuzzy Logic has rooted very deep into the area of control industry and decision-making Expert Systems. We thought in the other way to explore and exploit the illuminating ideas of Fuzzy Sets and Fuzzy Logic in the field of Electrical and Electronics component and circuit designing. With this notion in our mind we launched the research on the usage of Fuzzy Sets and Fuzzy Logic in the design process of a chokes and coils and, today to a good extent we are succeeded in doing so. However, ample scope exists to overcome and surmount the pitfalls that have remained in our attempt. For instance-

Limited and restricted data-base.

Missing of error-prone data entry indication.

Tuning of rule-base with new data remains non-transparent to the user, unless he becomes well acquainted with operation of MATLAB-tool and data files

Fuzzify the process of mechanical fit of winding in to the core space available.

There are plenty of degrees of freedom in developing the Fuzzy Systems. This opens up many opportunities to refine and enrich Fuzzy based design algorithm at least with following regards-

Encompass FLCAD-tool with greater amount of data.

Try other shapes for membership functions.

Examine the possible use of other implication and defuzzification methods.

Go for automatic selection of mapping between the design variables during the parameter optimization process.