

## **2.0 Research Objectives and Thesis Organization**

### **2.1 Problem Definition**

Design is an iterative process in which we proceed through several specific steps based on the design criterion, evaluate the results, and then return to an earlier phase in the procedure if some design limitation has not been satisfied. The traditional way of design is that the designer refers to a machine design book to familiarize himself or herself with the design procedure, specifies the known parameter values in the requisite formulae to calculate the unknown parameter values, chooses the appropriate weighing factors based upon application and usage, and proceeds to the next step in the design process on obtaining satisfactory results. All the calculations are performed by means of a calculator and the results are noted on paper to maintain a record of the process. A designer may have to perform several computations, and try out several initial values before arriving at a satisfactory solution for each step in the design. In addition, back-calculations may also need to be performed to recalculate design parameters after standardization. These calculations require data from standards, various tables, graphics and other sources [Dimi93]. The designer has to often refer back and forth, to the appropriate tables and

graphs, to select suitable design parameter values and to the appropriate standards to make the final design selection.

Due to the increasing awareness of the Internet as a source of information, an increasing number of machine element manufacturers have information regarding the design of a machine element on their websites. These sources can be harnessed and made available to the machine designer at the desktop, so that the designer can refer to pertinent information during the design process.

As is evident, design is a time-consuming process. Building a system that helps the designer catalogue on the desktop all the design information pertaining to the design of a machine element can considerably shorten the time spent in the design process. This includes allowing the designer to track information regarding machine elements on the Internet, and a means of saving this information on the desktop so that it is readily available for reference during the design process. In addition, the system must perform computations and provide quick access to the graphs, tables and standards regarding the design of a particular machine element. The limitations imposed due to space restrictions and design specifications need to be constantly referred to, while performing the calculations, to check for compliance and must be available for reference. The paper and pen routine of recording design data can also be replaced by providing a means of documenting the design process. As can be seen from the above discussion, the problem here is manifold owing to the non-linear and heuristic nature of design [Redd96]. In

addition, the attempt to not inhibit the designer's creativity involved in the design provides an added dimension to the problem.

## **2.2 Research Objectives**

The objective of this research is to build a system to aid the designer in the process of the design of machine elements in the following ways:

- To allow the designer to track and catalogue information that is available on the Internet, pertaining to the design of a particular machine element, on the desktop;
- To reduce the time involved in design by an appropriate arrangement on the desktop of the various tables, standards and graphs, pertaining to the design of a particular machine element;
- To reduce the time involved in the computation of various design parameters;
- To allow the designer to study changes due to variation in design parameters; and
- To provide a means of documenting the design process.

The focus is not only on reducing the design time but also to maintain an effective record of the final design parameters. The design of machine elements involves proceeding through several specific steps based on design criterion, evaluating results and returning to an earlier stage in the design process if the design constraints are not satisfied. There are various iterations that a designer may have to perform before finalizing a design parameter for a particular machine element, and a record of the various iterations needs to

be maintained. Thus, it is an iterative process and the decisions taken regarding the effectiveness of the design is dependent on the designer's perspective.

In spite of a simple goal, the means are deemed complex, as the system requires the integration of many disparate applications [Mill96]. The objective of this research is to provide the designer with a tool that aids the design process by providing a means of arranging all the resources pertaining to the design of a machine element without stifling the designer's creativity.

### **2.3 Proposed Method**

In order to develop a system to best aid the designer in the design process, it is essential to analyze and design the system prior to the implementation. For the test case, the design procedure prescribed by Shigley [Shig83] was chosen as it has found widespread acceptance as a reference for the design of machine elements. The methods prescribed by Yourdon [Edwa89] and Whitten [Whit98] were followed to develop models for the system prior to the implementation. This included developing the environmental and behavioral models.

On careful study of the machine design process, the essential components of the software application were identified:

- A means to store all the graphs, tables and standards that the user may refer to in the process of design on the desktop.

- Development of a suitable graphical user interface to display the above information.
- An implicit equation solving tool having an additional ability of back-solving.
- A means of interfacing with the World Wide Web to collect design information.
- A means of documenting the design by providing a means of saving optimal values.
- A means of interfacing the above components to form a single application.

Visual Basic is based on one of the world's most widely known languages, Basic, and is endowed with the ability to build applications for Microsoft® Windows - the world's most widely used platform [Deit99]. In addition, the language is appropriate for implementing Internet-based and World-Wide-Web based applications, and it contains built-in features such as graphical user interface components, file processing, linking to other Microsoft products such as Microsoft® Word and Microsoft® Access, and database processing. The language is extensible so that independent software vendors (ISVs) can provide componentry for a vast array of application arenas.

Solving and back-solving formulae to calculate design parameters are a critical aspect of the machine design process, owing to the heuristic and iterative nature of design. In addition, the known and unknown parameters may lie on either side of the equation, depending upon the design parameter that needs to be calculated. TKSolver® is an application that has been developed by Universal Technical Systems Inc. [Ugtk99]. The advantage of this application lies in the fact that there is no need to isolate the dependent variables on the left side of the equation; thus, reducing to a minimum the required algebraic manipulation of equations [Renc96]. Thus, any desired combination of the

known and unknown variables can be explored without rewriting the equations. The reasons for selecting TKSolver as the program of choice for this application are:

- *No need to isolate dependent variables:* The independent equations can be solved for values of unknown design parameters without introducing algebraic manipulation.
- *Equations may be entered in natural form:* Symbolic equations can be directly entered into TKSolver in the form they are derived.
- *Easy exchange of known and unknown variables:* TKSolver can solve for different combinations of known and unknown variables without having to rewrite the equations.
- *Linking with Visual Basic:* TKSolver adheres to COM specifications [Ugtk99], and it can therefore link with other products such as Visual Basic.

Given below is a list of the tools used in developing this system:

- Microsoft® Visual Basic 6.0 to develop the front-end application.
- TKSolver® as a back end to solve for the unknown parameters in the equations.
- Microsoft® Access 97 as the database for storing the equations, tables and standards for subsequent retrieval.
- Microsoft® Word 97 to document the design.

## 2.4 Thesis Organization

The system proposed in this research is a generic system for the design of machine elements. The reader has had a brief overview of the important features of the proposed methodology. Given below is a brief outline of the topics discussed in this thesis:

1. Introduction
2. Problem Definition, Proposed Methods, Research Objectives, and Thesis Outline.
3. Literature Review
4. System Analysis
5. Results
6. Conclusions
7. References

The material is presented with a view to allow readers at different levels to quickly locate areas of interest. The system analysis section acquaints the reader with the methodology used for developing a generic system for helping the designer to design machine elements. The section deals with the model of the functions of the proposed system using data flow diagrams and the description of the data model using the entity relationship diagram. The source code for the software developed using Microsoft® Visual Basic 6.0, TKSolver® and Microsoft® Access 97 is included in the appendix.