Chapter 3: Research Objectives and Methodology

Chapter 2 presented a review of various Flexible Fixturing Systems (FFS) and Computer Aided Fixture Design (CAFD) systems, considering the different approach areas, the merits and limitations and the scope for further research work. This chapter summarizes the findings of the literature review and industrial survey conducted, by stating the objectives of this dissertation. Subsequently the methodology adopted to achieve these objectives is presented in section 3.2.

3.1 Research Objectives

Section 1.4 listed the high level objectives of this research, and this section expands upon these aims. There are two parts of the research objectives, one related to the flexible fixture selection, adjustable fixture hardware and the other is the expert system for adjustable fixture design based on Case Based Reasoning.

The objectives with respect to selection of suitable flexible fixturing and the adjustable fixture hardware are,

1. To propose a suitable flexible fixture design system for manufacturing of parts with large variety and low volumes. The aim is to provide a decision making for selecting a fixture design system suitable for the said type of production so as to adopt and transform the dedicated fixturing systems gradually into flexible fixturing systems.
2. To develop a generic classification and coding system for workpieces with fixturing features in addition to the geometric features. To establish criterion for part family formation of workpieces with fixturing features.
3. To develop a suitable classification and coding system for adjustable fixtures, for the effective handling and manipulation of the fixture design data. To establish criterion for selection of appropriate fixture from available fixture family of adjustable fixtures.
4. To develop standardized and modularized fixture design data base for adjustable fixtures for the processing of the workpieces belonging to similar...
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part family irrespective of the machine tool used. To develop generic design heuristics for adjustable fixture design for selected part families.

The objectives with respect to Computer Aided Fixture Design are,

1. To develop an approach for assisting the fixture designers in the development of flexible fixturing system for part family. The aim is to develop a strategy for designing flexible fixtures by applying hybrid fixture design approach from variant to generative fixture design.
2. To assess and select a methodology suitable for Computer Aided Fixture Design System (CAFD).
3. To define task elements of CAFD those are required for a part family.
4. To develop a CAFD that integrates the fixture design strategy, fixture design activity and fixture design verification into a single design tool.
5. To develop a prototype Computer Aided Adjustable Fixture Design (CAAFD) System for a given part family based on Case-Based Reasoning methodology.
6. To develop a software implementation that demonstrates the operation of prototype CAFD system.

To achieve the above objectives, Case-Based Reasoning (CBR) approach was used. The fixture design activity is a task that is purely based on previous experience and majority of the fixture designs are variants of previous design. This makes the usage of CBR suitable for fixture design tasks, which is based on the concept that similar problems have similar solutions.

To apply the CBR methodology effectively in fixture design following CBR specific objectives need to be satisfied.

- A generic classification and coding system for the workpiece, fixture elements and assemblies of fixtures is required to be developed for the storage and retrieval of design data.
- When the classification and coding system is developed, it is essential to establish a method for specific similarity analysis of the coding system.
• As the design cases are available, a specific case representation strategy is required to be adopted to represent the workpiece and fixture cases in the library.

• Based on the classification and coding system and similarity analysis, a suitable indexing and retrieval strategy and mechanism is required to be designed.

• Case modification and case verification are the important stages in CBR. It is essential to decide the fixture specific assembly modification method suitable to adjustable fixture design.

• When the fixture is reconfigured its performance needs to be assessed interactively at the design stage to ensure the quality of the design, therefore a mechanism to assess these performances needs to be designed.

• The storage of previous successful cases is required to be worked so that they can be used to assist the fixture designers in future when similar fixturing requirements are generated.

• It is essential to study the different part families and their adjustable fixture designs to be worked and stored in the library as knowledge base and to demonstrate the working of the prototype software.

• It is required to apply suitable techniques to validate the design methodology and the prototype expert system based on CBR.

3.2 Proposed Methodology

To achieve these objectives, the Computer Aided Adjustable Fixture Design methodology (CAAFD) is proposed. One of the primary objectives of the CAAFD is to select the suitable adjustable fixture for processing of parts with similar fixturing features and processing requirements so that rapid fixture design can be generated. Initially, the workpiece is required to be checked for the membership of a typical part family based on the part family criterion. To establish the criterion, the development of a generic classification and coding system for the workpiece and fixtures is to be used. To support this activity a similarity analysis is proposed.
Once a part is recognized as a member of a part family then its corresponding adjustable fixtures design can be selected from the data base of fixture designs. Both these activities can be well supported by using a Case-Based Reasoning (CBR) approach, in which previous successful design cases can be retrieved and adopted as per the input problems. Within the CBR model, the classification and coding proposed helps in developing the indexing of cases and retrieval of the suitable cases. The case retrieval process can be accelerated by using template retrieval, and the useful case can be selected by using similarity analysis. For retrieval of fixture design cases the application of similarity analysis is proposed to select a suitable family of adjustable fixtures. Once a suitable family of fixture is retrieved it is essential to select the most suitable adjustable fixture for the candidate workpiece. The criterion for the adjustability of a workpiece is to be proposed, and the same is required to be used for fixture selection. A quantitative evaluation of the same is required to be established.

It is likely that the retrieved adjustable fixture design may accommodate the candidate workpiece. In such case, the fixture design is to be completed through interactive case modification, usually by adjustment of the locators, supports and clamps etc. If it is not possible to accommodate the candidate workpiece in the existing configuration of the available fixture elements, then it is proposed to apply variant fixture design process and a reconfigurable fixture design can be generated by modifying, adding or eliminating some of the fixture elements. Once the fixture is reconfigured by adjustment or modification of fixturing elements, then it is essential to verify the fixture design. Two major and important verification procedures are proposed to ensure the quality of new reconfigured fixture design, namely interference analysis and stability analysis. An interactive and rapid interference checking algorithm and simplified stability analysis algorithm is proposed. For retrieval and storage of fixture element data in the library a point model of fixture elements is proposed. The same can be used for the interference analysis and stability analysis. Finally, to demonstrate the operation of the CAAFD methodology a software implementation is developed using Visual Basic -6 having interface with 3 D modeling software, CATIA V5R-16. A particular advantage of using CATIA is its facility to develop the family tables for the workpieces, fixture elements, and adjustable fixtures.