CONCLUSIONS

In this chapter, a summary of the contributions made by the present research work and few suggestions for further research are presented. In the present work on Intelligent Design of Progressive Dies, five important problems have been investigated.

The first problem is to develop a knowledge-based system module for checking the design features of sheet metal parts from manufacturability point of view. Since the design of strip-layout forms the next stage of progressive die design, investigations have been made to develop an intelligent CAD system for design and modeling of strip-layout. The problem of selection of proper types and dimensions of progressive die components has been tackled through the development of a knowledge-based system. For automating the modeling of progressive die components and die assembly, an intelligent modeling system has been designed. Finally, an intelligent system has been developed for selection of suitable materials for progressive die components.

8.1 CONTRIBUTIONS OF THE PRESENT RESEARCH WORK

The basic elements for constructing knowledge-based system are considered and analyzed critically to tackle the progressive die design problems. Based on the considerations and critical study of the traditional process of progressive die design, a knowledge-based system framework has been developed. In this framework major activities of progressive die design have been identified in the form of knowledge-based system modules. To construct
these system modules, a procedure has been developed. The interfacing of AutoLISP and AutoCAD has been utilized in the development of system modules.

A knowledge-based system module CCKBS has been developed for checking the design features of sheet metal parts such as size of blank, size of holes, hole pitch, corner radius, distance of the internal features from the edge of the part, distance between two internal features, width of recesses or slots or projections, bend corner radius etc. The module also recommends the minimum scrap web allowances for manufacturing the parts on a progressive die. The module SELDIE has been developed for assisting the users for selection (selecting the) of suitable type of die.

The module MAXUTL has been proposed for determining the orientation of blank for maximum possible utilization of sheet. The process of strip-layout design has been automated through the development of an intelligent system ISSLD. The proposed system has been structured into six modules. The system imparts intelligent advices on the type of sheet metal operations required for manufacturing the parts, sequencing of operations, selection of proper piloting scheme, number of stations required and preferred staging of operations on progressive die; and selection of suitable sheet width and feed distance (i.e. pitch). Finally, the system automatically models the strip-layout in the drawing editor of AutoCAD. For selection of suitable type of press machine for the modeled strip-layout, a module PRSSEL has been developed.

A knowledge-based system PROCOMP has been designed to impart intelligent advices for selection of type and dimensions of major progressive die components namely die block, die gages (front spacer and back gage), stripper plate, punch plate, back plate, punches, die-set and fasteners. The system has been structured into seven modules and these modules have

236
been designed to store their outputs in various data files, which are recalled during automatic modeling of die components and die assembly.

The modeling of major die components namely die block, stripper plate, back plate, punch plate, bottom bolster, top bolster, and die assembly of progressive die has been automated through the development of an intelligent modeling system AUTOPROMOD. This system comprises of eight modules. These modules recall output data files generated automatically during the execution of modules developed for strip-layout design and selection of progressive die components.

An intelligent system SMPDC has been developed for selection of materials for progressive die components and selection of close hardness range of selected materials. The system has been structured in the form of two modules.

The proposed knowledge-based system INTPDIE developed for intelligent design of progressive dies is a low cost alternative for process planners and die designers working in small and medium sized sheet metal industries. The system INTPDIE overall comprises of more than 650 production rules of IF-THEN variety coded in AutoLISP language. However, the system is flexible enough as its knowledge base can be modified and updated depending upon the capabilities of a specific shop floor and advances in new technology. System modules are user interactive and designed to be loaded in to the prompt area of AutoCAD. The system has been tested for a wide variety of industrial sheet metal components. Required input data and advices imparted by the system modules for four example components are tabulated in Appendix-II. Recommendations with regard to checking of design features of sheet metal parts, design of strip-layout, selection of die components and selection of materials for progressive die components, and drawings generated by the system were found to be

237
reasonable and very similar to those actually used in sheet metal industries. The proposed system is capable of accomplishing the time-consuming task of progressive die design process in a very short time period. The system finally generates the drawings of progressive die components and die assembly.

The proposed system INTPDIE is limited to the design of progressive dies only. However, the system can be extended further for the design of other types of dies also.

8.2 SUGGESTIONS FOR FURTHER RESEARCH

The present investigation contributes to the growing field of knowledge-based system for intelligent design of progressive dies through the development of modules for checking the part design features, selection of type of die, strip-layout design, selection of progressive die components, automatic modeling of die components and die assembly of progressive die, and selection of materials for progressive die components. Although the knowledge-based system developed in the present work is ready for use in the sheet metal industries, there is scope for further improvements. Few suggestions for further research are given below.

1. A system can be developed for analysis of die design data from strength point of view using Finite Element Analysis (FEA) or some other suitable approach.
2. Investigations can be made for prediction of die stresses and die life.
3. A post processor program can be developed, which is capable of connecting the outputs of the proposed knowledge-based system to the Computer-Aided Manufacturing (CAM).
4. Investigations can be made for the development of knowledge-based system for intelligent design of other types of dies also such as drawing die, bending die, forming die, combination die and compound die.

238


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