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An expert system for design of progressive die for use in sheet metal industries

Shailendra Kumar[1]*, and Rajender Singh[2]

[1]Department of Mechanical Engineering, S V National Institute of Technology, Surat 395007, India

[2]Department of Mechanical Engineering, D C R University of Science & Technology, Murthal 131039, India

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An expert system for design of progressive die (ESPDIE) has been developed for die designers working in sheet metal industries. Production rule based expert system is utilized for constructing system modules. All modules are user interactive and designed to be loaded in AutoCAD. System is capable of automating all major activities (checking design features of sheet metal parts, design of strip-layout, selection of progressive die components, modeling of die components and die assembly, and selection of materials for die components) of design of progressive die.

Keywords: AutoCAD, Expert system, Progressive die, Stamping industries

Introduction

Design of progressive die is a complex and highly specialized procedure. Under development of computer aided designs for progressive die, Murikama & Shirai[1] developed a CAD/CAM system to generate assembly and dimensioned part drawings as final output but strip and die layouts are done manually. An integrated modelling and process planning system[2] have been developed for planning bending operations of progressive dies. Sim *et al*[3] developed center carrier type progressive die for U-bending part process. Ghatrehnaby & Arezoo[4] developed an automated nesting and piloting system for progressive dies. Duffy & Sun[5] developed a knowledge-based system for design of progressive stamping dies using a feature-based approach. Lee *et al*[6] developed IKOOPP, an intelligent knowledge-based process planning system for manufacture of progressive die plates. Cheok *et al*[7] developed an intelligent planning aid for progressive die design using PC development tools. Ismail *et al*[8] worked on expert systems for progressive piercing and blanking die design. Zheng *et al*[9] developed intelligent CAPP system for automobile panels. There is a stern need to develop an expert system to automate design of progressive dies using both CAD and AI technology collectively. This study presents development of ESPDIE (expert system for design of progressive die).

*Author for correspondence
E-mail: skbudhwar@med.svnit.ac.in

Experimental Section

Expert System for Design of Progressive Die (ESPDIE)

Procedure for Development of ESPDIE

Procedural steps[10] for development of ESPDIE includes knowledge acquisition, framing, verification and sequencing of production rules, identification of hardware and computer language, construction of knowledge base, choice of search strategy, and preparation of user interface. ESPDIE is implemented on PC (Pentium 4 CPU, 2.4 GHz, 256 MB of RAM) with Autodesk AutoCAD 2004. Production rules (> 1000) incorporated in all modules of ESPDIE were coded in AutoLISP language. As progressive die design process comprises of many activities, whole system has been structured into various sub-systems, modules and sub-modules[11] (Fig. 1) as follows:

Module CCKBS (Component Check Knowledge-Base System)

CCKBS is developed for checking design features[12,13] (size of blank and holes, hole pitch, corner radius, distance of internal features from edge of part, distance between two internal features, width of recesses /slots / projections, bend corner radius etc.) of sheet metal parts. It also recommends minimum scrap web allowances for manufacturing parts on a progressive die.

Module SELDIE (Selection of Die)

SELDIE is developed to assist die designer and process planner in selection of a suitable type of die for manufacturing of sheet metal parts.

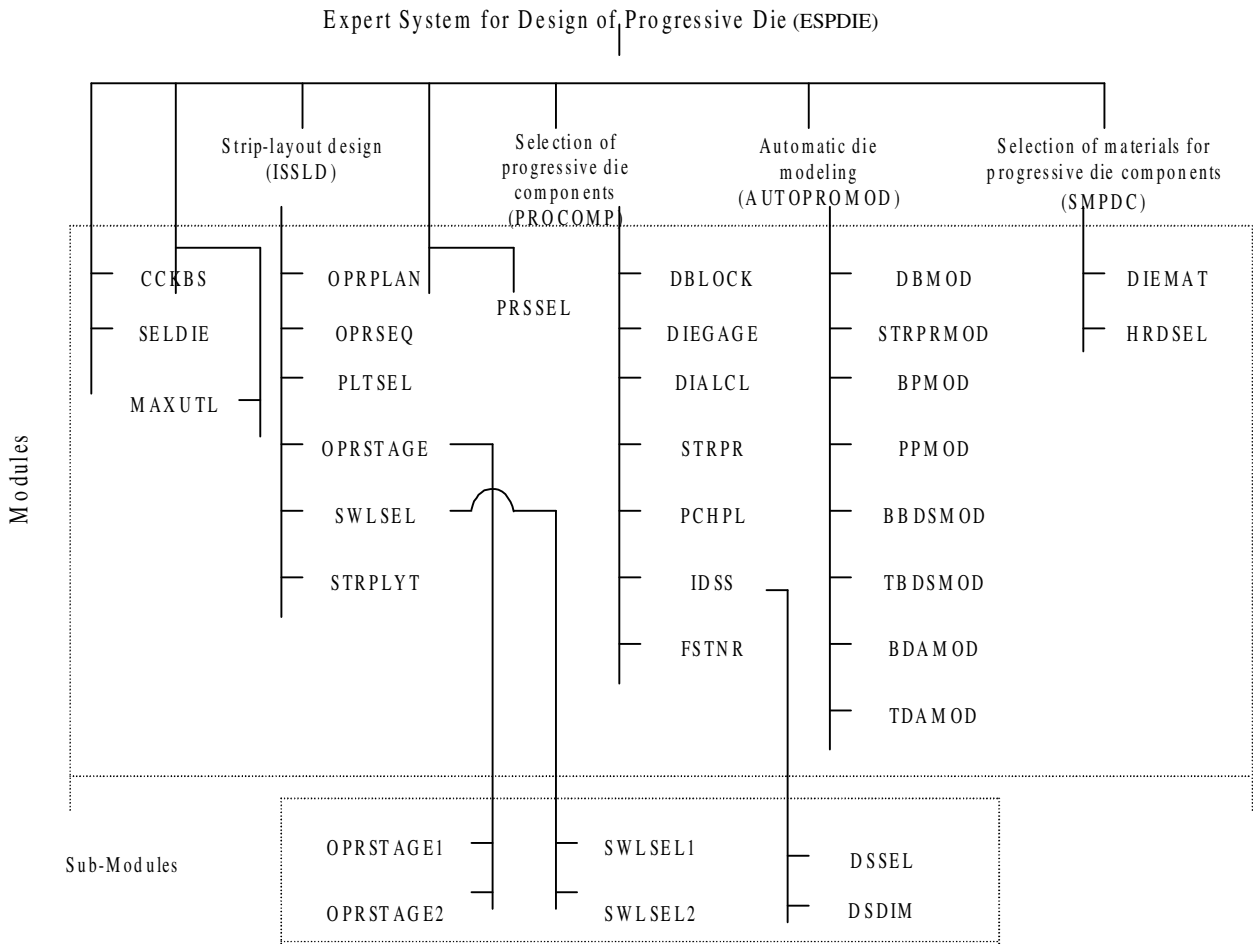

Fig. 1—Organization of expert system for design of progressive die (ESPDIE)

Module MAXUTL (Maximum Utilization)

MAXUTL is developed for determining angle of orientation of blank.

Sub-system ISSLD (Intelligent System for Strip Layout Design)

ISSLD is developed for intelligent design of strip-layout for metal stamping work on progressive die. ISSLD has 6 modules [OPRPLAN (Operation planning), OPRSEQ (Operations' sequencing), PLTSEL (Piloting selection), SWLSEL (Sheet width and length selection), OPRSTAGE (Operations' staging) and STRPLYT (Strip-layout)].

Module PRSSEL (Press Selection)

PRSSEL is developed to assist user in selection of suitable type of press machine for carrying out required sheet metal operations on progressive die. Program of module calculates and displays unit cost of part on each candidate press machine. Finally, it identifies press machine, on which sheet metal part can be produced most economically.

Sub-system PROCOMP (Progressive Components)

PROCOMP is developed to tackle selection problem of progressive die components. PROCOMP is structured in 7 modules [DBLOCK (Die block), DIEGAGE (Die-gage), DIALCL (Die angular and linear clearance), STRPR (Stripper), PCHPL (Punch and punch plate), IDSS (Intelligent die set selection) and FSTNR (Fasteners)].

Sub-system AUTOPROMOD (Automatic Progressive Modeling)

AUTOPROMOD is developed for automatic modeling of progressive die components and die assembly in drawing editor of AutoCAD. AUTOPROMOD has 8 modules [DBMOD (Die block modeling), STRPRMOD (Stripper modeling), BPMOD (Back plate modeling), PPMOD (Punch plate

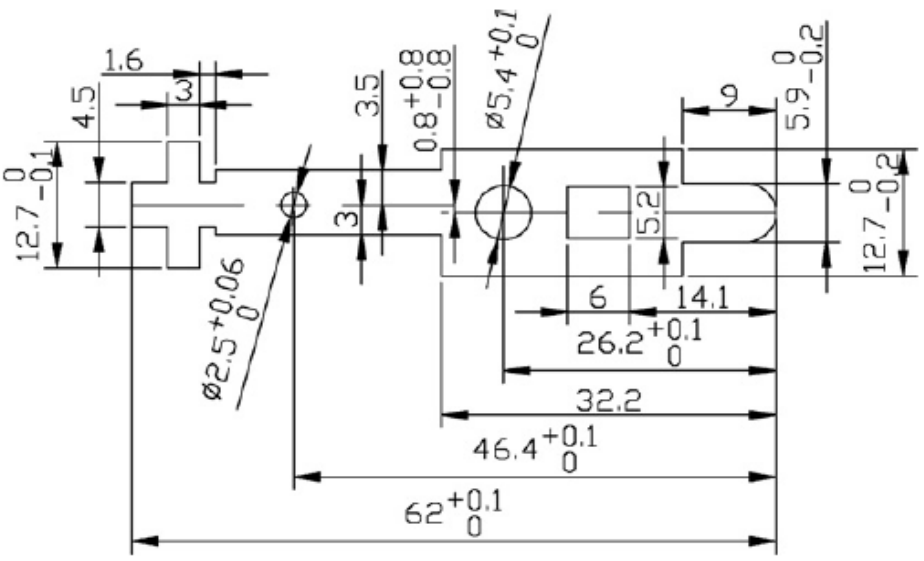

Fig. 2—Example component (material, brass; sheet thickness, 0.6 mm; other dimensions, mm)

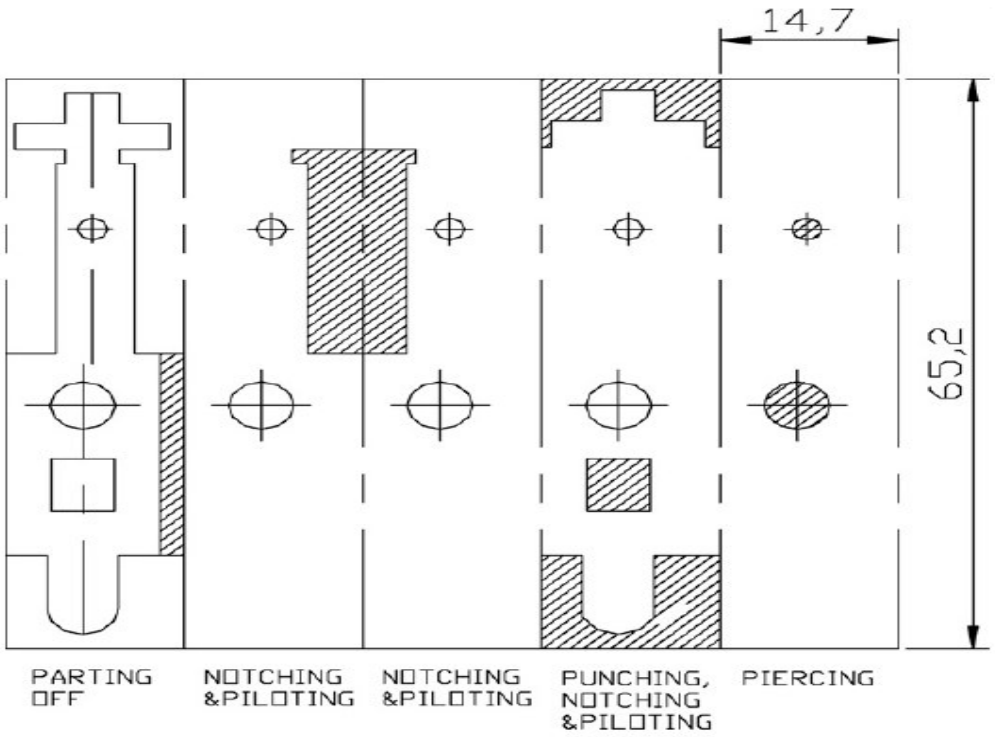

Fig. 3—Strip-layout generated by proposed system for example component

modeling), BBDSMOD (Bottom bolster die-set modeling), TBDSMOD (Top bolster die-set modeling), BDAMOD (Bottom die assembly modeling) and TDAMOD (Top die assembly modeling)]. This sub-system works in tandem with PROCOMP.

Sub-system SMPDC (Selection of Materials for Progressive Die Components)

SMPDC is developed for selection of materials for progressive die components. SMPDC has 2 modules [DIEMAT (Die material) and HRDSEL (Hardness

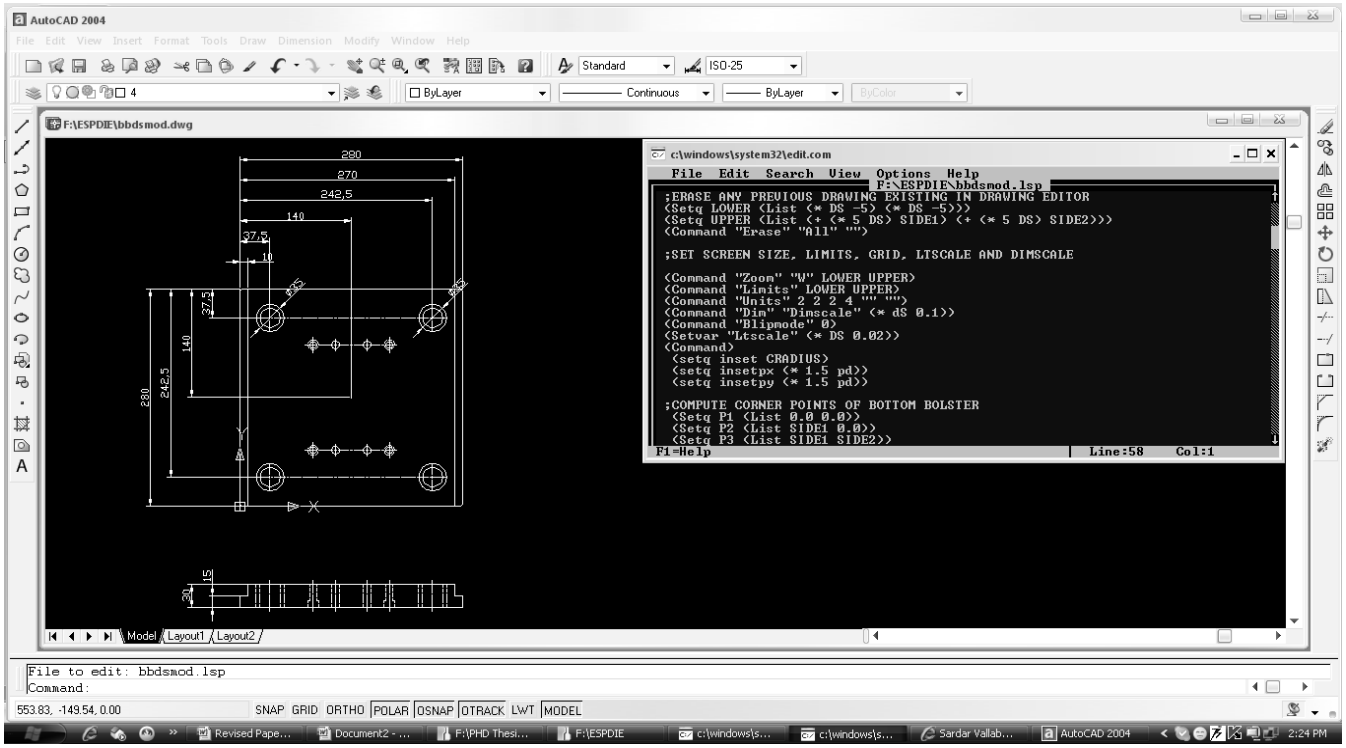

Fig. 4—Sample run of system generating top and bottom views of bottom bolster of die-set in AutoCAD for example component

selection)]. Output of sub-system includes intelligent advices for material selection for progressive die components and selection of close hardness range of material selected for punches and die/inserts.

Results: Sample run of ESPDIE

ESPDIE is tested for different types of sheet metal parts for design problem of progressive die. For one example component (Fig. 2), strip-layout generated by ESPDIE is shown in Fig. 3. Fig. 4 shows sample run of systemwhile generating drawings of bottom bolster of die-set in AutoCAD. Recommendations obtained by system and drawings generated were found to be reasonably close to those actually used in industry (M/S Indo-Asian Fuse Gear Pvt Ltd, Murthal, Haryana, India) for example component. ESPDIE takes only few minutes to complete design process of progressive die and generates output in detailed and assembled drawings.

Conclusions

ESPDIE automates progressive die design for use in sheet metal industries. It is flexible enough as its knowledge base can be modified and updated depending upon capabilities of a specific shop floor and advances in new technology. All modules of ESPDIE are user interactive and designed to be loaded in AutoCAD. ESPDIE was tested for a wide variety of industrial sheet metal components. It can accomplish tedious and time-consuming tasks of progressive die design in a very short time, and can also be extended for design of other types of dies.

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