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Research Article

Mini Review on Designing of Press Tools for Sheet Metal Parts

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Abstract: The model caters also for variation in the characteristics of the tool material, in the sense that a highly wear resistant tool is normally composed of carbide tips around its cutting profile Clearance plays important role in Punch design. A good clearance design not only increases the quality of product manufactured, but also reduces product's burr. Hence it implies that there is need to design such press tool which can punch different shape than conventional type of punching and which can withstand stresses acting and can run for long life.

INTRODUCTION

Sheet metal is simply metal formed into thin and flat pieces. It is one of the fundamental forms used in metalworking, and can be cut and bent into a variety of different shapes. The sheet metal industry has focused on the automation of punching, shearing and nesting processes for sheet metal parts[1], and only few researchers have investigated the bending operation related product models with features and processes for bending operation proposed a motion planning approach for robot-assisted multiple bent parts based on configuration-space and potential filed[2], developed a sheet metal CAPP system called PART-S which integrates cutting, nesting, bending and welding processes. It is developed an automatic bending process planner to generate plans with near minimum manufacturing costs[3]. This system consists of several sub-systems that work cooperatively to find the bending plan. Sheet metal operations are economical and quick means of producing intricate, accurate, strong and durable metal stampings in huge quantities. Applications of these operations are increasing day by day due to their high productivity, low cost per part, improvement in material quality, minimum scrap material and energy consumption.

Sheet metal bending is a metal forming process, in which flat sheets are bent along straight bend lines in a specific bending sequence to form three-dimensional parts. A large number of tools with different characteristics can be used in this process. The task to choose the right tooling for a requested sheet metal part is however one of the bottle necks in process planning. An inefficient tool selection may result in failure of finding a feasible bending sequence. In previous work, methodologies for tool selection and optimization have been proposed. The presented paper describes a framework to implement these methodologies into a system that allows automatic tool selection in consistent consideration of bend sequencing. As a result, automated and optimized tool selection for sheet metal bending is achieved, as illustrated by performance test results for a robust software implementation[4].

The selection of a proper material for press tool components has become one of the important aspects of press tool design because long tool life has become a necessity for achieving higher productivity and reducing cost of sheet metal parts. Traditional methods of selection of materials of press tool components are dependent on the vast experience and depth of knowledge of domain experts in the area of material science and die design[5]. Most of the times, material selection for press tool components is carried out manually using die design handbooks, material handbooks, thumb-rules and heuristics If all this knowledge is stored in a knowledge base system then the selection of materials will become easier, As the tedious search in handbooks will be eliminated[6], Most of the existing computer-aided die design systems have still not fully dealt with the core die design issue of material selection of press tool components. Some existing CAD/CAM systems are able to generate bill of materials[7,] , however these systems do not take in account the availability of other suitable materials for the choice of user for better performance of press tool components and hence the long life of press tool. Further, these systems do not have even knowledge base consisting of experienced knowledge of domain experts in material selection of press tool components. In selecting materials, designers and engineers have to take into account a large number of factors[8] worldwide researchers[9] have stressed to apply research efforts for capturing and documenting the invaluable practical knowledge of experienced die designers and toolmakers through the applications of Artificial Intelligence (AI) techniques. The highly experience based stamping die design activities such as material selection of press tool components can be simplified by using knowledge base system or intelligent system approach[10]. Development of such system can prove a landmark to ease the complexities involved in the process of material selection. The specific objective of the present work is the development of an intelligent system for selection of materials of press tool components to assist the die designers and toolmakers working in small and medium size sheet metal industries.

Sheet metal bending operations involve placing sheet metal on a die up against a back gauge to precisely locate the part. At this time, the machine is commanded to close the gap between the punch and die until the part is bent into the V-space of the die. In air-bending the part is not forced into the bottom of the V but rather is left in the air. This process causes less wear on the machine and tools than a bottoming (or coining) operation. When the part is taken out of the machine, the bend partially "springs back" by a small, but unknown amount which is usually determined by experiments. The bending operation can either be done manually or automatically. The automatic bending system (Amada BM100) used in this research, which has been augmented by our own open architecture controller. The system in our laboratory currently consists of a CNC press brake, a five-axis robot and a loader/unloader [11].

CONSIDERATIONS FOR DEVELOPMENT OF PROPOSED SYSTEM 'SMPTC'

Economic considerations reducing the manufacturing cost of press tool is generally considered as one of the important parameter to reduce the cost of sheet metal parts[12]. The cost of a press tool consists of the costs involved in material, machining of die components during their manufacturing, assembly and heat treatment. A general cost distribution of manufacturing of a press tool is depicted in **Figure 1**. The material cost contributes approximately 20% of the total cost of a press tool. Besides this, machining and heat treatment costs also somewhere related with the selection of materials of press tool components. Sheet metal industries are giving due consideration to reduce the manufacturing cost of press tools and hence the cost of sheet metal parts. The selection of proper materials for manufacturing of press tool component Ts essentially increases the die life and hence reduces the cost of production of sheet metal parts. Factors influencing life of press tool components The life of press tool components is generally governed by many factors such as design of components, selection of materials, heat treatment, techniques of manufacturing of components, work material, production conditions and the maintenance of components. The factors influencing life of press tool components in sheet metal work are shown in Figure 2. Although long life of all the components of press tool is desirable, however special due attention is required to improve the life of active components (i.e. punch and die/inserts). The term "die life" refers to a dimension, specifically, the length of the land in a cutting edge. This dimension is decided on the basis of the number of stampings expected from the die. Press tools are usually built to produce millions of sheet metal parts and are reasonable to expect that cutting sections will have to be replaced when they have been ground and shimmed over a period of time. However, the sections should be designed for maximum possible use and, generally speaking, each cutting edge should have 3 to 5 mm land ending at 1/4 to 3/4 degree draft depending upon the size of die & punch and type of sheet material [13] Press tool failure mechanisms Failure investigations on numerous worn-out press tools from many different applications specify that five main failure mechanisms are encountered in sheet metal tooling. These are wearing, chipping, plastic deformation, cracking/total failure, and galling as are shown schematically in **Figure 2**.All these die failure mechanisms have mechanical origins. These failures are due to the large forces and sliding contact between the working surfaces of the die or punch and the sheet material. Wear always occurs to a greater or lesser extent in every sheet metal work. However, depending on the sheet metal operations, working conditions and sheet material, one or more of the above mechanisms can be present at the same time. The sheet material itself has fundamental influence on the die failure mechanisms.

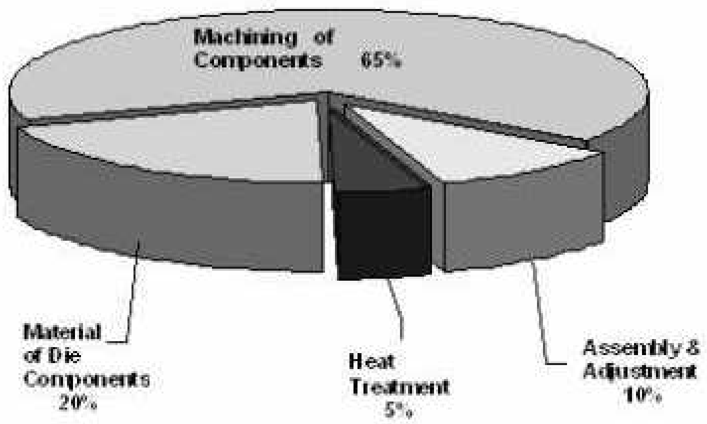

Fig. 1: General cost distribution of manufacturing of a press tools

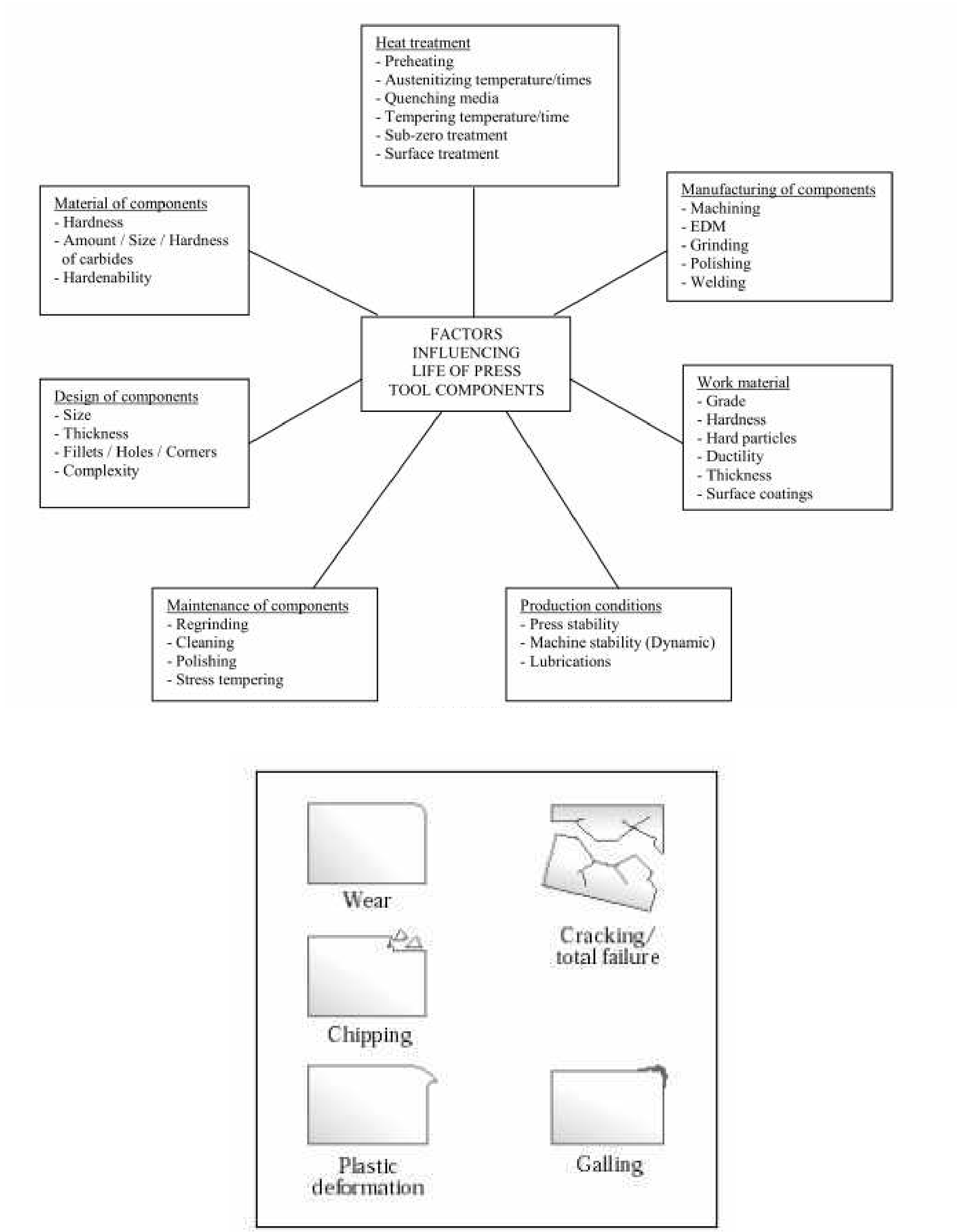

Fig. 2: Factors influencing life of press tool components, the most frequent failure mechanisms in sheet metal tooling.

Representation of a sheet metal part should provide sufficient information to make a complete production plan. As a first step, the design must be unambiguous; it should represent one and exactly one part, in either flat pattern or final shape. Secondly, the design must be complete so all the information required to recognize a correct part is present, such as tolerances. Finally, additional information helps identify aspects of the design such as known features. While this last item is not necessary, it can make an extremely difficult planning task relatively easy. We have identified several important features for bending process. These features are later used to help prepare the process plans[14]. The most important task for bending process planning is the determination of bending sequence. The number of possible bending sequences is usually large even for a moderately complex part. Thus, enumerating and evaluating most or all possible sequences is not practical and sometimes not possible. As a result, the design is usually interpreted as a set of features during the planning stage. Some of the features suggest precedence constraints and heuristics for the feasible bending sequences. The precedence constraints and heuristics can then be used to reduce the search space and guide the search[11].

Tools selection and setup: The certain stages (pairs of punches and dies) to meet the bending requirements such as bending angle, bending radius, and material type. For each bend, we need to determine the number of stages and the stage lengths. Special tools should be selected for hemming bends and large radius bends. To treat these features as constraints in selecting the tools during the planning in order to satisfy the part design. For the given bending sequence, the initial shape begins with flat pattern, and the intermediate shape is simulated before and after the bend in the punch-die space, then checks the collisions between the part and tool

Efficient Method of Producing Oval Punching holes on Sheet Metal: Punching process is increasingly used in manufacture industry. Punching is among the most important sheet metal in manufacturing process in mass production of metal parts and components. This operation has a great impact in variety of industries such as automotive industry. In recent years, a further understanding of the technological aspects of the punching process has been gained especially in punching tools Punching is the most cost effective process of making holes in strip or sheet metal for average to high fabrication

It is able to create multiple shaped holes as method for punching in oval shapes is not readily available press tool for punching in oval shapes is required in various industries according to their applications. There are press tools for punching in circular shape, but when shapes other than circular shape are desired, they have to design according to dimensions required by industry. The cost of tooling in sheet metal industries contributes a considerable part to the overall cost of manufacturing a component. It is therefore imperative to keep down this cost by ensuring that the tool works for a long period in production without interruption. One way of achieving this objective is to reduce the stress on the tool during punching. 3-D finite-element models of various types of punching/blanking tools have been developed, these models enabling the analysis of the effects of variations in tool geometry on the punching/blanking force and on the deformation of the punch, a parameter highly relevant to the assessment of tool performance in terms of the accuracy of the manufactured components. The model caters also for variation in the characteristics of the tool material, in the sense that a highly wear resistant tool is normally composed of carbide tips around its cutting profile Clearance plays important role in Punch design. A good clearance design not only increases the quality of product manufactured, but also reduces product’s burr .Hence it implies that there is need to design such press tool which can punch different shape than conventional type of punching and which can withstand stresses acting and can run for long life.

Development of system for selection of materials for press tool: Metal stampings are important structural components of automobiles, computers, refrigerators, type writers, kitchen utensils, electrical, electronics and telecommunication equipments. Sheet metal operations are economical and quick means of producing intricate, accurate, strong and durable metal stampings in huge quantities. Applications of these operations are increasing day by day due to their high productivity, low cost per part, improvement in material quality, minimum scrap material and energy consumption. One of the important tasks in the production of metal stampings is the design of press tools and selection of materials for press tool components to suit the product features. The selection of a proper material for press tool components has become one of the important aspects of press tool design because long tool life has become a necessity for achieving higher productivity and reducing cost of sheet metal parts. Traditional methods of selection of materials of press tool components are dependent on the vast experience and depth of knowledge of domain experts in the area of material science and die design. Most of the times, material selection for press tool components is carried out manually using die design handbooks, material handbooks, thumb-rules and heuristics. If all this knowledge is stored in a knowledge base system then the selection of materials will become easier as the tedious search in handbooks will be eliminated. Most of the existing computer-aided die design systems have still not fully dealt with the core die design issue of material selection of press tool components. Some existing CAD/CAM systems are able to generate bill of materials, however these systems do not take in account the availability of other suitable materials for the choice of user for better performance of press tool components and hence the long life of press tool. Further, these systems do not have even knowledge base consisting of experienced knowledge of domain experts in material selection of press tool components. In selecting materials, designers and engineers have to take into account a large number of factors. Worldwide researchers have stressed to apply research efforts for capturing and documenting the invaluable practical knowledge of experienced die designers and toolmakers through the applications of Artificial Intelligence (AI) techniques. The highly experience based stamping die design activities such as material selection of press tool components can be simplified by using knowledge base system or intelligent system approach . Development of such system can prove a landmark to ease the complexities involved in the process of material selection.

Selection of materials for press tool components: The selection of materials for press tool components for a given application depend on which die failure mechanisms dominates. It requires more than just knowledge of materials properties. The step by- step manual process of material selection is investigated during industrial visits and discussion with die design experts and is given as under[15]

Step1. Identify the type of wear: This is the most fundamental step because it will determine which wear resistance profile the die material should have. The following factors are considered to establish the dominating wear (abrasive, adhesive or mixed) to be expected:

• Type of sheet material

• Hardness of sheet material

• Presence of hard particles in the sheet material.

Step2. Occurrence of chipping or plastic deformation: The following factors determine the extent of the risk for chipping and/or plastic deformation, i.e. whether high ductility and/or high hardness are needed here

• Type of operations to be performed on press tool

• Thickness and hardness of sheet material

• Geometrical complexity of parts to be produced.

The die designer normally uses his vast experience.

Step3. Risk of cracking: The following factors give an indication of the risk for cracking, i.e. whether tough material and/or moderate hardness levels have to be used:

• Type of operations to be performed on press tool

• Geometry of part to be produced

• Die design and die size

• Thickness and hardness of sheet material[17].

DISCUSSION

Design Calculations

Blanking Force Calculation: The blanking force or cutting force is the force required to punch a blank. This determines the capacity of the press to be used for the tool.

F = p x t x fus

Where, F – Blanking force (N), p – Perimeter (mm, t – Thickness of sheet (mm),

Fus – Ultimate shear strength of sheet (N/mm2)

Press Capacity: The rated capacity of press is the force which the slide or ram will exert near the bottom of the stroke.

Capacity = 1.1 of Blanking force

(10% more than blanking force)

Where, blank force in N,

Die Opening Dimensions: Die is one of the cutting elements of a blanking tool. It admits the punch to enter in for cutting action. For blanking process, die dimensions are same as the output component. Slot length, Width, Radius;

Punch Dimensions: Punch is the other cutting element of a blanking tool. It exerts a force on the strip material placed on the die to punch the desired contour.

Length = (Dimension – 2 x clearance)

Width = (Dimension – 2 x clearance)

Clearance = C x t x√ (Fus/10)

[C = constant 0.01, t = thick of sheet, fus = shear strength of sh

More other factors are calculated in press tool design.

1. Strength of die and punch plates.

2. Design drawing of press tools. (Die & Punch)

3. Profile cutting of press tools according to drawing of sheet metal parts by using wire cut (0.25mm, brass) CNC machine and ELCAM software used and distilled mineral water used (coolent, pH 100-150)

4. Clearance of die and punch. (8% of thickness)

5. Manufacturing and assembly of the parts.

DESIGN DRAWINGS

Child Parts and Function: The press tool consists of following major parts and their functions are stated below.

Top Plate: The punch assembly consisting of punch, punch holder and thrust plate is mounted on the top plate with screws and dowels. Shank also screwed to top plate.

Bottom Plate*:* Bottom plate is the base of the tool. The die and guide pillars are fitted to this plate. It provides cushioning effect to the die. It employs an opening at bottom to collect the output blanked part.

Blanking Die Plate: Die is one of important cutting tool in the blanking tool. The size or contour of the die opening will be same as the dimension of the desired output component.

Blanking Punch: Punch is the other important cutting tool in the blanking tool. A force is exerted on the punch by the press to punch the strip placed on the die. The size of the punch will be smaller than dimension of the desired component. It will penetrate into die for minimum of 3 to 5mm.

Stripper Plate: After blanking operation when punch is withdrawn back, the blanked part adhere (Stick on) to punch surface. To facilitate removal of part from punch, stripper used. Also it used for guiding punch and to hold the strip flat during punching operation.

Thrust Plate: While punching the strip, the punch exerts an upward thrust. To prevent that thrust being transmitted to top plate, a thrust or back plate is provided behind the punch. Otherwise it will damage the top plate.

Punch Holder: It is a plate used to hold the punch in position without any transition. Punch holder provides a rigid support to the punch during punching.

Guide Bush and Pillar: Guide pillar and bushes are used to align the top and bottom plate. They keep the complete alignment of tool during entire operation.

Shank: Shank is a connector between tool and the press ram. It is screwed to the top plate firmly.

The individual part drawings with dimensions are followed.

All dimensions are in "mm"

Tolerances

Length: ± 0.1mm

Diameter: ±0.05mm

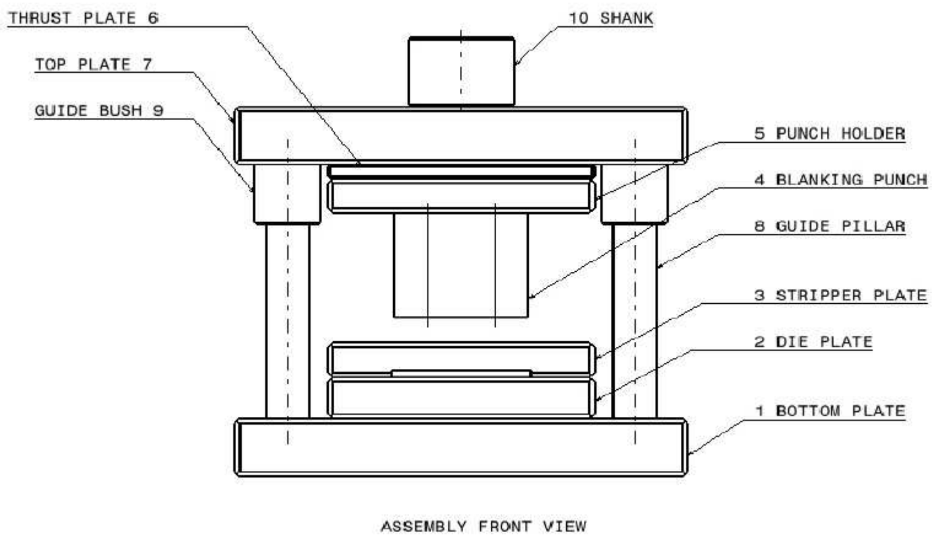

Figure.3- 2D Assembly of Press Tools

Table -1:- Press Tool Assembly: Bill of Materials

PART NO.	DESCRIPTION	MATERIAL	NO. OFF
1	BOTTOM PLATE	MILD STEEL	1
2	BLANKING DIE	HCHCR	1
3	STRIPPER PLATE	MILD STEEL	1
4	BLANKING PUNCH	HCHCR	1
5	PUNCH HOLDER	MILD STEEL	1
6	THRUST PLATE	MILD STEEL	1
7	TOP PLATE	MILD STEEL	1
8	GUIDE PILLAR	MILD STEEL	2
9	GUIDE BUSH	MILD STEEL	2
10	SHANK & SCREW	MILD STEEL & STD	1,-

The general problems and solutions of press tools and others during manufacturing of sheet metal parts in an industry such as-

In Die & Punch: 1-clearance between die & punch and it should be 0.08 X thickness 0f the sheet metal parts i.e. 8% of the thickness, and clearance should be given in the die & punch should be according to hole size, clearance is used for remove burr of the parts.

2-Alignment of die & punch problems and it can be solved by given clearance between die & punch according to sheet metal parts.

3-In Piercing & Blanking process, clearance is occurred & it can be solved by setting of pillar gauge.

4-Proper location of stopper is not located.

5-Dowel & L-Key bolts are not tight.

In Production:

1.Die radius variation problems due to wear problems and die & punch can be damage and it can be solved by grinding & change new die & punch.

2.Not in proper dimension.

3.Power press peddle break.

4.Maintenance problem of the machine.

5.Generally in forming operation due to exceed thickness (5mm in place of 3 mm) due to operator mistake, die and tool can be break, machining break, and blockage of the die and tools.

6.Due to lack of raw materials.

7.Man power & power supply problems.

In Maintenance: 1-Shaft & key problems, Gear bush problem, spring fails, Machining, Break problem. break down problems.

Ideas for higher production:

1. Proper setting of the tool.

2. Use progressive or compound die (mostly used in piercing & cropping operation).

3. Clamping device fast and improve it.

4. Tool changing method improves for reducing tool set up.

5. Skilled operator training.

6. Proper layout of the industry.

7. Proper maintenance of the machines.

8. Proper material supply.

CONCLUSION

Most of the existing computer-aided die design systems have still not fully dealt with the core die design issue of material selection of press tool components. Some existing CAD/CAM systems are able to generate bill of materials, however these systems do not take in account the availability of other suitable materials for the choice of user for better performance of press tool components and hence the long life of press tool. Further, these systems do not have even knowledge base consisting of experienced knowledge of domain experts in material selection of press tool components. In selecting materials, designers and engineers have to take into account a large number of factors. Worldwide researchers have stressed to apply research efforts for capturing and documenting the invaluable practical knowledge of experienced die designers and toolmakers through the applications of Artificial Intelligence (AI) techniques.

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