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Design and Modeling of a Single Stroke Compound Die for Concentric Washers

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Abstract.

Compound tools are frequently employed in the production of washer components, enabling concurrent blanking and piercing operations. The precision of these components will be notably high because the operations will be executed simultaneously in a single station unaffected by strip feeding. This article discusses the design and modeling of a compound tool that simultaneously produces two concentric washers. It will eliminate the requirement to build two tools and their associated operation conditions. The first step entailed creating a model of the Compound tool using AutoCAD. During the second stage, Compound tool elements were modeled using Unigraphics NX. The results produced from theoretical calculations are acceptable, ensuring that the tool used to manufacture concentric washers operates in a safe manner.

Keywords: Sheet metal stampings, Compound tool, AutoCAD, Unigraphics NX

1. Introduction

Producing components from sheet metal stampings offers a cost-effective option compared to casting, forging, and machining across a diverse range of applications. The stamping process

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leads to material waste and cost savings. It is extremely productive and precise. Presswork is required for mass manufacture of items such as electronic equipment, steel furniture, cutlery, and automobiles. Stampings are manufactured using non-machinable tools. The tools are categorized into four primary groups according to their functions: cutting, bending, shaping, and drawing [1].

Within sheet metal industries, compound tools are frequently employed to create pierced blanks that exhibit excellent flatness and finish [2]. These tools differ from Progressive tools in that they perform both piercing and blanking operations at a single workstation, making them small. The construction of compound tools involves the inversion of the blanking punch and die, with the blanking punch serving a dual purpose as a piercing die. When the die ejects the blank, there should be a provision in place to collect the component as the tool is opened[3].

Plain or flat washers are thin plates, used to distribute the load of a threaded fastener, such as a bolt or nut. They are normally round and formed by piercing a hole in a large blank [4].

2. Literature review

Kashid et al. (2014)[2] introduced an ANN model to estimate the lifespan of compound die punches, correlating it with the quantity of sheet metal parts manufactured. Tagade et al. (2013)[5] investigated the development and construction of a compound press tool designed for a 3mm thick washer made of spring steel. AutoCAD and SolidWorks were used to study. Shaheen et al.(2020)[6] investigated the impact of different piercing punch designs in a compound die on sheets of AISI 1018 and AISI 202, each with 1mm and 2mm thicknesses. The best punch is selected based on the product's minimum burr height.

Kumar and colleagues (2017) [7] created and evaluated a progressive four-stage tool designed for a wire clip employed in residential electrical wiring. In component design, CPMnS-based galvanised steel with a thickness of 0.3mm was employed, with a strip layout efficiency factor of more than 77%. For drawing, modelling, and analysis, the author utilized AutoCAD 2016, Creo2.0, and ANSYS 17.2. Satpute et al. (2019) [8] introduced an compound tool that performs both piercing and blanking operations simultaneously in a single stroke. The project's major objective was to increase productivity and decrease manufacturing

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costs.Pawar et al. (2014)[9] proposed a computer-aided design technique for a compound die set for downlight housing.

Kashid et al. (2015)[10] reported research on stripper plate selection, modelling, and life prediction in compound dies. To choose the size, model, and forecast the lifespan of the stripper plate, authors used a Knowledge-Based System (KBS), CAD, and Artificial Neural Network (ANN) model, respectively. Jayshree et al. (2019)[11] conducted an experimental investigation to enhance quality, production rate, and reducing expenses through the creation and examination of a progressive die tailored for an industrial component. Kushwaha et al. (2017)[12] chose the industrial challenge of producing a concentricity shell.The problem was overcome by constructing a progressive tool and switching the raw material section from rod to plate.

By optimizing the volume of material used to create the progressive die, Raja et al. (2014)[13] intended to minimize the cost of the progressive die without affecting the quality of components.Chavan et al. (2019)[14] investigated the design of a progressive tooling for the production of an automotive part with the aim of decreasing development costs (by comparing individual die costs) and increasing productivity. The literature review highlights the need for efforts to minimize costs linked to the component. Consequently, this study focuses on improving the tool design to facilitate the production of multiple components with a single pressing motion.

3. Compound die design

The following phases comprise the design process of compound die to manufacture two concentric washer components.

3.1 Component selection

Two washer components of MS are designated such that the large component's inner diameter is the same as the tiny component's outer diameter. The chosen components are shown in Figure 1. These components include operations for blanking and piercing.

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Figure1 Geometry of the washers

3.2 Component dimensions

Washers with a thickness of 1.5mm are to be produced, and Figure 2 displays the dimensions. Washers are typically produced to IT14 specifications.

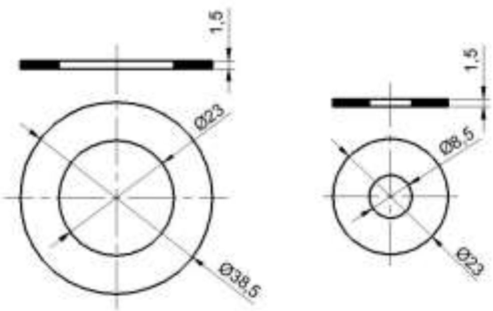

Figure2 Dimensions of two washers

3.3 Stock strip component layout

The initial phase in developing a compound tool is to create the strip arrangement. It illustrates the operation sequence for each stage, strip feeding's direction, strip halting, scrap bridge, and strip width values. The Strip arrangement of the suggested components is depicted in Figure 3. Equation 1[15] calculates the stock's percentage utilization in strip form.

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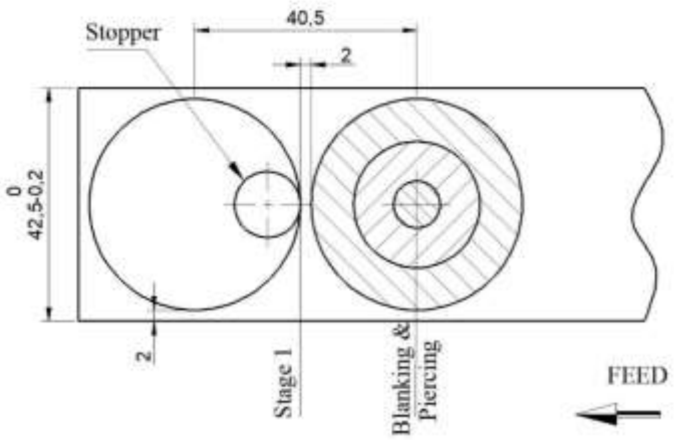

Figure3 Development of Strip arrangement

Percentage stock strip utilization (n) $= \frac{\text{Area of the blank x No.of rows x 100}}{\text{Strip width X Pitch}} = 67.6\%$ (1)

3.4 Cutting and Stripping force requirement

Die's cutting force is corresponds to the total of the force needed for every punch (blanking and piercing) and is required for press selection. Equation2[3] and Equation.3[5] are utilized to determine the cutting and stripping forces respectively.

Cutting Force (Fsh) = Perimeter of the profiles x Thickness x Shear strength≈ 13.5 t (2)

Stripping Force (Fstr) = 5 to 20% of Fsh = 2.7 t (3)

3.5 Press capacity

Capacity decides the choice of a press for its continuous operation without any interruption. Press is designated by maximum force in tonnes that it can exert on press tools. The required press force is found by using Equation4[5] and 20tMechanical press is selected.

Press Force = (Cutting Force + Stripping Force) × Factor of safety(1.2) = 19.4 t (4)

3.6 Punch-die clearance

It is expressed in millimeters per side or as a percentage of the sheet thickness and is based on the physical characteristics of the material to be sheared. The formula for estimating punch-die clearance appears in Equation 5. Considering the clearance, the punch and die functional dimensions are decided [12] and are given Table 1.

Clearance = 0.01 × Sheet thickness × √Shear strength/10 = 0.09mm/side (5)

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Table1 Punch and Die dimensions

Piercing operation				Blanking operation			
Punch size (Ø8.5)	Punch size (Ø23)	Die Size (Ø8.5)	Die Size (Ø23)	Punch size (Ø23)	Punch size (Ø38.5)	Die Size (Ø23)	Die Size (Ø38.5)
8.5	23	8.68	23.18	23	38.32	23.18	38.5

3.7 Compound die design

Simultaneous blanking and piercing are accomplished with the Compound tool by supplying blanking and piercing elements in the top and lower halves of the tool. The component's burr side is on one thickness side as a result of the arrangement of these parts, which causes the piercing punch to act in the opposite direction of the blanking punch. The blanking and piercing processes can be completed simultaneously with this method. A diagonal pillar die set is used to make operations easier, and the use of different pillar diameters ensures error-proof closing. To save production time, round-shaped parts are chosen for tool elements.

3.8Materials for compound die elements

Based on the literature review, D2 material is utilized for both die and punch components. Table 2[5] shows the materials selected for other tool components.

Table 2 Material for Compound Die elements

Sl. No.	Elements	Material	Hardness
1	Top & Bottom bolsters	MS	-
2	Cutting Punches (i.e., for Piercing & Blanking)	D2	58-60 HRC
3	Cutting Dies (i.e., for Piercing & Blanking)	D2	60-62 HRC
4	Back Plates	OHNS	45-50 HRC
5	Ejector	OHNS	45-50 HRC
6	Shedder	OHNS	45-50 HRC
7	Stopper	OHNS	45-50 HRC
8	Stripper plate	OHNS	45-50 HRC
9	Guide Pillar & Guide Bush	EN36	Case Hardened
10	Shank	MS	-
11	Knockout rod	EN8	-
12	Knockout plate	EN8	-
13	Transfer pins	EN8	-
14	Limit Bolts	EN8	-
15	Punch Holder	EN8	-

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3.9 Compound die element sizes

Table 3[16] lists the required thickness and height values for various tool components.

Table3 Compound tool element thickness values

Sl. No.	Element	Formulae	Valuescalculated (mm)	Values considered (mm)
1	Thickness of blanking die (Ø38.5)	td = $\sqrt[3]{Fsh}\ x\ 10$	19.5 ≈ 20	36
2	Compound die height (for Ø23 blanking & Ø8.5 piercing)	$7.5\sqrt{\frac{D^3-d^3}{t}}$	max. 658	36
3	Compound die height (for Ø38.5 blanking & Ø23 piercing)	$7.5\sqrt{\frac{D^3-d^3}{t}}$	max. 1297	38.5
4	Piercing punch (Ø8.5)	$7.5\sqrt{\frac{d^3}{t}}$	max. 151	38.5
5	Punch holder's thickness	tn = 0.75 td	15	20
6	Thickness of Top Bolster	1.25 Td where Td is thickness due to press force (Td = $\sqrt[3]{20}\ x\ 10$ = 27.14mm)	33.9	36
7	Thickness of Bottom Bolster	1.75 Td	47.5	48
8	Thickness of Stripper plate	0.5 td	10	12
9	Movement of Stripper	Ystr = t + 2	3.5	3.5
10	Land in the Piercing Die (i.e., Ø8.5 size)			5
11	Tool Shut height (as per CAD model)			173.5
12	Press stroke length			50
13	Shank location	Centre of pressure		Component centre

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3.10 Compound die assembly

Figure4 shows the Compound tool assembly in sectional front and top views. It differs from conventional design [4] in that the Top bolster contains a Compound die that serves as a blanking punch (Ø38.5), cum piercing die (Ø23) and Piercing punch(Ø8.5). Bottom bolster is equipped with a Blanking die (Ø38.5) and a Compound die that serves as a blanking punch (Ø23) cum piercing die (Ø8.5). Stripper takes out the scrap from Compound die. The slug produced by Piercing punch falls out downwards. The concentric washers are pushed back into the strip using an ejector and a shedder.

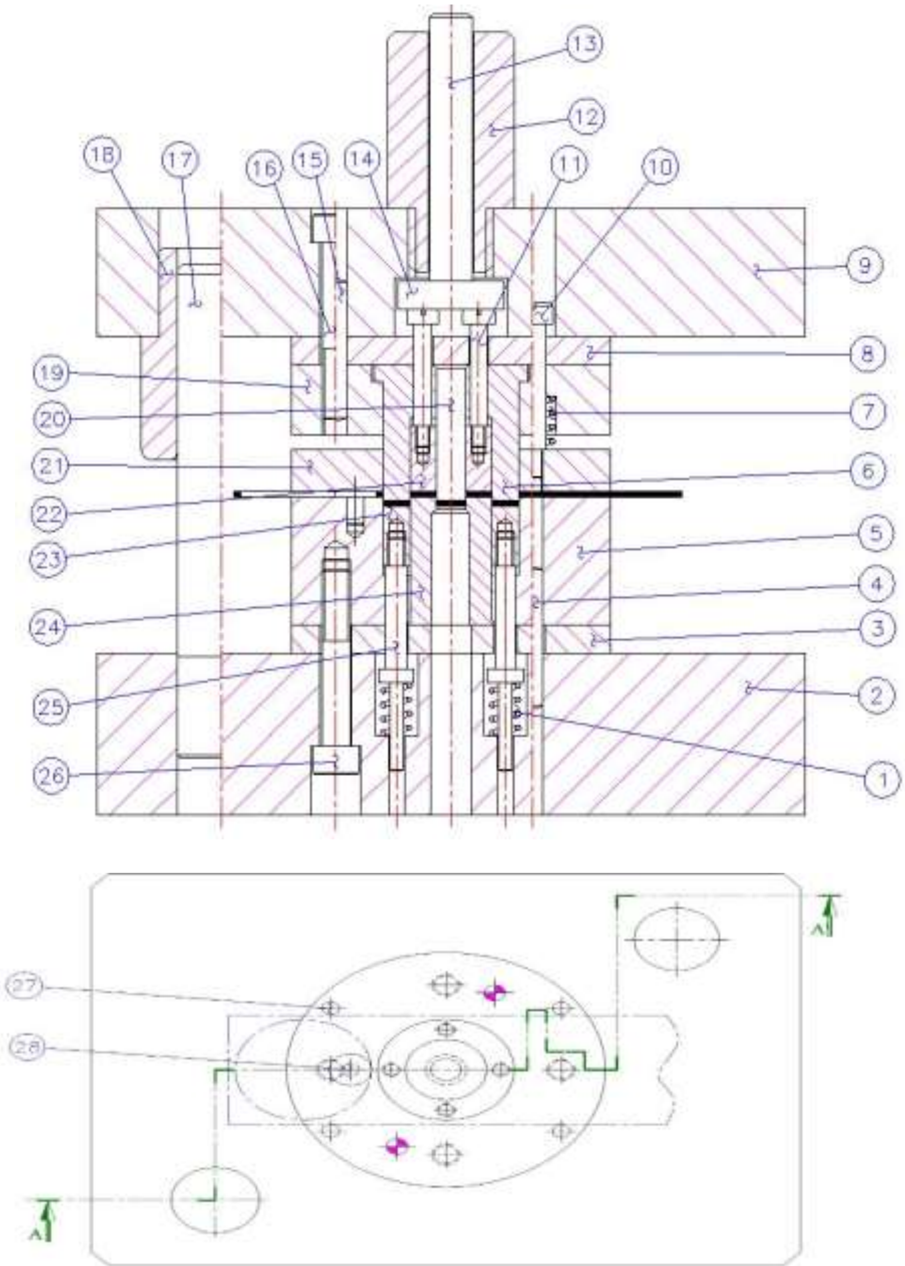

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Figure4CAD model of Compound die assembly

3.11 Modelling of compound die

All the tool elements are created using the required material using NX software. These components are put together to have the feel of an actual tool. Figure 5 shows a 3D model of the compound tool assembly. Figures 6 and 7 depict the tool's top and bottom halves, respectively.

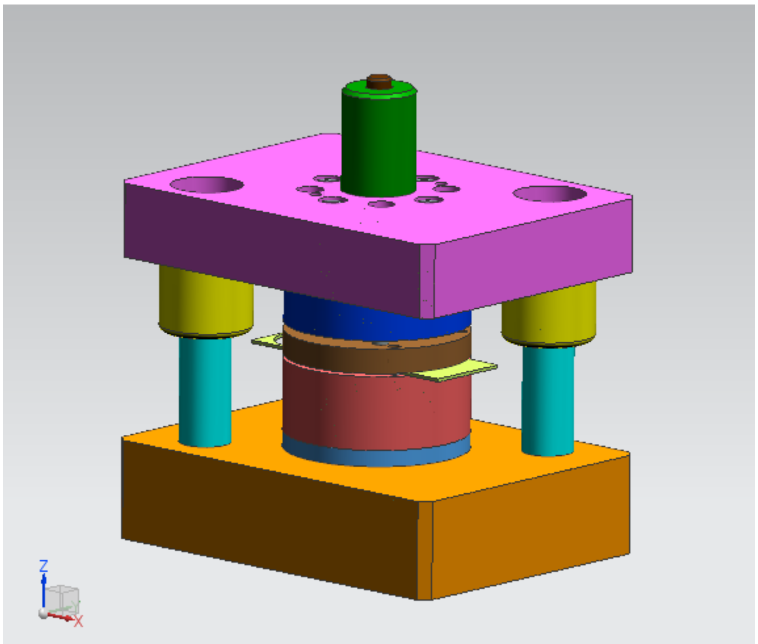

Figure53D model of Compound die assembly

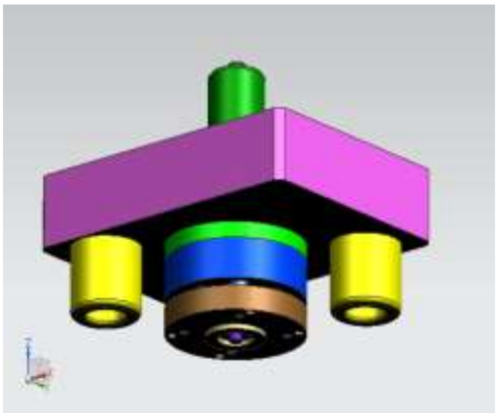

Figure 6 Top half of the Compound die

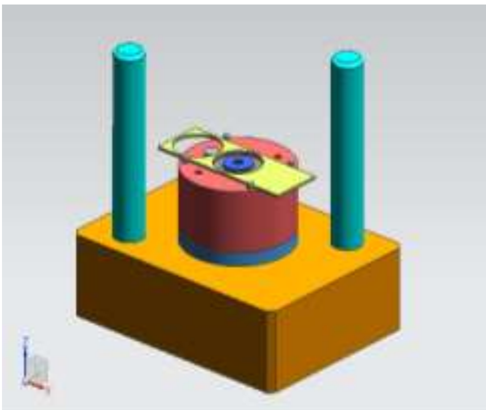

Figure7 Bottom half of the Compound die

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5. Results and discussion

Theoretical calculations affirm the acceptability of results, confirming the safe operational performance of the tool designed for manufacturing concentric washers. This outcome underscores the tool's reliability and adherence to safety standards, providing confidence in its application for efficient and secure production processes.

6. Conclusion

Compound dies are widely employed in the sheet metal stamping sector for blanking and piercing operations on components such as washers. The aim of this task is to show how to make two concentric washers at the same time using the Compound Die.

- The aim is to reduce tooling and operating costs so as to make washer components more cheaply.
- There are two washer components recognised, at least one of which has a similar inner diameter to the other's outer diameter. This tool's 2D designs are created using AutoCAD software. Unigraphics NX software is used to model the tool components with their sizes.
- It is an ideal design for producing similar components in the industry.

References

[1] Prakash H Joshi. Press Tools Design and Construction. Wheeler Publishing;1997.

[2]Kashid S, Kumar S. Prediction of life of compound die using artificial neural network (ANN). Key Engineering Materials. 2014; 622–623: 664–671.

[3] Rehaman I, Reddy P S, ManojM, Murthy N G. Design and Analysis of Progressive Die for Chain Link Plate. International Journal of Recent Technology and Engineering. 2019; *8*(4): 820–826.

[4] Jyothirmayi N, Rao B V S. The design and fabrication of a compound die to make hexagonal washer. International Journal of Mechanical and Production Engineering Research and Development.2019; 9(4): 517–528.

[5] TagadeA A, NirwanN. Design & Manufacturing of Compound Press Tool for Washer. International Journal of Science and Research (IJSR).2013; 5(8): 1381–1386.

ISSN PRINT 2319 1775 Online 2320 7876

  UGC CARE Listed (Group -I) Journal Volume 8, Issue 2, 2019

[6] ShaheenW, Kanapathipillai S, Mathew P, Prusty B G. Optimization of compound die piercing punches and double cutting process parameters using finite element analysis. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture.2018; 234(1–2): 3–13.

[7] KumarS, Patnaik L. Design and Analysis of Four Stage Progressive Tool for House-wiring Wire Clip, CVR Journal of Science and Technology. 2017; 13: 88-95.

[8] Satpute B F, Harne M S. Design and Development of Compound Die for BearingCap. Novateur Publications Journal. 2019; (02):50–61.

[9] S S P. Computer Assisted Compound Die Design: a Case Study. International Journal of Research in Engineering and Technology.2014; 03(05): 465–469.

[10] Kashid S, KumarS, Hussein HM. Selection, modeling and prediction of life of stripper of compound die. Key Engineering Materials.2015; 639:501–508.

[11] Jayshree M Gadhe1, AYadao, Design and Analysis of Progressive Die for Industrial Component Tail Gate Stricker.International Research Journal of Engineering and Technology (IRJET).2019; 06(08):117-121.

[12]Kushwaha D K, Banwait S S, Mehdi H. Design and Analysis of Progressive Die Using Finite Element Method.International journal of advanced production and industrial engineering. 2017; 2:65–70.

[13] Raja Shakarappa. Analysis and simulation of progressive die. International Journal of Research in Engineering and Technology.2014; 03(03):642–655.

[14] Chavan HA, Wani V P. Design and analysis of progressive tool for an automobile component. Journal of Physics: Conference Series.2019;1240(1).

[15] V K A. Design of Progressive Press Tool for an Alpha Meter Component. International Journal of Research in Engineering and Technology.2015; 04(06):36–40.

[16] Frank W Wilson. Die Design Handbook. McGraw-Hill book company; 1956.

[17] Tool Engineering Parameters. Indian Society of Tool Engineers; 1981.