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Modeling and analysis of a compound tool for piercing two concentric washers with a singular press action

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Abstract.

Compound tools are frequently employed in the production of washer components, enabling concurrent blanking and piercing operations. This article explores the creation and examination of a compound tool capable of generating two concentric washers simultaneously. It will eliminate the requirement to build two tools and their associated operation conditions. Unigraphics NX was employed to model and perform finite element analysis on the components of the Compound tool, with the goal of evaluating deformations and stresses. The results produced from theoretical calculations and analytical values are comparable, ensuring that the tool used to manufacture concentric washers operates in a safe manner.

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

1. Introduction

Stamped metal sheets are a cost-effective alternative to casting, forging, and machining for an extensive range of components. The stamping process leads in 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

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manufactured using non-machinable tools. The tools are categorized into four primary groups according to their functions: cutting, bending, forming, and drawing [1].

Compound tools are commonly used in metal sheet pressing industries to produce pierced blanks with good 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. In the assembly of compound tools, the blanking punch and die are reversed, with the blanking punch also serving the dual purpose of a piercing die. When the knockout mechanism removes the blank from the die, arrangements need to be in place to collect the component when 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].

Section 2 reviews the literature on compound tooling. Section 3 presents the modeling of a compound tool. Section 4 deals with the analysis of the compound tool using calculation and FEA methods. Section 5 depicts a comparison of the analysis results obtained. Section 6 discusses the major conclusions of the present research work.

2. Literature review

Kashid et al. (2014)[2] presented the predicted lifespan of a compound die punches in terms of the number of sheet metal parts produced using Artificial Neural Network (ANN) model. Tagade et al. (2013)[5] explored the design and production of a compound pressing tool for a 3mm thick spring steel washer. AutoCAD and SolidWorks were used to study. Shaheen et al. (2020)[6] analyzed the effect of different types of punches for piercing in compound dies on AISI 1018 and AISI 202 sheets with thicknesses of 1mm and 2mm. The best punch is selected based on the product's minimum burr height.

Kumar et al. (2017)[7] designed and analyzed a four-stage Progressive die for a wire clip used in house wiring. In component design, CPMnS-based galvanised steel with a thickness of 0.3mm was employed, with an efficiency factor for strip layout exceeding 77%. For drawing, modelling, and analysis, the author utilized AutoCAD 2016, Creo2.0, and ANSYS 17.2. Satpute et al. (2019)[8] developed a compound tool that integrates blanking and piercing procedures in one stroke. The project's major objective was to increase productivity and decrease manufacturing costs. Pawar et al. (2014)[9] proposed a computer-aided design

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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 predict 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 cost reduction by designing and analyzing a progressive tooling for an industrial part. 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 die for an automotive part with the aim of decreasing development costs (by comparing individual die costs) and increasing productivity.

From the literature review, it is understood that efficiency of the compound tool needs to be improved by producing multiple components in a single press stroke. For that the tool parts to be confirmed for loads acting through various analyses methods.

3. Modeling of compound tool

The modeling of compound tool starts with designing of Compound tool comprises of the following phases.

- Component selection
- Component dimensions
- Component layout on sheet metal
- Calculation of Cutting and Stripping force requirements
- Press Selection
- Calculation of Punch-die clearance
- Compound tool design
- Choosing materials for components of compound tools
- Calculation of optimal Compound tool element sizes

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3.1 Modelling of compound tool

All the tool elements are created using the required material using NX software. All these elements are assembled to feel like a real tool. In Figure 1, a 3D model of the composite tool assembly is illustrated. Figures 2 and 3 showcase the upper and lower halves of the tool, respectively. Figure 4 displays the two concentric washers manufactured by the tool.

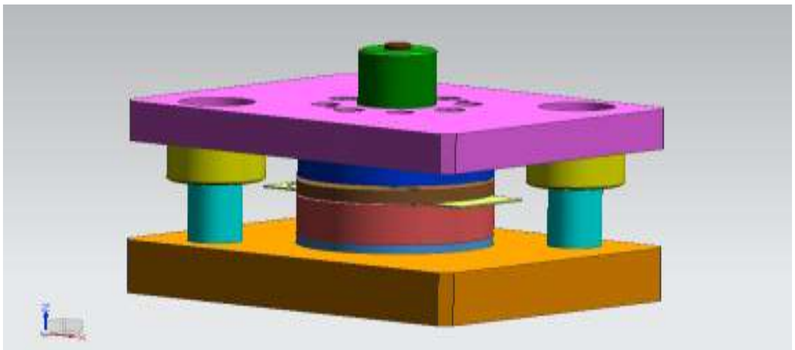

Figure 1 3D model of Compound tool assembly

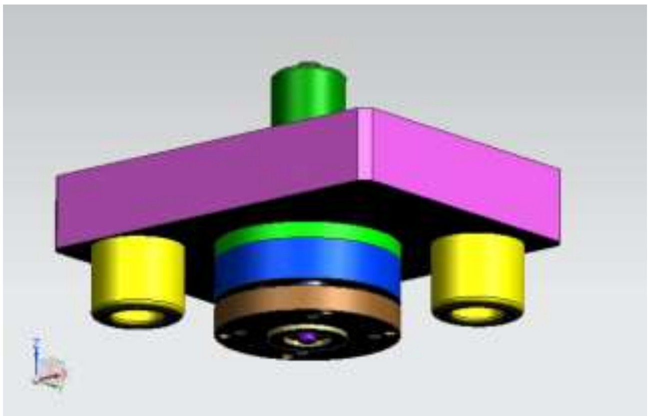

Figure 2 Top half of the Compound tool

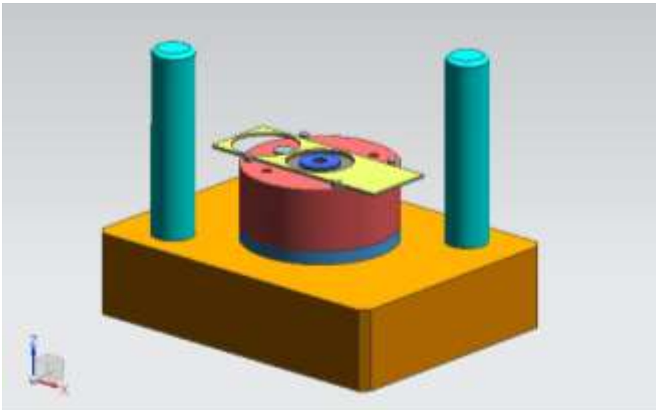

Figure 3 Bottom half of the Compound tool

Figure 4 Concentric washers to be produced from Compound tool

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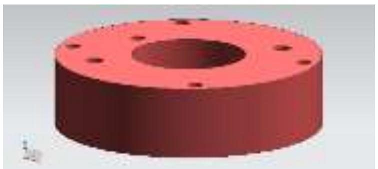
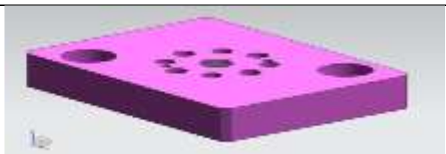
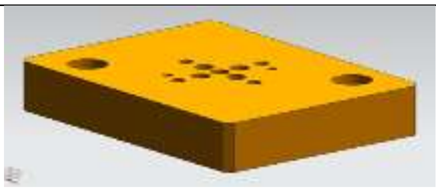
4. Analysis

Using strength of materials formulae, the deflection and stress values are computed for all cutting elements, including punches, dies, and both bolster plates. Table 1 displays the theoretical deflection and stress values.

Table 1 Deflection and stress values of tool elements

Element	3D View	Formulae		Value
Blanking die		Deflection (δ)	$\frac{FL^3}{192EI}$	3.94×10^{-3} mm
		Stress (σ)	$\frac{F}{A}$	22.4×10^{6} Pa
Compound die		Deflection (δ)	$\frac{FL^3}{192EI}$	5.34×10^{-3}mm
		Stress (σ)	$\frac{F}{A}$	165.54×10^{6} Pa
Compound die		Deflection (δ)	$\frac{FL^3}{192EI}$	1.83×10^{-3}mm
		Stress (σ)	$\frac{F}{A}$	154.86×10^{6} Pa
Piercing punch		Deflection (δ)	$\frac{FL^3}{192EI}$	1×10^{-3}mm
		Stress (σ)	$\frac{F}{A}$	282.39×10^{6} Pa
Top bolster		Deflection (δ)	$\frac{FL^3}{48EI}$	0.226 mm
		Stress (σ)	$\frac{F}{A}$	29.33×10^{6} Pa
Bottom bolster		Deflection (δ)	$\frac{FL^3}{354EI}$	0.096 mm
		Stress (σ)	$\frac{F}{A}$	22×10^{6} Pa

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4.1 Analysis of compound tool elements

Unigraphics NX (Siemens) software is employed to analyze the components of the compound tool. The steps involved are listed below.

- Tetrahedral element and default meshing
- Selecting the right material for each tool element
- Static structural analysis, one end of the element is fixed while the other is left free.
- Load is applied to each element's free end.
- Determining the maximum deflection and stress

The maximum and minimum values of distortion and the dispersion of stress are indicated by the orange and blue colours in the figure.

4.1.1 Analysis of blanking die

Figure 5 shows the deformation of the Blanking die, while Figure 6 shows the corresponding stresses of the Blanking die.

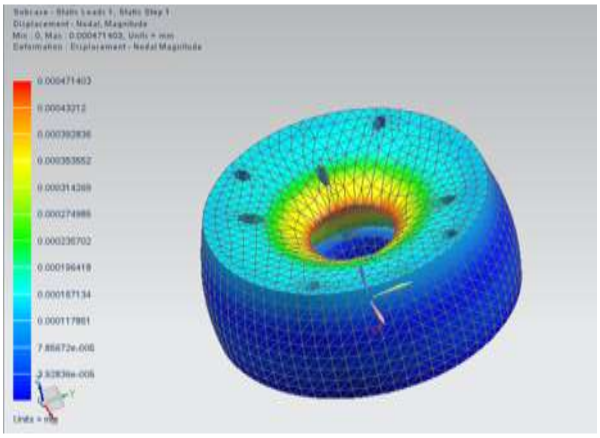

Figure 5 Total deformation in Blanking die

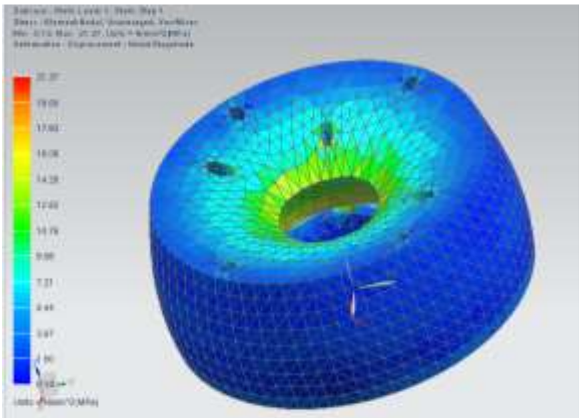

Figure 6 Equivalent stresses in Blanking die

4.1.2 Analysis of compound die

Figure 7 shows the Compound die’s deformation findings, while Figure 8 displays the corresponding stresses in the Compound die.

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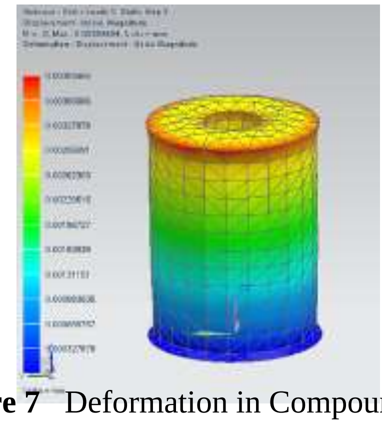

Figure 7 Deformation in Compound die

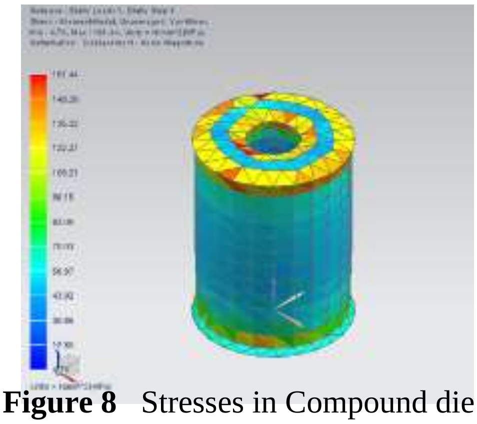

Figure 8 Stresses in Compound die

4.1.3 Analysis of compound die

Figure 9 depicts the Compound die's deformation findings, while Figure 10 depicts the corresponding stresses in the Compound die.

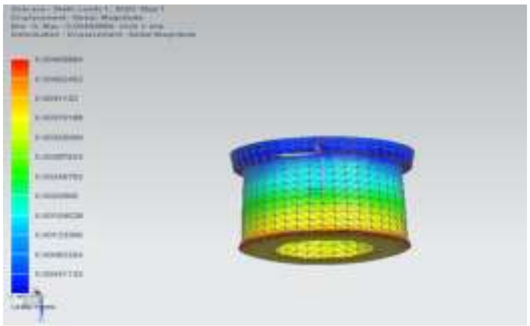

Figure 9 Deformation in Compound die

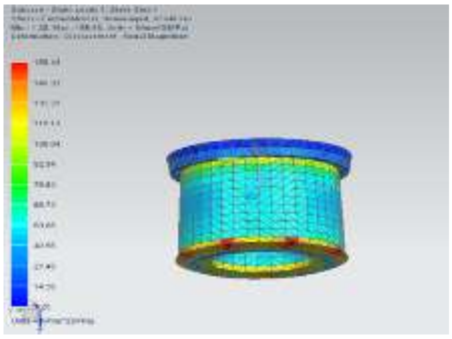

Figure 10 Stresses in Compound die

4.1.4 Analysis of piercing punch

Figures 11 and 12 show the deformation and stress results of the Piercing punch.

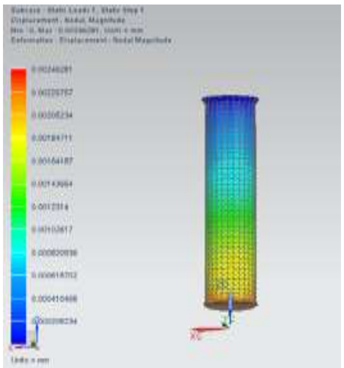

Figure 11 Deformation in punch for piercing

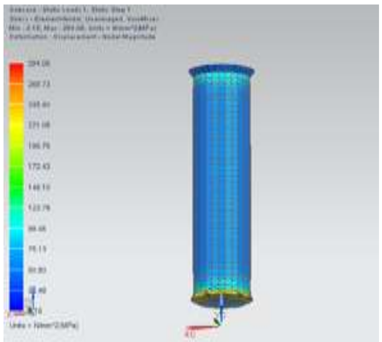

Figure 12 Stresses in punch for piercing

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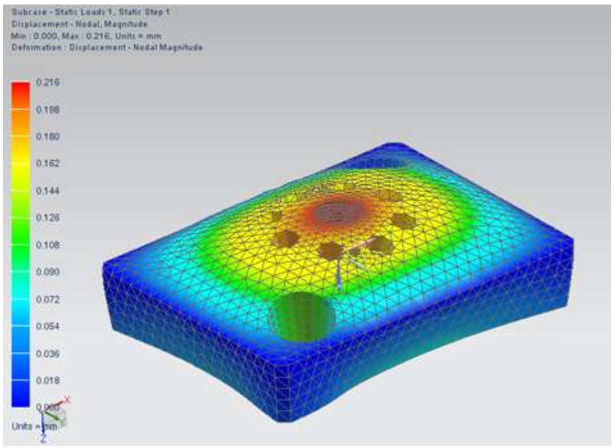
4.1.5 Analysis of top bolster

Figure 13 depicts the Top bolster's deformation findings, while Figure 14 depicts the Top bolster's equivalent stresses.



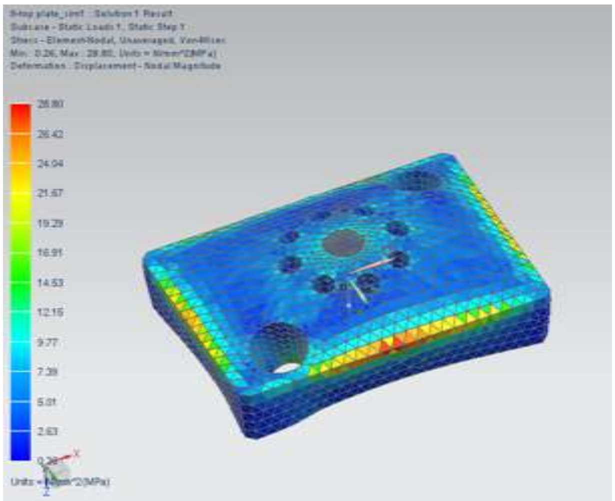


Figure 13 Total deformation in Top bolster

Figure 14 Equivalent stresses in Top bolster

4.7 Analysis of bottom bolster

Figure 15 depicts the Bottom bolster's deformation findings, while Figure 16 depicts the Bottom bolster's equivalent stresses.

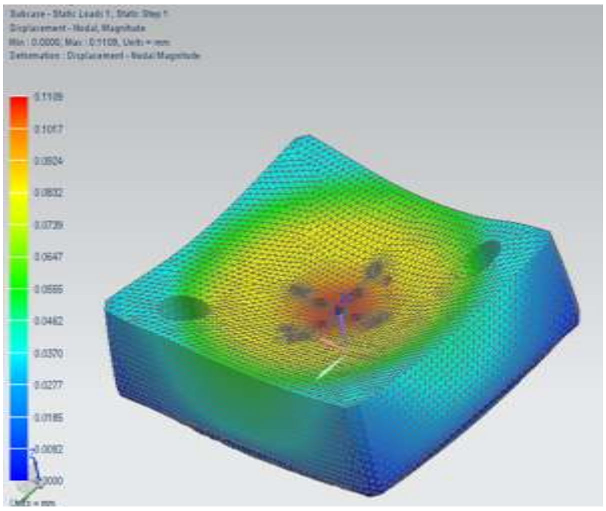


Figure 15 Total deformation in Bottom bolster

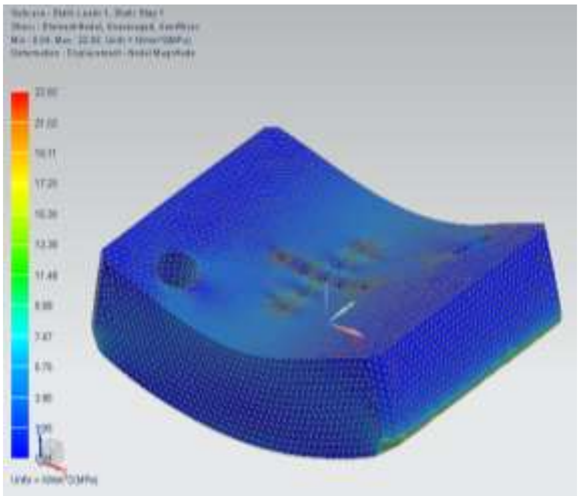


Figure 16 Equivalent stresses in Bottom bolster

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5. Results and discussion

In Table 2, all the Compound tool element analysis findings are presented. The difference between the theoretical and analytical results was shown to be low and acceptable. It can be discovered that the tool components are able to withstand the applied loads and are safe to use.

Table 2 Findings of the Analysis

Sl. No.	Description	Thickness (mm)	Theoretical results		Analysis results	
			Deflection (mm)	Stress (MPa)	Deflection (mm)	Stress (MPa)
1	Blanking Die	36	3.94×10^{-3}	22.4	4.7×10^{-4}	21.37
2	Compound Die	36	5.34×10^{-3}	165.54	3.9×10^{-3}	161.44
3	Compound Die	38.5	1.83×10^{-3}	154.86	4.9×10^{-3}	158.43
4	Piercing punch	38.5	1×10^{-3}	282.39	2.4×10^{-3}	294.05
5	Top Bolster	36	0.226	29.33	0.216	28.8
6	Bottom Bolster	48	0.096	22	0.11	22.92

6. Conclusion

Compound tools are frequently utilized in the sheet metal stamping industry for blanking and piercing operations on components such as washers. The purpose of this task is to demonstrate how to use the Compound tool to simultaneously make two concentric washers.

- There are two washer parts recognized, 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 utilized to model and analyse tool components that have forces acting on them.
- The results of the analysis are close to theoretical values. The design of this Compound tool is safe for producing selected washer components because all stresses are within the material's allowable limits.
- It is an ideal design for producing similar components in the industry.

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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, Manoj M, 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] Tagade A A, Nirwan N. Design & Manufacturing of Compound Press Tool for Washer. International Journal of Science and Research (IJSR). 2013; 5(8): 1381–1386.

[6] Shaheen W, 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. 2016; 234(1–2): 3–13.

[7] Kumar S, 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 Bearing Cap. 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, Kumar S, Hussein H M. Selection, modeling and prediction of life of stripper of compound die. Key Engineering Materials. 2015; 639:501–508.

[11] Jayshree M Gadhe1, A Yadao, 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

ISSN PRINT 2319 1775 Online 2320 7876

Research paper

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

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

[14] Chavan H A, 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.