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Automatic die design and fatigue life prediction of forming die using AI technique: Expert System

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***Abstract*—** Sheet metal forming is an important process which causes some changes in the shape of solid metal parts via plastic (permanent) deformation. When deliberating with sheet metal forming process in this scenario, die and punch cost plays a vital role, making the processes costlier in whole production cycle. It is required to estimate the die life because it is repeatedly used in manufacturing process. Approximate calculation of fatigue life of axisymmetric forming dies helps in planning for the production. This is calculated using AI technique Expert system. In present research work, the development of expert system has been done using VB, python and AutoCAD environment. The developed ES is enabling to generate manufacturing drawing of the designed die which requires few input parameters. Based on few input parameters, ES predict the fatigue life of these dies during deep drawing forming operations.

***Keywords*—** Deep Drawing, Die Design, Fatigue, Expert System(ES), AI

I. INTRODUCTION

Sheet Metal forming is a one type of process where metal is deformed into necessary shape without adding or removing material. During this process the material is subjected to plastic deformation. Various processes like drawing, bending, shearing, punching, cutting, piercing, forging, rolling etc come under forming category.

The operation is normally performed on hydraulic or mechanical press. Automobile and aerospace body panels, electronic equipments body, food containers, house hold utensils etc. are the typical examples which are manufactured by deep drawing (sheet metal forming operation). From last decade, few researchers started working on different manufacturing process like casting, welding, forming and machining etc. A lot of research has been done to study the deformation of metal during this process using various tools.

Normally expert system is the collective bunch of computer program which contains skills/expertise (experience and/or analytical) of human experts. Logistics, medical, accountancy, fisheries, computers, Air Space, Manufacturing etc. domains are already proven the importance of the knowledge and rule based systems using expert system.

II. RELATED WORK

Xie et al. [1] used CAD environment to develop knowledge based CAPP considering global and concurrent data for integration. The design and manufacturing are integrated with the use of this knowledge based system in real time. For the blend of such cutting and punching method, the pro/INTRALINK & STEP scope box were used. Ramana & Rao [2] introduced a system to access the design, process planning and automatic assessment of manufacturability for shearing and bending process. Ghatrehnaby and Arezoo [3] computerized the piloting and nesting for progressive dies considering CAD module. Kim and Park [4] developed an automated design process using a system which is based on rules for axi-symmetric hot die forged components. They used FORTRAN and AutoLISP of AUTOCAD. Kim et al. [5] developed a computerized system to design die and process planning using AutoLISP for cold forged axi-symmetric components. The material workability dependant expert system was developed by Ravi et al. [6] for hot forging. Ohashi et al. [7] mechanized rule based system which generates process plan and profile of die from product's configuration based on feature elimination for cold forging. Lee et al. [8] established an expert system for trimming function of car body enterprise. The main features were to estimate holes of piercing and boundaries of car body to minimize scrap. CATIA was coupled with C++ to establish the system. Zhang et al. [9] showed a procedure to recognize fault in automobile engines. They have used integration of neural network based model to detect and solve the problems with rate of low precision.

To design die and predict process planning for cutting and piercing operations, Giannakakis and Vosniakos [10] developed an expert system by using data from theories and empirical equations, handbooks and industry experts. Zhang et al. [11] established an expert system using Dreamweaver and Microsoft SQL server to design balls of automobile applications. Johnston et al. [12] established a computerized system for hard disc manufacturing. It was used to control mechanisms of read, write and overall construction during manufacturing. An expert system was emerged by Dale et al. [13] which can be used to estimate forging values and cost of axi symmetric part. Veera Babu et al. [14] generated an expert system for tailor welded blanks forming process using PAM-STAMP FE code. Many expert systems have been developed in various areas including medical. Reddy and kavitha[15] have developed an expert system to indentify the type of fever from database. They have used data mining concept in their work.

III. METHODOLOGY

When dealing with sheet metal forming process, it is quite necessary to design a die and predict the effect of various factors on the life of die. However, the issue like designing along with an analysis of the die (fatigue analysis) is an untouched aspect. Hence, in present research, an integrated expert system using rules and knowledge has been proposed to design and analyzed the die of deep drawing forming process. The current work aims at studying the effect of different blank materials on the life of the die. Different punch forces are simulated during the process. Table 1 gives the various input parameters that are used to define the model during simulations.

A. Development of ES

The die designing is a very tedious job even it is the combination of science, art and knowledge. Further, the die characteristics are non uniform because as the workpiece material and configuration changes die configuration changes. Such, limitation has been addressed in present work. The system is comprises of user friendly graphic user interface (GUI). Thus semi skilled operator can also operate the system in effective manner.

The prediction part is developed under VB and AUTOCAD environment. Further, the integration to analyze the die has been carried out using ABAQUS with the use of PYTHON scripting. Figure 1(a) and (b) shows input data like cup diameter, height of cup. Thicknesses of cup wall, material types, yield stress etc. These are the basic properties of material.

Based on input data, ES calculates blank diameter, clearance, number of draw and total force applied on die (Fig 2(a), (b) and (c)). For these calculations some rules are generated. Sample rules are reveled as bellowed. Calculated data presented in Table 2(a), (b) and (c).

Planning Rules for modeling of axisymmetric deep drawing operation

R 1: If axisymmetric shape is required to be drawn then first form of the material of sheet metal blank must be a circular plate.

R 2: If current shape is cup of 1, 2 or 3 element (height, width and diameter) then previous shape is a circular blank.

R 3: If a drawn sheet metal product wraps itself to the punch head then the product may be undergoes to stretching.

R4: If the draw can be resulted but unwanted geometrical calculation are predicted then a failing is predicted.

R5: If required punch load cannot passes to blank then perfect deformation cannot be achieved.

R6: If multi stage drawing is introduce then in ach intermediate pass, except for last one, the out coming cup will utilized the LDR

R7: If wrinkling in product are expected then reduce the compressive stresses and follow rule no 10.

R8: Wrinkling tendency classification by thickness ratio TR
- If Very thin then
- If Thin then
- If Moderate then
- If Thick then

R9: If defect is predicted in product then draw can be achieved but with an unwanted geometry

R10: If failure is predicted in final product then the draw cannot be completed.

R11: Limiting thickness to blank diameter is greater than equal to 0.01

R12: Limiting height to blank diameter is greater than half of their diameter

R13: Draw radius
D0/d = 1.8 AL
= 1.9 Steel
= 2.0 S.S.

R14: Die radius
If steel then 4 to 6 time thicker than material
If S.S or AL then 5 to 10 time thicker than material

R15: Punch radius
If steel then 4 to 8 time thicker
If AL or S.s then 8 to 10 time thicker

R16: If rule 13, 14, 15, 16 and 17 are achieved then part is feasible for form

R17: If rule 18 is achieved then manufacturability is passed

R18: For force
Fmax=II*d*t*ult((D/d)*0.7)

R19: Blank load
Fmax * 1/3 * punch force

R20: Total load= Force+Blank load

R21: If number of draw is required than total load calculated separate

R22: If all necessary data is entered than manufacturability is pass and ready for next step

R23: If data is plot with CAD than is produce required Die Design in CAD

These are the sample rules for calculations. Here flow of process is forward chaining. Forward chaining is a process flow to find out the solution in a forward direction. It starts with the data and reasons its way to the answers. In this process data and rules are selected and used, so it is called data-driven process or forward chaining.

In this paper, authors have developed and expert system for sheet metal forming dies. Rules and knowledge based expert system is developed under VB and AutoCAD environment. Developed system is capable to draw a die design automatically based on few parameters. In more fatigue life of die is predicted. So by using ES, manufactures industries can easily survives in fluctuating market. This section is divided in to two categories. 1. Die design module and 2. Fatigue life prediction module

1. Die Design module

Developed expert system is GUI based so input data is required. This input data are basically production information

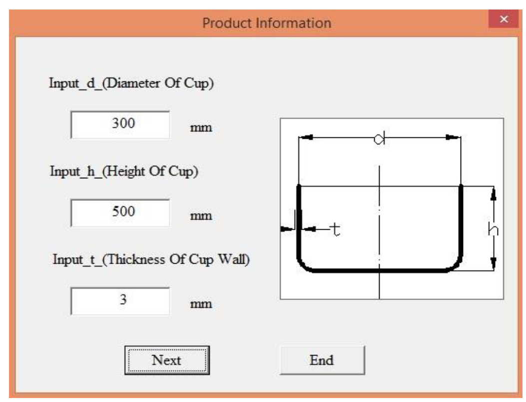

Fig 1. Input definition (a) product

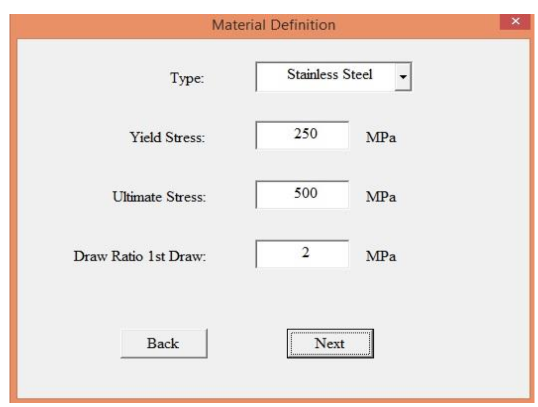

Fig 1. (b) product Material Definition

like- height, thickness and diameter of cup and material information like- material type and stresses (fig 1(a), (b)).

Based on few input parameter system generates a die design (axisymmetric) in AutoCAD environment. Input

Parameters have presented in table 1

Table 1: Model Design Parameters

Product Information		Material Information	
Diameter of Cup	300 mm	Type	SS(Stainless steel)
Height of Cup	500 mm	Yields stress	250 mm
Thickness of Cup	3 mm	Ultimate Stress	500 mpa
		Drawing ratio for 1st	2 mpa

Here yield stress and ultimate stress are mechanical property.

Based on input data and sample rules, ES generates calculation of blank diameter (table 2(a)), no of draw for each draws Table 2(b) and drawing details for each draw Table 2(c).

1. Blank Diameter Calculation Details

Table 2(a): Blank (Sheet Material Diameter calculation)

1	Blank Diameter	830.66 mm
2	Clearance	3.55 mm
3	Punch and Die Profile	30 mm (Punch), 30 mm (Die)

2. Number of Draw

Here number of draw is 3 that are generated by ES based on rules and knowledge.

Table 2(b): Number of Draw for Each Draw : 3

	Cup Diameter for each Draw	Height of cup for each Draw
1	498.29 mm	221.60 mm
2	348.94 mm	407.10 mm
3	300 mm	500

3. Drawing details for each draw

Sometimes die design required number of draw. Because if height of product is very high than it is not possible to generate a product within a once punch force. Generally in deep drawing forming operation number of draw is required and that is based on input data like height and diameter of product. Here number of draw required is three that is generated by ES. So punch diameter, die diameter, punch load, blank load and total force are generated for each and every draw that is reveled in table 2(c).

Table 2(c): Drawing details for each draw 3

No. of dr.	Punch dia.	Die dia.	Punch Load	Blank holder Load	Total Force
1	498.3	505.4	2270.68	756.89	3027.57
2	348.95	356.05	1197.11	399.04	1596.15
3	300	307.1	654.79	218.26	873.05

Graphical representation of this calculation have been reveled in figure 2(a, b, and c). By clicking on AutoCAD Plot (fig 2(c)), ES have generates die design in AutoCAD environment. Axisymmetric die design is presented in figure 3.

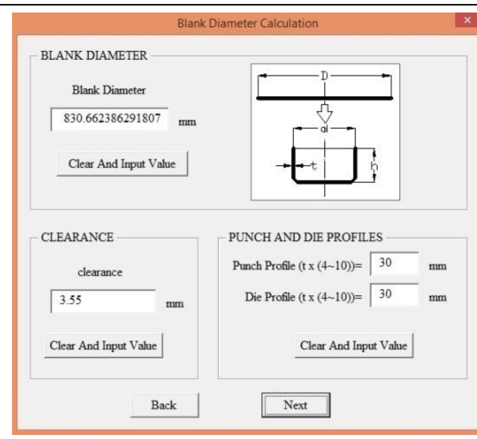

Fig 2. Determination of (a) blank diameter, clearance, and punch & die profile

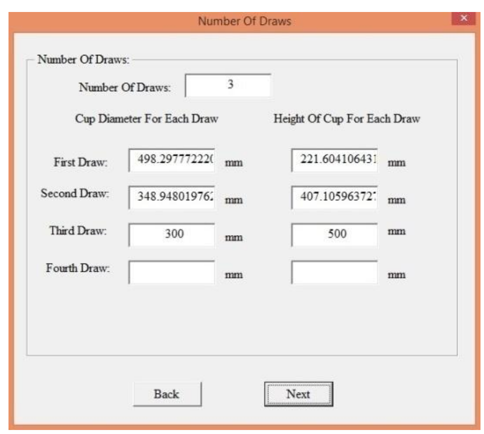

Fig 2. (b) no. of draws

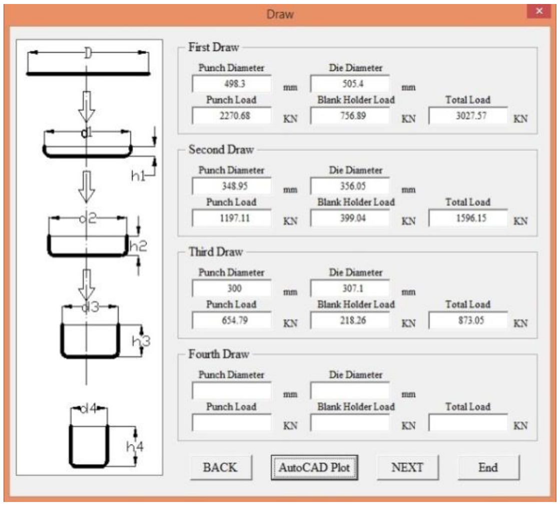

Fig 2(c) Estimation of punch diameter, die diameter, punch load, blank holder load and total load

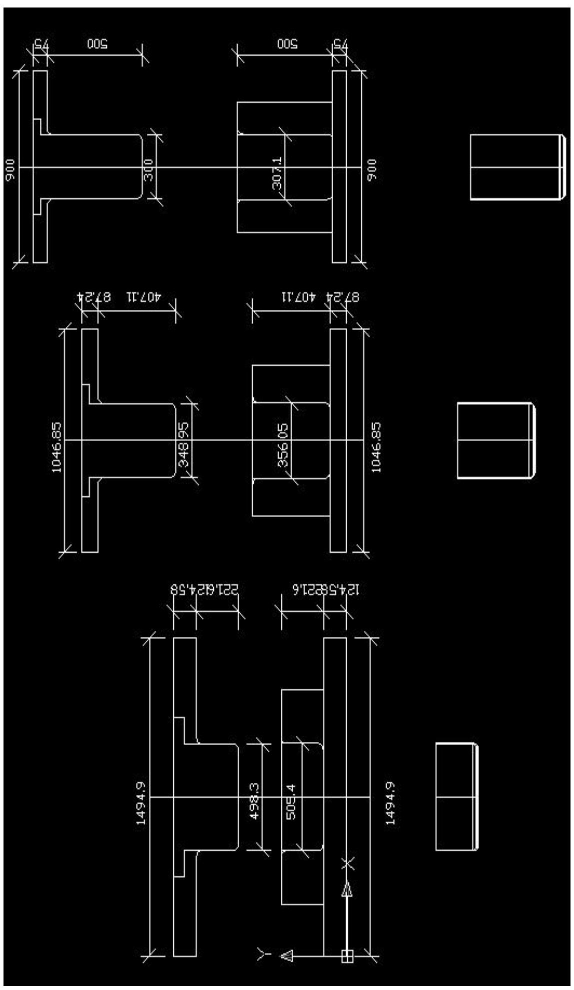

Fig 3. Manufacturing drawing using ES

2 Fatigue life prediction modules

Generally fatigue failure occurs due to stresses that are much more or less than the required stress. Based on industrial data and research it has been observed that fatigue contributes up to 90% to all mechanical service failures like forming, casting, welding etc. Automobiles product like- car, aircraft product like - jet engines, wings and body, water vehicles like- ships, house hold utensils like- food container etc are subject to fatigue failures. Fatigue problem was initially identified in the early 1800s.

2.1 Related Work

Today, much work has been reported in the area of fatigue in mechanical and many more sectors too. Falk et al., [16] investigated on fatigue behavior of cold forging die using FEM (finite element analysis). It was reported that the material data should be combined with information about failure probability in four point bending. Also, the volume based damage approach is less accurate. Hasen et al., [17] studied on crack initiation and crack growth to predict the number of forming cycles considering finite element modeling for cold forging dies. It was found by the authors that the predicted tool life for low cycle fatigue test was 782 cycles. That was experimentally determined as 1000 cycles. Kashid and Kumar [19] investigated on the fatigue life of punches of the compound dies using ANN. Hari Shankar et al., [20] demonstrated the fatigue analysis of the polymer composite die of deep drawing using FE simulations. It was stated that polymer composite material, Renshape 5166 dies made by rapid tooling techniques prove to be good solution in this scenario. Vlasov [21] reported on the thermo mechanical fatigue of dies for hot stamping. The QFORMV8 software was used for test calculation of the hot stamping of conical gear. It was illustrated that that this die withstands around 400 forgings and breaks down in the section of the matrix surface formed by the tooth channel at the base of the fillet.

However, from the literatures, it was observed that either FEM or experimental approach was used by many researchers. FE based approach is an approximate method as it is governed by Newton Raphson, Gauss Newton etc. methods. Further, experimental approach is uneconomical way to determine fatigue life. Hence, theoretical method could be an appropriate approach to predict the fatigue life.

2.1.2 Calculation for fatigue life

This section described fatigue life phenomenon. Here the method followed for fatigue analysis is based on Bhandari [22]. It was stated that if stresses applied on product form punch and die are not as same as it is required than operation causes a fatigue failure during production cycle. This phenomenon decreases the resistance power of material and that is the main characteristics of fatigue failure. Further, few terminologies associated with the fatigue analysis and recommended values are briefly explained below. This are

1. Endurance limit
2. Approximate endurance limit stress
3. Failure stress and
4. Fatigue limit (Plotting S-N diagram: stress vs. number of cycle calculation)

All above are used to describe the property of materials.

1) Endurance limit

The highest stress that a material can stand with for an infinite number of cycles without any fail is called as endurance limit. But fatigue test cannot be expected for infinite number of times. It is generally 10^6 Endurance limit is used to predict the fatigue life stress on a part.

2) Endurance limit – Approximate estimation

There is an approximate relationship between the endurance limit and the ultimate tensile strength (S_{ut}) of the material.

for Steel,

$$S'_e = 0.4 S_{ut}$$

Where, S'_e = endurance limit stress (maximum sustainable amplitude) of a rotating beam specimen subjected to reversed bending stress (N/mm^2 or MPa). Also, S_e = endurance limit stress of a particular mechanical component subjected to reversed bending stress (N/mm^2 or MPa)

for cast iron or cast steel,

$$S'_e = 0.4 S_{ut}$$

for wrought aluminum alloys,

$$S'_e = 0.4 S_{ut}$$

for Cast aluminum alloys,

$$S'_e = 0.3 S_{ut}$$

The relationship between (S_e) and (S'_e) is as follows (Bhandari, 2013),

$$S_e = K_a K_b K_c K_d S'_e$$

Where, Ka = surface finish factor, Kb = size factor, Kc = reliability factor, and Kd = stress concentration factor.

(i) Surface finish factor – *ka*

The surface finish of the component is mainly depending upon the process of manufacturing. It is impossible to generate same surface finish for differently processed samples. High strength materials are more sensitive to stress concentration introduced by surface irregularities. The equation to determine Ka is following term,

$K_a = a(S_{ut})^b$ [if Ka>1, set Ka =1]

Where, S_{ut} is an ultimate tensile strength

The recommended values of co-efficient *a* and *b* are given in table below.

Table 4.3: values of coefficients *a* and *b* in surface finish factor

Surface finish	*a*	*b*
Ground	1.58	-0.085
Machined or cold drawn	4.51	-0.265
Hot worked	57.7	-0.718
Forged	272	-0.995

(ii)Size factor

Based on industrial data the recommended values for size factor are given below.

Table 4.4: values of size factor

Diameter (d) (mm)	Kb
d $\leq$ 7.5	1.00
7.5 < d $\leq$ 50	0.85
d > 50	0.75

(iii)Reliability factor

The laboratory values of endurance limit are usually mean values. There is considerable dispersion of the data when a number of tests are conducted even using the same material and same conditions. The reliability factor depends upon the reliability that is used in the design of the component.

Table 4.5: Reliability factor

Reliability R (%)	Kc
50	1.000
90	0.897
95	0.868
99	0.702
99.99	0.659

(iv) Stress concentration factor

The endurance limit is reduced due to stress concentration. The stress concentration factor used for cyclic loading is less than the theoretical stress concentration factor due to the notch sensitivity of the material.
The stress concentration factor is defined as,

$$K_d = 1/K_f$$

The above mentioned four factors are used to find out the endurance limit of the actual component.

2.1.3 Calculation of the present research problem

Here the material of the die is taken as D2 (HCHC die steel) based on the industrial data.
The material properties are: yield strength of the material (S_{yt}) = 2150 MPa, ultimate tensile strength (S_{ut}) = 2503 MPa [28] Rockwell hardness = 60 HRC. The inner diameter (di) of die is calculated from the ES (expert system) data i.e. 300 mm product diameter thus die diameter is considered as 300 mm considering 2.5 mm air gap on each side. It is assumed as no stress concentration in the die because it is very rapid process of deformation.

1. Endurance limit stress (for the cast steel material) (die)

$$se' = 0.4 * S_{ut}$$
$$se' = 0.4 * 2503$$
$$se' = 1001.2\ MPa$$

2. Surface finished factor and endurance limit

The die is hot worked. Hence Ka can be calculated as so that from Table 1 the coefficients are a = 57.7 and b = -0.718

$$ka = a(S_{ut})^b$$
$$= 57.7(2503)^{-0.718}$$
$$ka = 0.2094$$

2.1 Size factor as the di = 125 mm the size factor Kb = 0.75 based on Table 2. (Constant)
2.2 The reliability factor Kc is taken as 0.702 from Table 3 considering 99% reliability.

So that, Endurance limit is,
$se = ka * kb * kc * se'$
$= 0.2094 * 0.75 * 0.702 * 1251.5$
$= 137\ MPa$

3. Failure stress

The calculation of S_f is given below

$sf = force/area$

$$Sf = \frac{2270.68 * 10^3}{\pi/4 * 300^2}$$ (here 300=di)

So,
S*f*= 32.13 MPa (here the force is 2270.68 is taken from the expert system)

4. fatigue life

Generally fatigue life is calculated with Stress vs. number of cycle called S-N diagram that was published in year 1870.

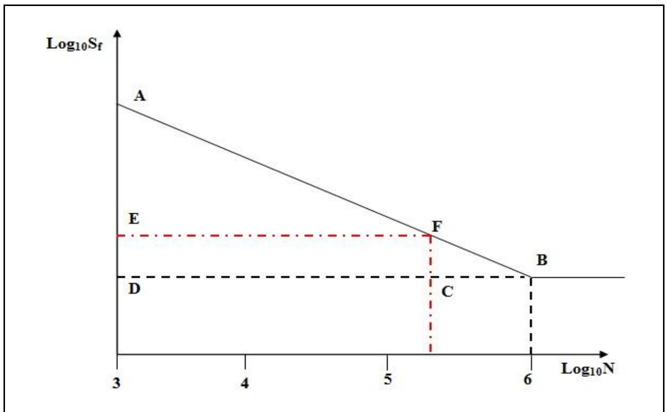

Fig 4. S-N diagram for present study

From S-N diagram (Fig 4),

$$EF = \frac{DB*AE}{AD}$$

Here DB, AE and AD is required.

$0.9\,(S_{ut}) = 0.9 * 2503$ (here $S_{ut} = 2503$)
$= 2252.7$
$\log_{10} 0.9\,(S_{ut}) = 3.3527$

now, calculate $\log_{10}(Se)$ and $\log\,(Sf)$

1. $\underline{\log_{10}(Se)}$

$\Rightarrow \log_{10}(Se) = \log_{10}(137)$
$= 2.139$

2. $\underline{\log_{10}(Sf)}$

$\Rightarrow \log_{10}(Sf) = \log_{10}(32.13)$
$= 1.507$

Also, $\log_{10}(10^3) = 3$ and $\log_{10}(10^6) = 6$

Here based on S-N diagram,

$$EF = \frac{DB*AE}{AD}$$
$$= \frac{(6-3) * (3.3527 - 1.507)}{(3.3527 - 2.139)}$$
$$= 4.5621 = 4.5$$

$\log_{10} N = 3 + EF = 7.5621$

So,
N = 878636.67 cycle

Means based on input data product survives up to 878636.67 number of times without any fail. Using Expert System Model, the detailed manufacturing drawing with force of the punch and die for all draws are developed into the AUTOCAD (Fig. 3, 5).

In more, approximate fatigue life of axisymmetric die is calculated in advance. Graphical representation is reveled in Fig 6.

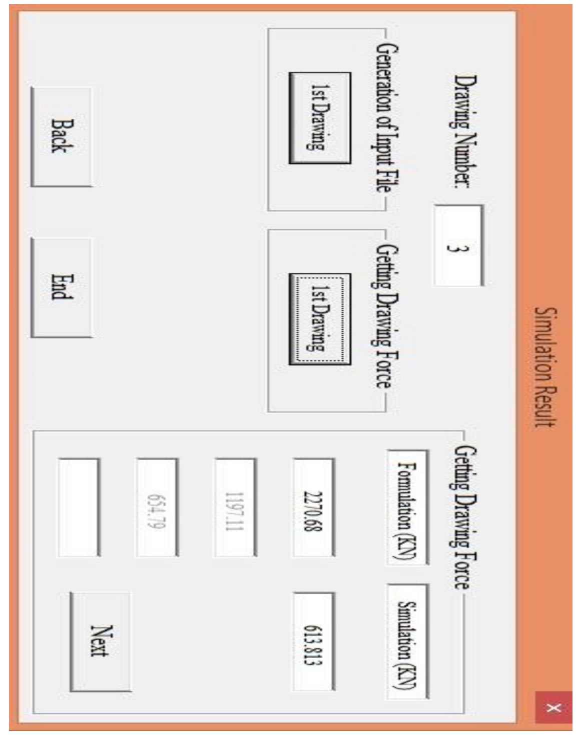

Fig 5. Manufacturing drawing force of tooling for each draw

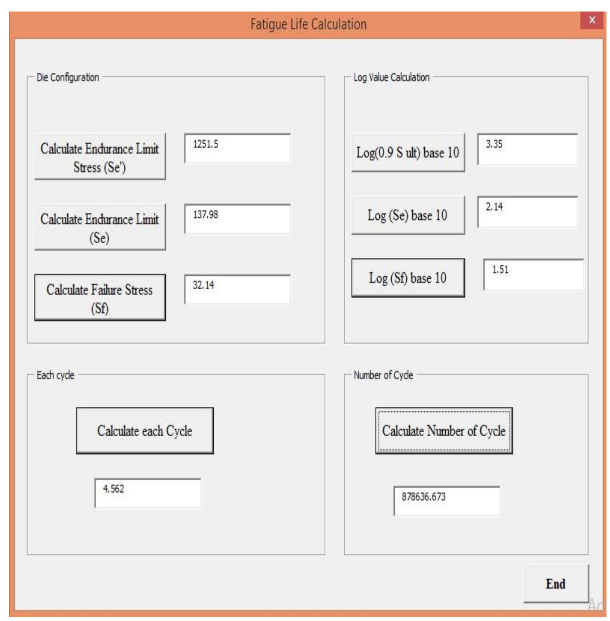

Fig 6. Fatigue Analysis using ES

1. Fatigue life calculations(Appendix II)

Table 3: Fatigue life calculation

Endurance Limit (se)	Endurance Limit (se')	Failure Stress	No. of cycle
1251.5	137.97	32.13	878636.67

Calculated force data (Table 2, Fig 3) are compared with other analysis tools like abaqus (Fig .7, Table 4). Result calculated by ES is approximate same as others tools.

Table 4: Simulation Result- Forces

ES Result	Abacus Result
654.79 KN	613.81 KN

Script file is generated for import a data in analysis tools (Appendix 1).

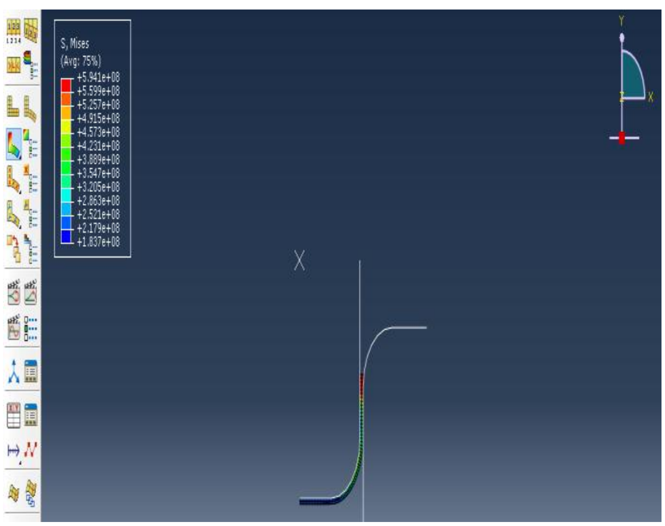

Fig 7. Simulation in Abaqus

IV. RESULTS AND DISCUSSION

In this study the lives of die with above configuration (Table 1), runs approximate 878636.67 number of cycle without any fail. These drawing and calculation can be directly used in manufacturing process such a way indirect costs can be reduced. Also the enterprise can be able to survive in floating market demand.

Results of the ES indicated that the stresses in the punch are varied by each draw. With die, it is observed that the max compressive stresses are being generated at the tip of the shoulder radius and tensile stresses are just above that of the shoulder radius.

Based on the results, it is observed that for a sheet thickness of 3 mm with stronger material like Stainless Steel as sheet material then the die life is limited to around 878636.67 numbers of cycles.

V. ACKNOWLEDGEMENT

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REFERENCES

[1] S. Q. Xie, and J. Q. Liu, *"Integrated concurrent approach for compound sheet metal cutting and punching"*, International Journal of Production Research, Vol.39, Issue.6, pp.1095–1112, 2001

[2] K. V. Ramana, and P. V. M. Rao, "*Automated manufacturability evaluation system for sheet metal components in mass production"*, International Journal of Production Research, Vol.43, Issue.B, pp.3889-3913, 2005

[3] M. Ghatrehnaby, and B. Arezoo, *"A fully automated nest-ing and piloting system for progressive dies"*, Journal of Materials Processing Technology, Vol.209, Issue.1, pp.525–535, 2009

[4] D. Y. Kim, and J. J. Park, *"Development of an expert sys-tem for the process design of axisymmetric hot steel forging"*, Journal of Materials Processing Technology, Vol-01, Issue.1-3, pp.223-230, 2000

[5] M. S. Kim, J. C. Choi, Y. H. Kim, G. J. Huh, and C. Kim, *"An Automated Process Planning and Die Design System for Quasi-Axisymmetric Cold Forging Products"*, International Journal of Advanced Manufacturing Technology, Vol.20 Issue.3, pp. 201–213, 2002

[6] R. Ravi, Y. V. R. K. Prasad, and V. V. S. Sarma, *"Development of Expert Systems for the Design of a Hot-Forging Process Based on Material Workability"*, Journal of Materials Engineering and Performance, Vol.12, pp. 646-652, 2003

[7] T. Ohashi, S. Imamura, T. Shimizu, M. Motomur, "*Computer-aided die design for axis-symmetric cold forging products by feature elimination"*, Journal of Materials Processing Technology, Vol.137, issue.1-3, ,pp. 138–144, 2003

[8] S. J. Lee, T. S. Kim, S. S. Lee, and K. S. Park, *"Development of an Expert System for the Trim Die Design in Au-tomotive Industry"*, In Tenth Computer Supported Cooperative Work in Design Conference (CSCWD), IEEE pp.1-6, 2006

[9] X. Zhang, M. Lu, P. Su, G. Xu, and H. Zhao, *"Research on Neural Network Integration Fusion Method and Application on the Fault diagnosis of Automotive Engine"*, In the Proceedings of the 2007 IEEE Second Industrial Electronics and Applications Conference (ICIEA 2007), IEEE. pp.48, 2007
[10] T. Giannakakis, and G. C. Vosniakos, *"Sheet metal cutting and piercing operations planning and tools configuration by an expert system"*, International Journal of Advanced Manufacturing Technology, Vol.36 Issue.7-8,, pp. 658–670, 2008
[11] X. Zhang, C. Y. Han, Y. Cui, Y. P. Lu, E.F. Liu, and H. B.Cui, *"An Active Knowledge Support System for Design of Automobile Ball"*, in International Workshop on Intelli-gent Systems and Applications (ISA 2009), IEEE, pp. 1-4, 2009
[12] A. B. Johnston, L. P. Maguire, and T. M. McGinnity, *"Downstream performance prediction for a manufacturing system using neural networks and six-sigma improvement techniques"*, Robotics and Computer-Integrated Manufacturing, vol.25, Issue.3, pp. 513– 521, 2009
[13] T. M. Dale, W. A. Young, and R. P. Judd, *"A rule-based approach to predict forging volume for cost estimation during product design"*, International Journal of Advanced Manufacturing Technology, Vol.46 Issue.1-4, pp.31–41,2010
[14] K. VeeraBabu, R. Ganesh Narayanan, and G. Saravana Kumar, *"An expert system for predicting the deep drawing behavior of tailor welded blanks"*, Expert Systems with Applications, Vol.37, pp. 7802–7812, 2010
[15] M.V.Jagannatha Reddy , B.Kavitha, "Expert System to Predict the Type of Fever Using Data Mining Techniques on Medical Databases", International Journal of Computer Science and Engineering, Vol.3 , Issue.9 , pp. 165-171, 2015
[16] B. Falk, U. Engel, and M. Gieger, *"Fundamental aspects for the evaluation of the fatigue behavior of cold forging tools"*, Journal of Materials Processing Technology, Vol.119, pp.158-164, 2001
[17] P. Skov-Hansen, N. Bay, J. Grùnbñk, and P. Brùndsted, *"Fatigue in cold-forging dies: tool life analysis"*, Journal of Materials Processing Technology, Vol.95, pp. 40-48, 1999
[18] ABAQUS user guide, 2013
[19]S. Kashid, and S. Kumar, "*prediction of life of punches of compound die using artificial neural network"*, in 5th International & 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014), vol.62, pp. 1-6, 2014
[20]V. H. Shankar, V. R. Kumar, and N. V. S. Shankar, *"fatigue analysis of polymer composite deep drawing die"*, International Journal of Mechanical Engineering and Robotics Research, Vol.4, Issue.2, pp. 22-29,2015
[21] A. V. Valsov, Thermomechanical Fatigue of Dies for Hot Stamping, in Steel In Translation, Vol.46, Isuue.5 pp. 356-360,2016
[22] V. B. Bhandari, Design of Machine Elements, Third Ed., Tata McGrow Hill Edu. Pvt. Ltd., 2013.
[23] AUTOCAD user manual, 2010
[24]ASM International, Fatigue, Elements of Metallurgy and Engineering Alloys, 2008.

Authors Profile

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Dr. Sanjay Buch is IT Professional, With PhD in Computer Science from V.N.S.G.U (Year 2003). Data Warehousing, Data Analytics and Data Quality are his main research areas. He is also certified with (PMP) certified by the Project Management Institute, USA & ITIL V3 by OGC-UK. He has more than 34 plus years of cross functional experience in multiple IT domains such as Petrochemical & Polyester Manufacturing, Mutual Fund & Investor Services, Capital Market, Public Policy Research, Retail and Application Management/Operations at Enterprise level. He has worked at many big locations like Delhi, Mumbai, Ahmedabad, Vadodara and Surat. Post superannuation with effect from 31/05/2018 Dr. Sanjay Buch is associated as Professor in Computer Engineering and Information Technology, CGPIT, Uka Tarsadia University (UTU), Bardoli, Dist. Surat from 01/07/2017. He is also registered guide with UTU and R K University Rajkot.

APPENDIX A: Sample Python Scrip

```
from abaqus import*
from abaqusConstants import*
```



```
backwardCompatibility.setValues(includeDeprecated=True,
reportDeprecated=False)
myModel=mdb.Model(name='DeepDrawing1')
import part
blankSketch=myModel.ConstrainedSketch(name='blankProfi
le',sheetSize=1.)
blankSketch.rectangle(point1=(0.0,.0042),point2=(
.14696938456699 ,0.0))
blankSketch.ConstructionLine(point1=(0.0,0.05),point2=(0.0
,-0.05))
myBlank=myModel.Part(name='Blank',dimensionality=AXI
SYMMETRIC,type=DEFORMABLE_BODY)
myBlank.BaseShell (sketch = blankSketch)
myBlank.Set(name='Blankset',faces=myBlank.faces)
punchSketch=myModel.ConstrainedSketch(name='punchPro
file',sheetSize=1.)
line1=punchSketch.Line(point1=(0.0,.0084),point2=(
.088165 , .0084 ))
line2=punchSketch.Line(point1=(    .088165,  .0084),point2=(
.088165 , .17633 ))
punchSketch.FilletByRadius(radius=.042
,curve1=line1,nearPoint1=(0.0,.0084
),curve2=line2,nearPoint2=(  .088165 , .17633 ))
punchSketch.ConstructionLine(point1=(0.0,0.05),point2=(0.
0,-0.05))
myPunch=myModel.Part(name='Punch',dimensionality=AXI
SYMMETRIC,type=ANALYTIC_RIGID_SURFACE)
```

APPENDIX B: Sample VB code

```
Private Sub btn_se_Click()
        ka = 0.2094
        kb = 0.75
        kc = 0.702
        kd = 1
        se1 = (0.5 * 2503)
        se = (ka * kb * kc * se1)
        txt_se.Text = se
End Sub

Private Sub btn_se_desh_Click()
        se1 = (0.5 * 2503)
        txt_se_desh.Text = se1
End Sub
```