DESIGN & ANALYSIS OF CRANKSHAFT OF DIE STATION OF VACUUM FORMING MACHINE

C. P. Gaikwad
Pune University, MET Institute of Engineering,
Department of Mechanical Engineering, Adgaon, Nashik
S. D. Kalpande
Pune University, MET Institute of Engineering,
Department of Mechanical Engineering, Adgaon, Nashik

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Abstract:

The objective of this work is to design and analyze the performance of crankshaft, through a simple experimental model of Forming and Cutting Die Station of Vacuum Forming Machine. A crankshaft is basically designed for bending failure of the crank pin. A parametric mathematical model of crankshaft is modeled using Pro-E Wildfire 4.0 Software and its Static Structural Analysis is carried on Ansys v-11.0 Workbench.FEA of crankshaft is done to determine its von-Misses stress, Max shear Stress, von-Misses strain and Alternating stress to cycles graph.

Keywords: *crankshaft, bending, FEA, stress, forming, vacuum, machine, ProE, model, failure, static, structural.*

In its simplest form the Vacuum forming process consists essentially of inserting a thermoplastic sheet in a cold state into the forming clamp area, heating it to the desired temperature either with just a surface heater or with twin heaters and then raising a mould from below. The trapped air is evacuated with the assistance of a vacuum system and once cooled a reverse air supply is activated to release the plastic part from the mould. [3].The crank shaft is used to convert rotary motion into reciprocation motion of Die plates.

Experimental Setup

Forming and Cutting Die Pillar Station

Thermoforming machine is used to form the plastic parts to desired shape. In this Figure1 there is a top and bottom plate within which the forming cum cutting die is placed between the two plates. The Vacuum System is used to form the plastic by means of high vacuum pressure as well as high pressure air from top also for equal distribution of wall thickness of plastic. Before this station there is heating station to preheat the sheet which is to be formed and after heating station this forming cum cutting station is placed.Figure:1 show the Experimental setup of forming cum cutting die pillar station. The various parts of the Die pillar stations are as follows: 1)Top plate, 2)Bottom plate, 3)Shaft, 4)Crankshaft, 5)Connecting rod, 6)Bearings, 7)Die Pillars, 8)Gear box and 9)Motor. Out of all these parts we are designing the Crankshaft which is an important part in transmitting motion

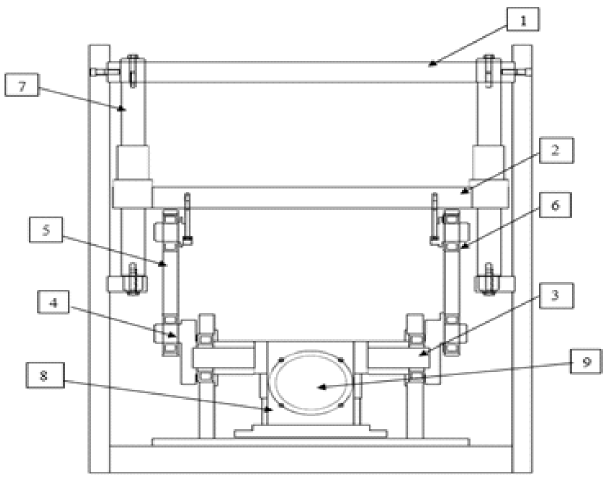

Figure 1 – Forming & Cutting Die pillar station of Vacuum forming Machine.

Table 1: Vacuum forming Machine Specifications

Machine Specifications	
Die Size	1010 mm x 300 mm
Cutting Force	50 tons = 490.5 KN
No: of cycles	40 cycles/min
Forming Process	Vacuum forming
Heaters capacity	55 KW
Material to be Formed & Cut	PVC,PET,HIPS,ABS
Thickness Range	0.1 – 4 mm

Design of Crankshaft

Crankshaft is connected to shaft and connecting rod.

It is used to transmit power and torque.

The design of Crankshaft involves design of crank pin and thickness of crank web. [1]

Let,

M= Bending Moment, N.mm

W = Load applied

l_c = Length of crankpin,mm

l = Length of connecting rod, mm

r= Radius of crank = 82 mm

t_c = thickness of crankweb,mm

á$_b$ = Bending Stress, N/mm^2

Z= Section modulus, mm^3

w= width of crankweb, mm

d_c= Diameter of crank pin, mm

P_b = Bearing pressure (Generally 9.8 – 12.6 N/mm^2)

1) Design of crank Pin

$W = d_c \times l_c \times P_b$

$245.25 \times 10^3 = d_c \times 0.8\ d_c \times 12.6$

d_c = 160 mm approx

l_c = 124 mm

Bending Moment at Crank pin,

$M = ¾\ W \times l_c$

$= 22.808 \times 10^6$ N.mm

$Z = \pi/32 \times d_c^3$

$= 402.12 \times 10^3$ mm^3

$\delta_b = M/Z$

$= 56.71$ N/mm^2 < 212.5 N/mm^2

Therefore the design of crank pin is safe

2) Design of Crank Web Thickness of crank web (t_c)

$t_c = 0.6\ d_c$

$= 0.6 \times 160$

$= 96$ mm

The Bending moment

$M= W (0.75\ l_c + 0.5\ t_c)$

$= 245.25 \times 10^3\ ((0.75 \times 108) + (0.5 \times 108))$

$= 34.58 \times 10^6$ N.mm

Section modulus

$Z = w\ t_c^2 / 6$

$= \frac{w \times 96^2}{6}$

$= 1536$ w mm^3

Bending stress

$\delta_b = M/Z$

$212.5 = \frac{34.58 \times 10^6}{1536\ w}$

w= 106 mm

But, d_c is attached to crank web so w is increased to about

w= 180 mm

Table 2 – Parameters Values

Parameters	**Values**
Diameter of Crank pin	160 mm
Length of Crank pin	124 mm
Crank web thickness	96 mm
Width of Crank web	106 mm
Diameter of small shaft	112 mm
Length of small shaft	100 mm

Methodology

Modeling of Crankshaft

Crankshaft is modeled on Pro-E Wildfire 4.0 software. The Mathematical Model is imported to ansys software is shown in Fig

Steps to Model Crankshaft

Open Pro-E Wildfire 4.0 software enter into sketching plane section draw the sketch of Connecting rod with help of various sketching commands and 3D modeling commands in modeling the connecting rod. Once the Mathematical model is prepared and exported to iges format and imported to Ansys v 11.0 software for analysis purpose.

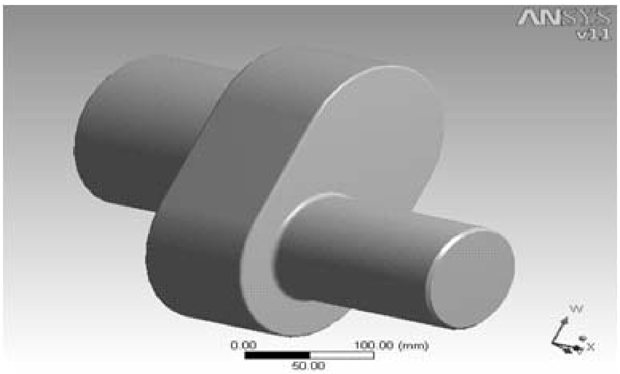

Figure 2 – Mathematical model of Crankshaft

Finite Element Analysis (FEA)

In this study, the crankshaft is designed for bending strength of crank pin .In this study of FEA of crankshaft the calculated bending stress value is compared with Ansys Von-Mises stress. Basically the analysis is in Static Structural Analysis module.

Steps Involved in FEA

Following steps are used for making Finite element analysis of crankshaft in Ansys v 11.0 software.

Meshing

Basically in Ansys v 11.0 software it automatically selects the type of mesh .In this case Tetrahedral meshing of element size 3 mm is selected for its analysis. For analysis the element size selected is 3mm with fine mesh.

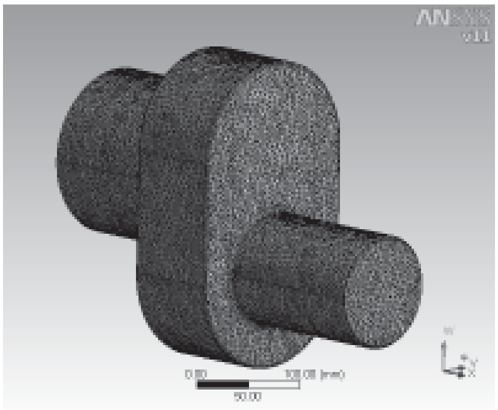

Figure 3 – Meshed Mathematical model of Crankshaft

Table 3 – Number of Nodes and Elements

Statistics	
Nodes	244866
Elements	156881

Properties

The material properties given in below table are entered in Engineering Data with name as Structural Steel.

Table 4 – Material Properties [4]

Material Properties	
Young's Modulus	2.1e+005 MPa
Poisson's Ratio	0.3
Density	7.85e-006 kg/mm³
Yield Strength	600. MPa
Tensile Ultimate Strength	850 MPa

Constraints

Crankshaft is a constraint with bearings .The bearings are press fit to the crankshaft and does not allow the crankshaft to have any motion other than rotation about its main axis. Since only 180 degrees of bearing surface facing the load direction constraint the motion of crankshaft, this constraint is defined as fixed semicircular surface as wide as bearing width. [2].The load applied on crank pin is 245.25 KN.

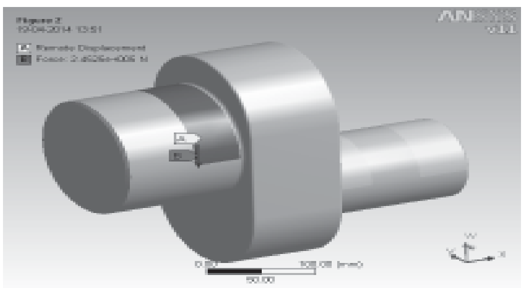

Figure 4 – Boundary Conditions of Crankshaft

Structural Analysis

When all loads and displacement are applied analysis would be last step. Select the option called Solve .The software starts analyzing automatically and finally solves the problem.

Result

Once the individual attachment is done for viewing different results select each attachment for viewing individual results.

Results and Discussion

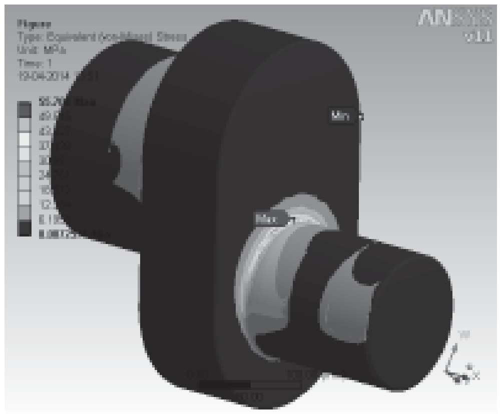

Figure 5: Von-misses Stress for Crankshaft

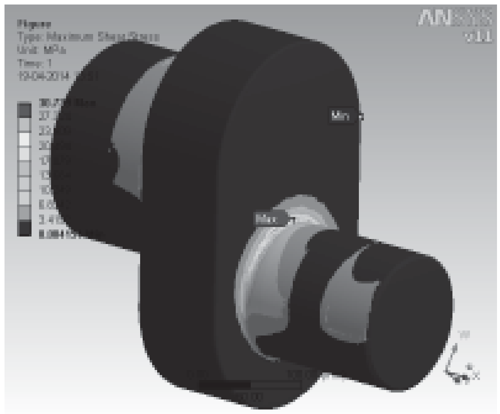

Figure 6: Maximum Shear Stress for Crankshaft

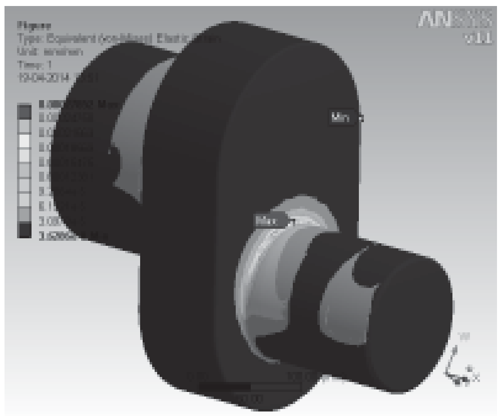

Figure 7: Von-misses Strain for Crankshaft

Table 5 – Results

Theoretical Stress Value	Ansys Von misses Stress Value
56.71 N/mm²	55.70 N/mm²

The theoretical design of crank pin seemed to be safe. The theoretical stress value is 56.71N/mm^2 which is less than the prescribed value. In addition to theoretical design, analysis was made on Ansys v 11.0 workbench in order to conform the theoretical results and it was found that results are almost nearer to each other. The Figure 5. Indicates that maximum stress value occurs at the smaller shaft end which indicates as the weaker section.

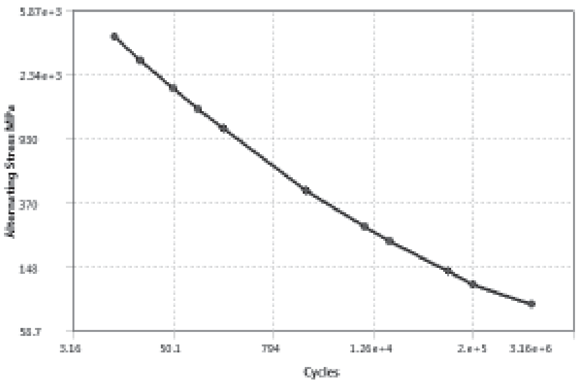

Figure 8: Alternating Stress v/s Cycles Graph

Table 6: Alternating stress Values for given cycles

Cycles	Alternating Stress MPa
10.	3999.
20.	2827.
50.	1896.
100.	1413.
200.	1069.
2000.	441.
10000	262.
20000	214.
1.e+005	138.
2.e+005	114.
1.e+006	86.2

Table 6: shows the graph of Alternating Stress values for given cycles indicate the life of crankshaft. It shows that crankshaft will have a life span of about 3.16 e+6 cycles.

Conclusion

The theoretical stress and Ansys v 11.0 workbench stress values were compared in order to confirm the accuracy and reliability of the design. Crankshaft will have a life span of about 3.16 e+6 cycles from Figure 8.In addition to that the maximum stress values is also estimated in ansys as 30.73 N/mm^2 and Von misses strain as 0.00027852 .

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