COMPUTER AIDED DESIGN AND ANALYSIS (UME411)

(Jan-May, 2020)

PROJECT 1

MODELLING, ANALYSIS, OPTIMIZATION OF CRANKSHAFT BY REVERSE ENGINEERING

Presented To

Mr. Ajayinder S Jawanda

Associate Professor

Mechanical Department

Prepared By

Shivu Chauhan

101809031

2MTX2

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Mechanical Engineering Department

TABLE OF CONTENTS

LIST OF FIGURES AND GRAPHS

EXECUTIVE SUMMARY

The purpose of this report is to model and optimize the crankshaft of the HONDA GX160 engine using CREO parametric 6 software. We will have to model the shaft with the initial dimensions given. By default, CG point is not visible on screen so we will display is using mass properties option. The CG should lie on the axis of rotation for minimum vibrations during working of shaft. For this, we need to know the initial distance on CG from axis and so define a feature as AXIS DISTANCE using measure command. Its initial value came 1.84331 mm.

BMX module of CREO allows us to define our own features for analysis.

The total height of shaft along Y direction is constraint to 84mm. Now sensitivity analysis is done to know the variation of CG with changing dimension through graphs plotted by the sensitivity analysis command box. First it was done for the width of the counterweight and a range of value where the minima of graph was obtained was noted and the same procedure done for another dimension.

DIMENSION	MINIMUM(mm)	MAXIMUM(mm)
HEIGHT	30	42
Distance of centre of smaller radii from axis	0	7

The next aim was to minimise the total mass of the shaft. It is done using the powerful Optimization and Feasibility command of CREO under analysis tab. Under this we have to set the design constraints that AXIS distance should be 0mm. After 6 iterations the model was completely optimized and the Axis distance became 0 along Y direction correct up to 6 decimal places. And the mass that was initially **1.9878899e-03 TONNE** reduced to 1.8035333e-03 TONNE.

ABSTRACT

Whether it's rebuilding a car engine or diagramming a sentence, people can learn about many things simply by taking them apart and putting them back together again. This is what we call as reverse engineering.

REVERSE ENGINEERING is nowadays used in almost every field as it is a powerful tool for not only learning but also create a new way of making a product already existing in the market so that it's cost of production could be lowered.

The aim of this project is to model the HONDA GX160 ENGINE crankshaft using reverse engineering and then optimize the design of crankshaft so that:

1. COG of crankshaft lie on axis of rotation.

   Note: For the CRANKSHAFT to work with minimum vibrations, the COG (Centre of Gravity) of the body should lie exactly on the axis of rotation of the crankshaft.

2. Crankshaft should have **minimum mass** possible.

BMX MODULE (CREO):

BMX is the ultimate in feature based parametric modelling through which we create features that ensure changes to geometry and update the rest of your model.

GETTING STARTED

I. MESURING THE DIMENSIONS OF HONDA GX160 CRANKSHAFT:

To start with the modelling, we should know the dimensions of the body. All dimensions were taken by using proper measuring devices like Vernier callipers and are sketched as below:
Crank Radius to be taken as 22.48mm.

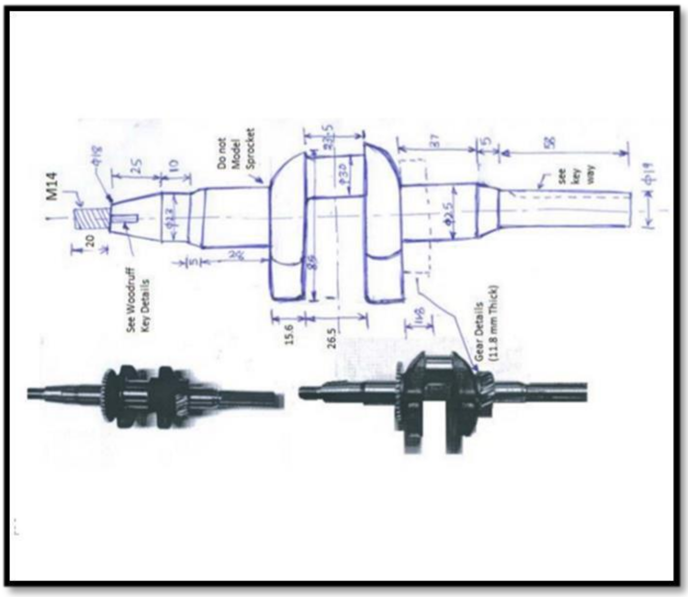


Fig 1. Dimensions of shaft

II. MODELLING IN CREO PARAMETRIC:

CREO 6 is a powerful tool for modelling 3D shapes and assemblies. Creo Parametric is used for modelling the crankshaft using various features like Revolve, Extrude, Helical sweep etc.

The initial dimensions of the counter weight are taken as given and the unknown dimensions to be taken proportionately.

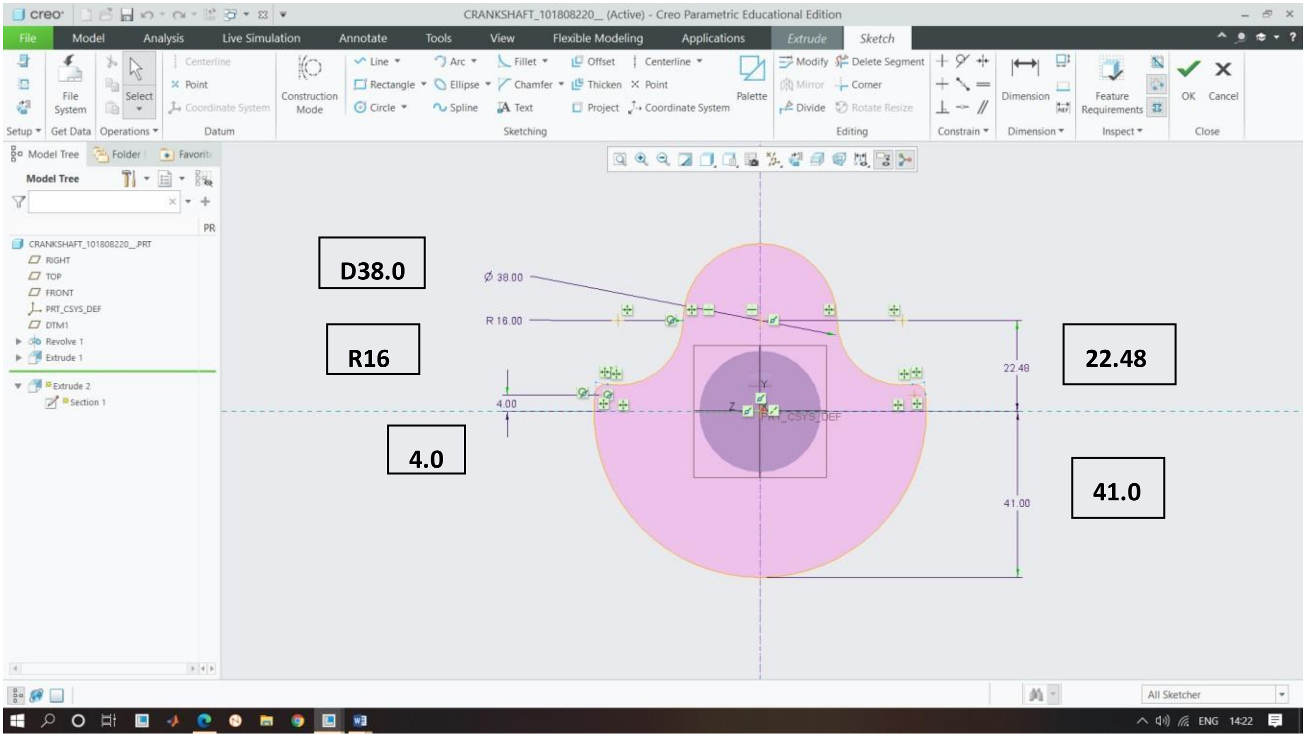


Fig 2. Initial dimensions of counterweight

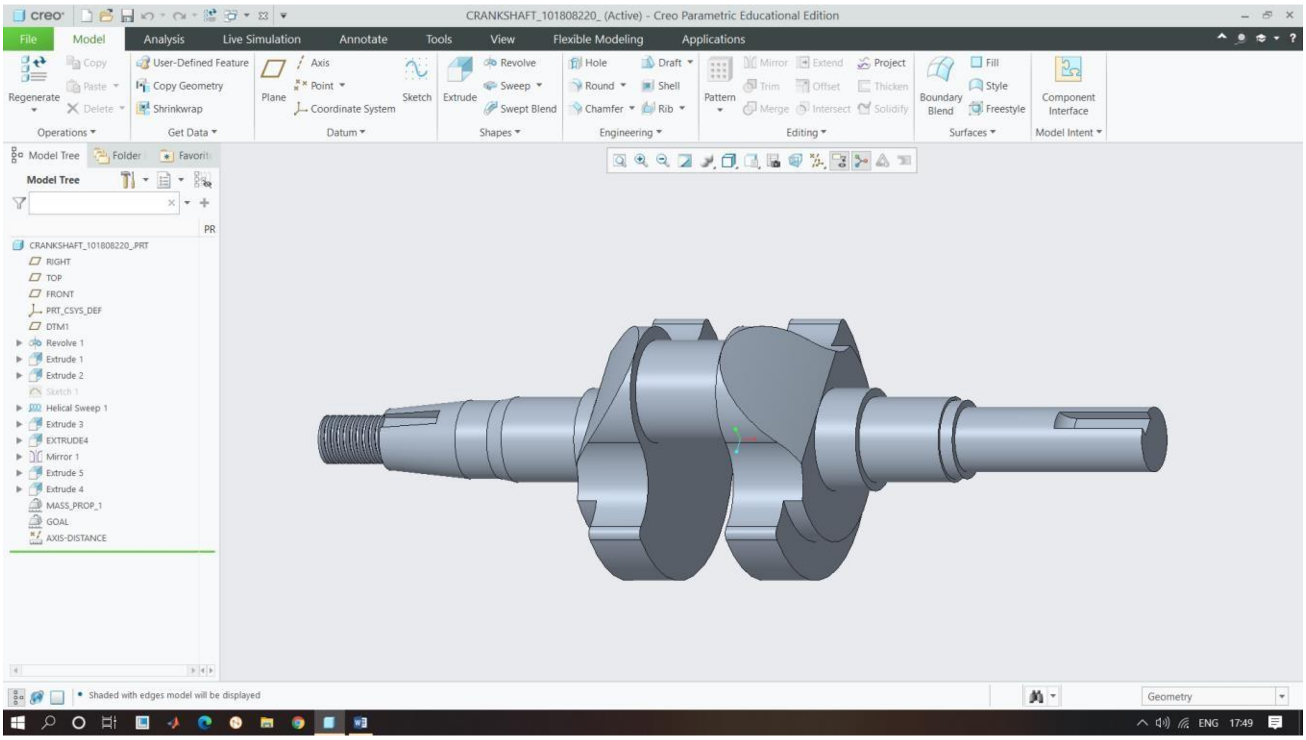


Fig 3.Modelled Shaft

III. LOCATING COG:

Centre of Gravity is a point from which the weight of a body or system may be considered to act. In uniform gravity it is the same as the centre of mass. By default in Creo, COG is not visible onscreen.

For adding COG we have to click on the **Mass Properties** Button under **Analysis** and add **PNT_COG** as a Feature.

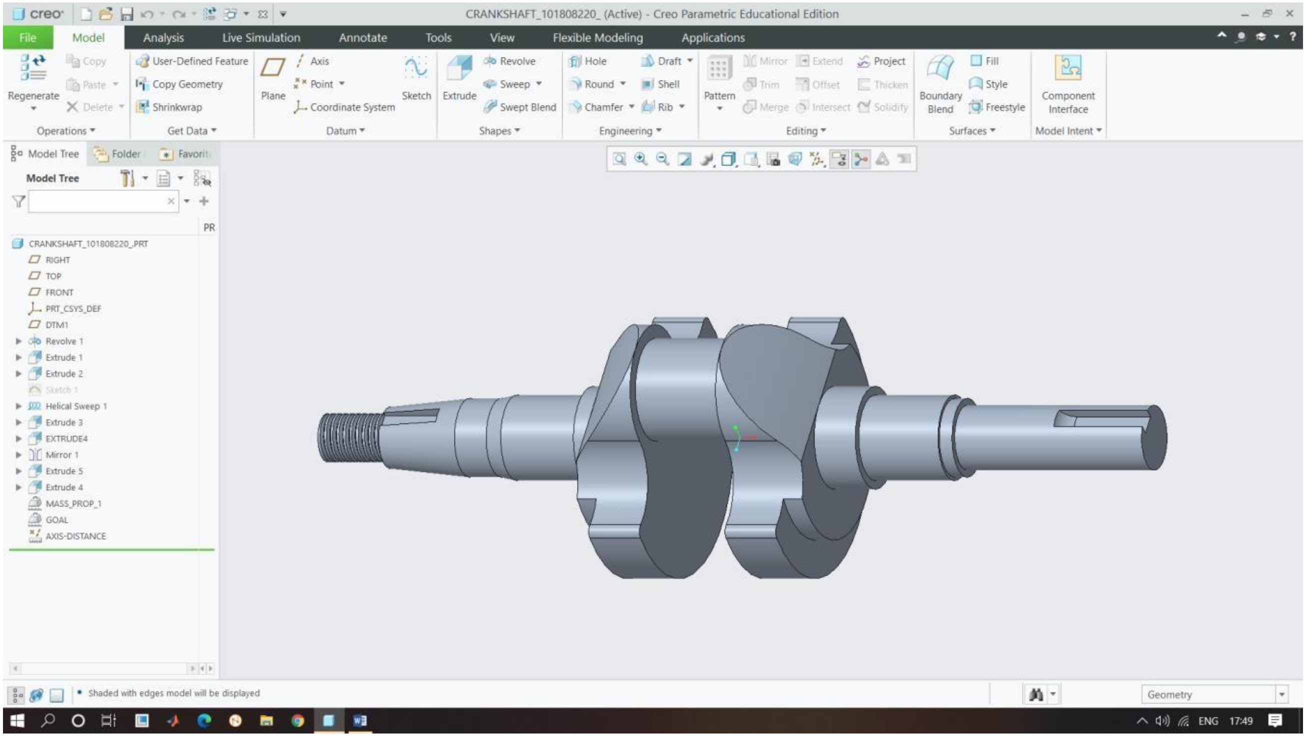


Fig 4. Mass Property Dialogue Box

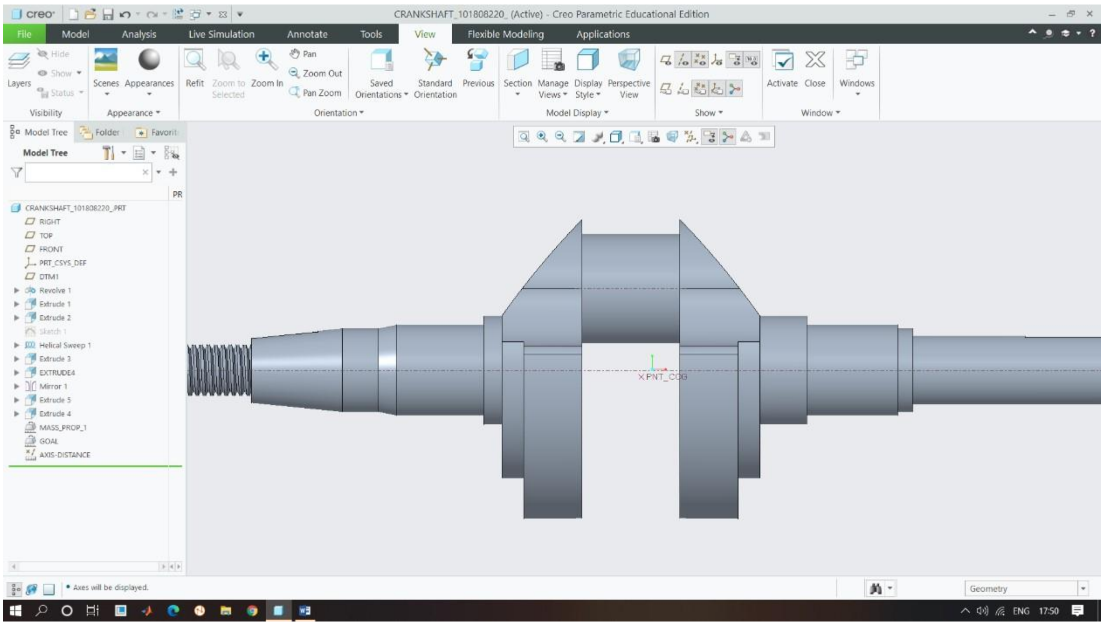


Fig 5. Display of COG

USER DEFINED FEATURES

BMX module under CREO parametric allows user to define its own features for analysis and optimization of various parts or assemblies in 3D.

We will define 3 features for our Optimization of crankshaft as given below:

A. MASS PROPERY(GOAL):

By default, the material is assigned with the mass density of 1.0000e00 long ton/mm3 but we are using **STEEL** so we will specify density as **7.780e-09 long ton/mm3.** Initial mass is displayed as **1.9878899e-03 TONNE**.

OUR AIM IS TO MINIMISE THIS MASS BY THE END OF OPTIMIZATION

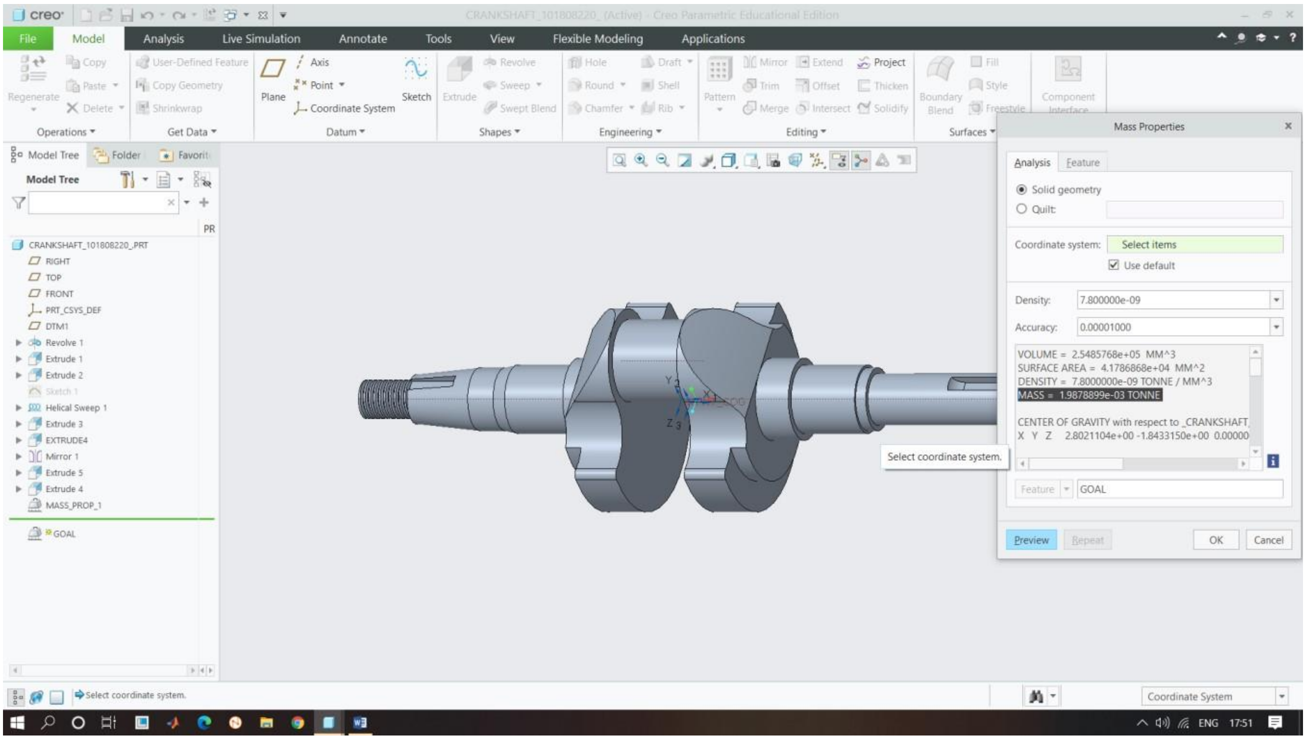
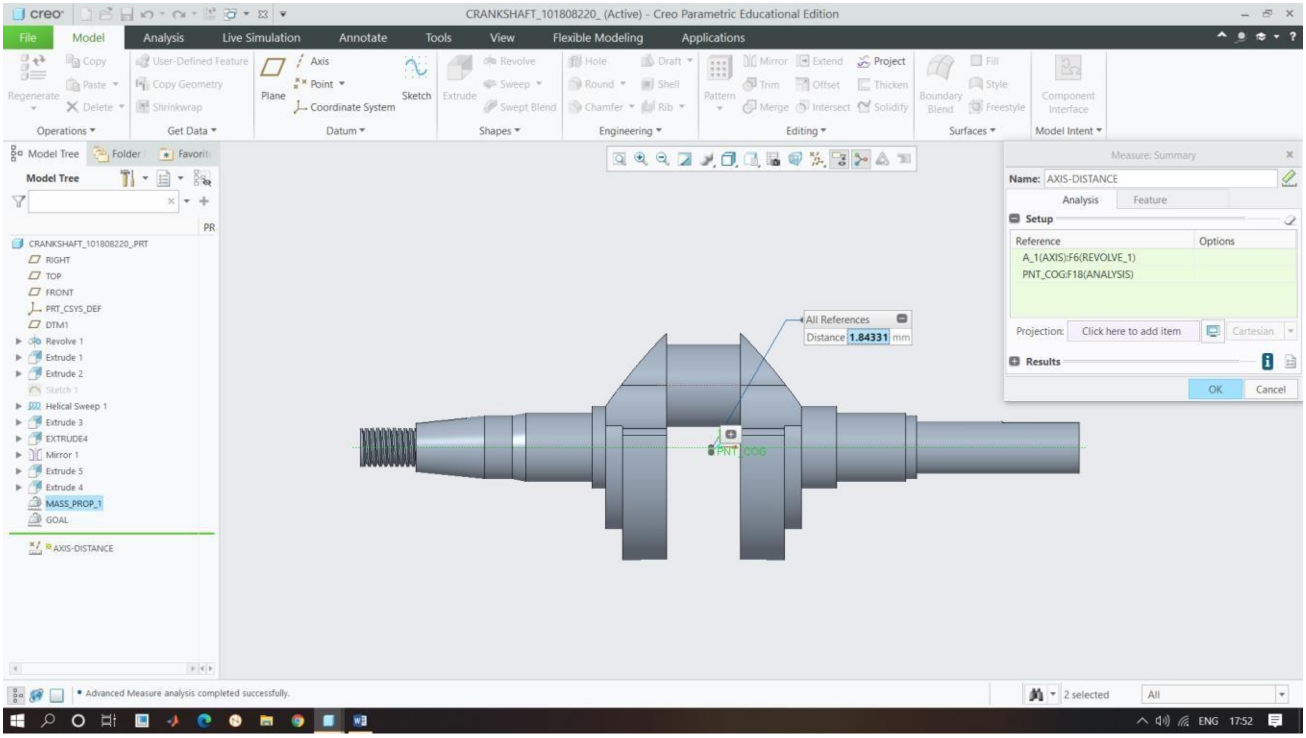


Fig 6. Mass Property to be minimised

B. AXIS DISTANCE:

Axis distance is the perpendicular distance between the COG point and AXIS OF ROTATION. It is defined using the **MEASURE** command by selecting COG and Axis at the same time and saving it as a Feature "AXISDISTANCE" .Initially it is 1.21905 mm.

❖ We are defining this feature as the COG point must lie on the Axis of Rotation for minimizing the amount of vibration produced during the operation of the crankshaft



and will result in greater performance of engine.

Fig 7. AXIS-DISTANCE (1.84331 mm)

SENSITIVITY ANALYSIS

Sensitivity analysis allows you to analyse how various measured quantities (parameters) vary when a model dimension or an independent model parameter is varied within a specified range. The result is a graph for each selected parameter showing the value of the parameter as a function of the dimension.

Main purpose of sensitivity analysis is to reduce the number of iterations to be performed during optimization since it helps us to known only that range in which the parameter is giving an output.

We will be performing sensitivity analysis for various dimensions and plot the graph **between dimension and AXIS DISTANCE**. It is done using sensitivity analysis feature under analysis section.

A. HEIGHT OF COUNTERWEIGHT:

The maximum total height can be **up to 84mm** since we have to assemble this shaft in engine and if it is more than 84mm, it will interfere with the piston head of the assembly.

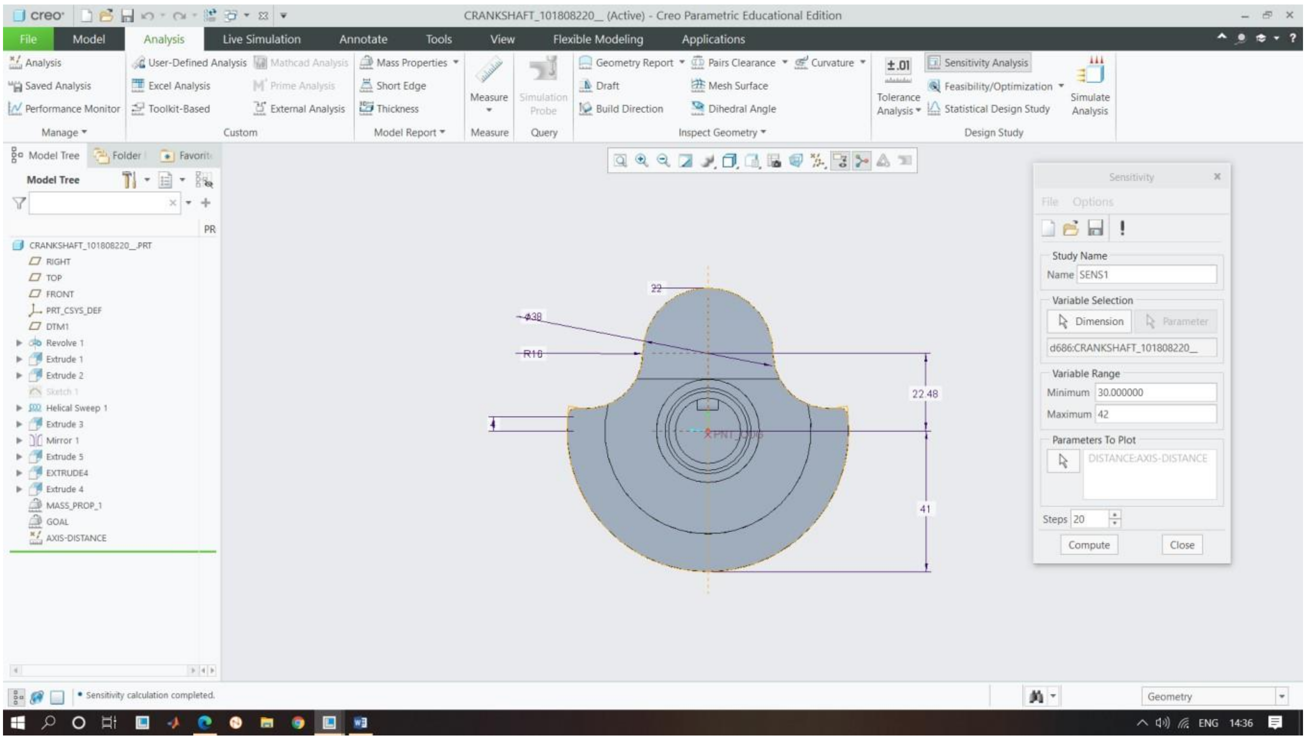


Fig 8. Sensitivity analysis of Height

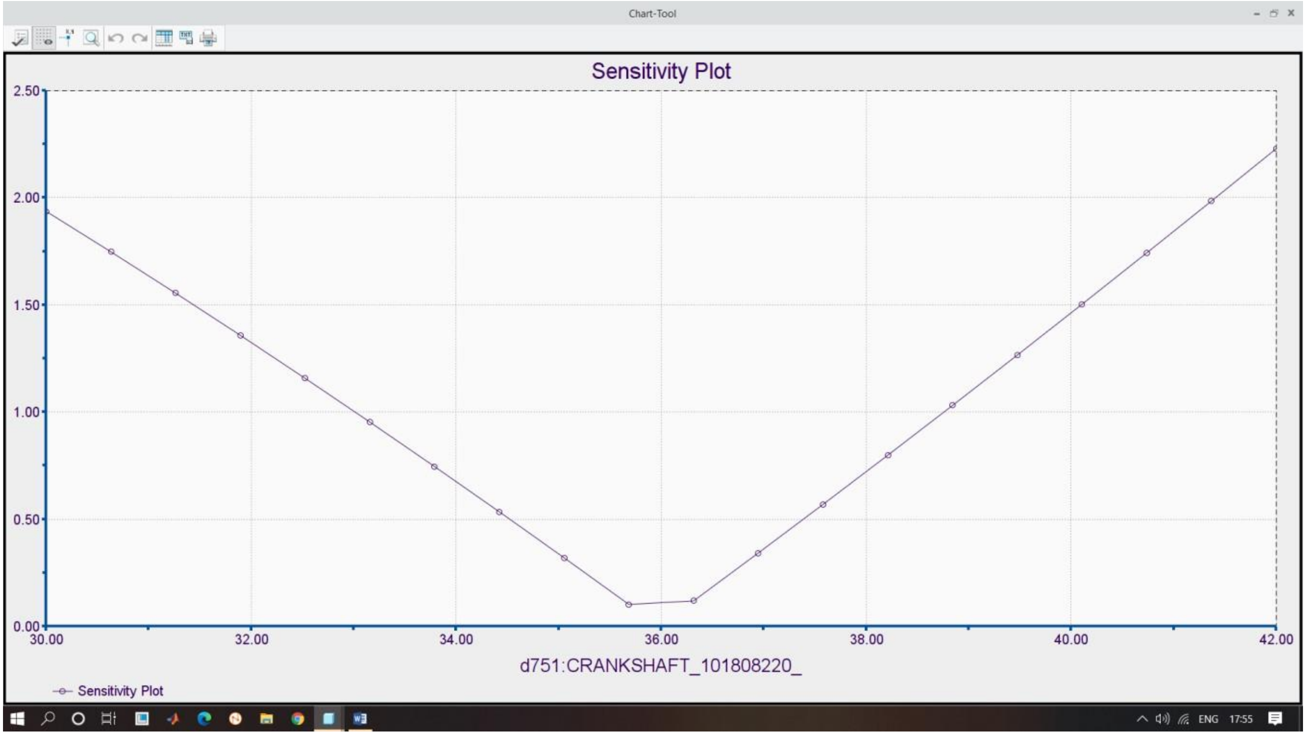


Fig 9. Sensitivity analysis graph (HEIGHT)

FROM TRY ERROR METHOD WE FIND THAT THE AXIS DISTANCE IS MINIMUM IN RANGE OF **30 TO 42 MM**.

B. HEIGHT OF SMALLER RADIUS FROM AXIS:

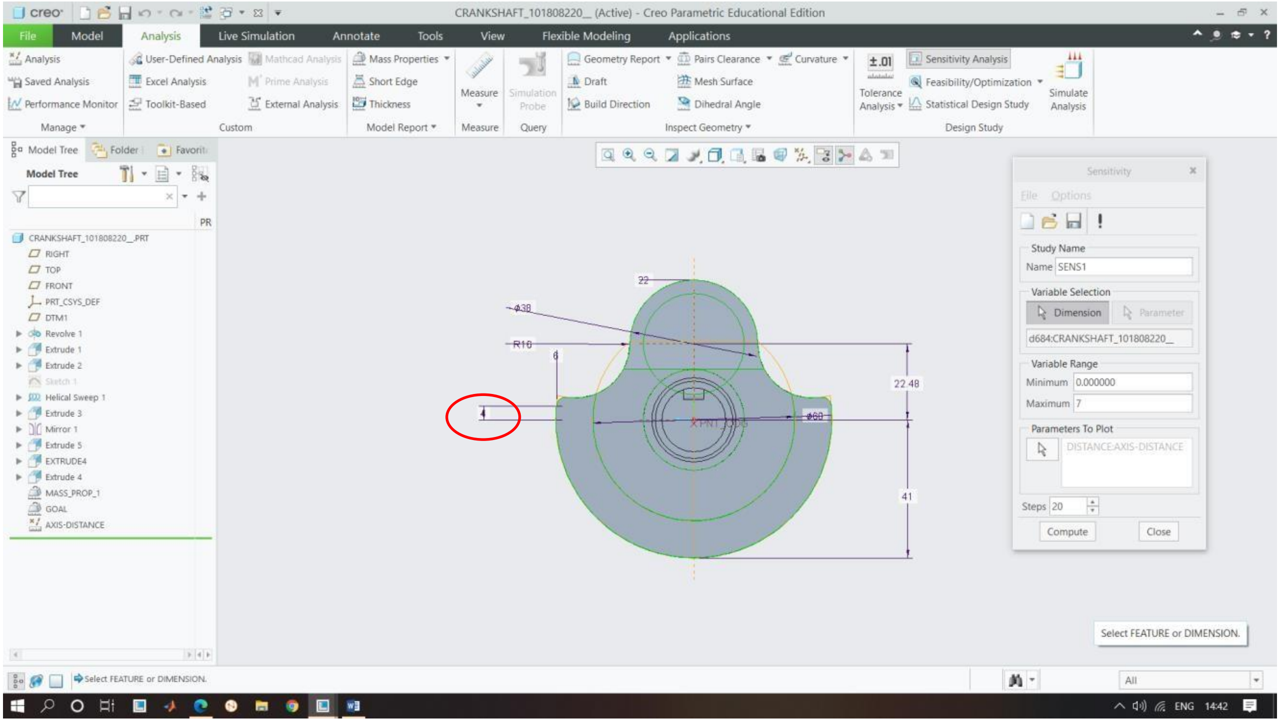


Fig 10. Sensitivity analysis of Smaller Radius

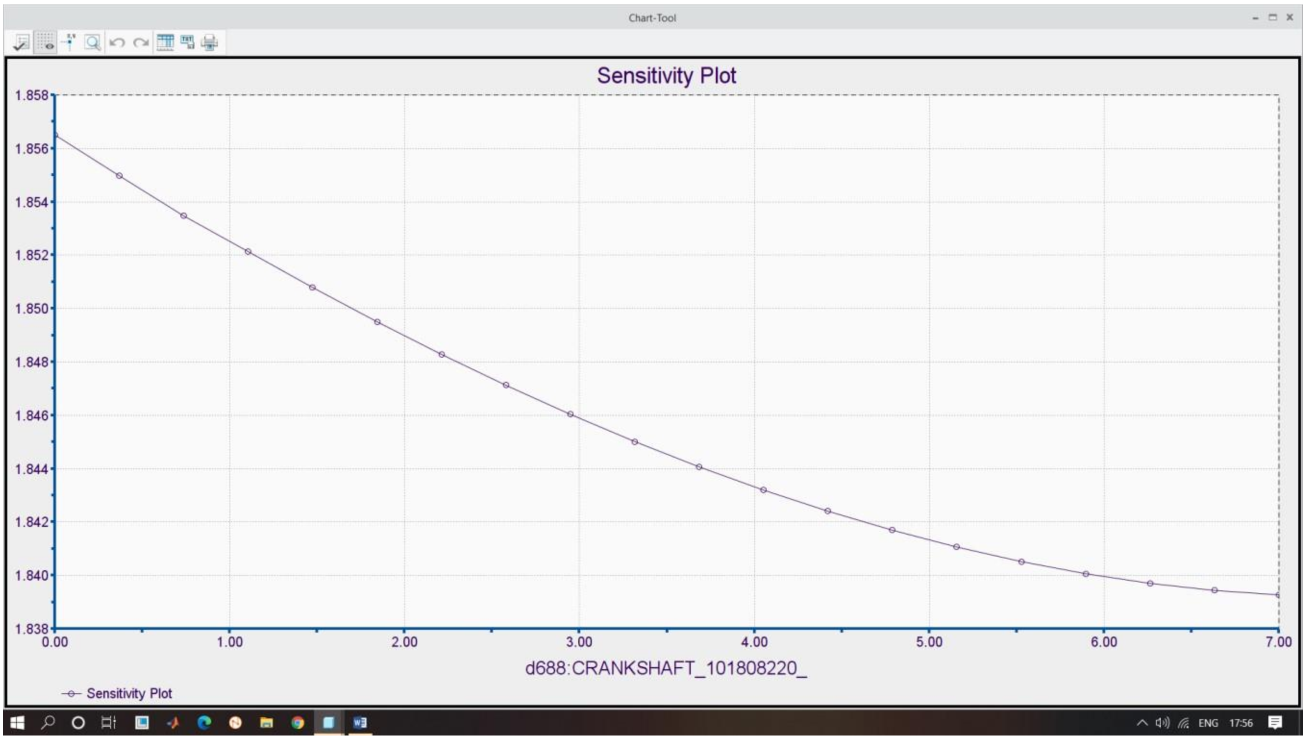


Fig 11. Sensitivity analysis graph (Smaller Height radii)

FROM THE GRAPH WE CONCLUDED THAT AXIS DISTANCE BECOMES MINIMUM IN RANGE OF 0 TO 7 MM.

NOTE: In the Feasibility and optimization I have taken an extra dimension for better result.

FEASIBILITY AND OPTIMIZATION

Feasibility and optimization studies allow you to have the system compute dimension values that cause the model to satisfy certain user-specified constraints. To access a feasibility or optimization study, click **Analysis** and then click the arrow next to **Feasibility/Optimization**. Click **Feasibility/Optimization** and select the type of study from the dialog box.

A. FEASIBILITY :

We have to get the dimensions of the crankshaft such that:
AXIS DISTANCE turns approx. 0 mm.

We have to add **DESIGN CONSTRAINTS** under the feasibility dialogue box and add the above mentioned constraints as shown and add to dimensions to be changed.

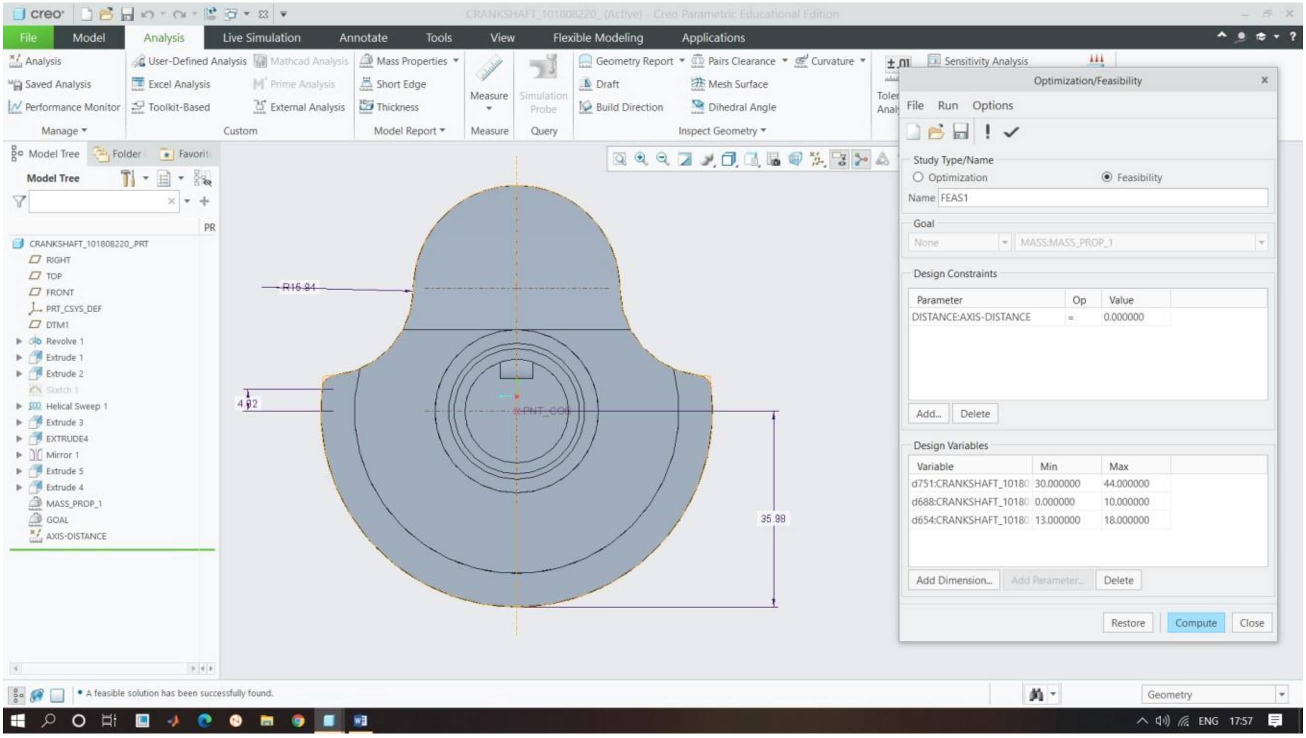


Fig 12. Setting up feasibility test

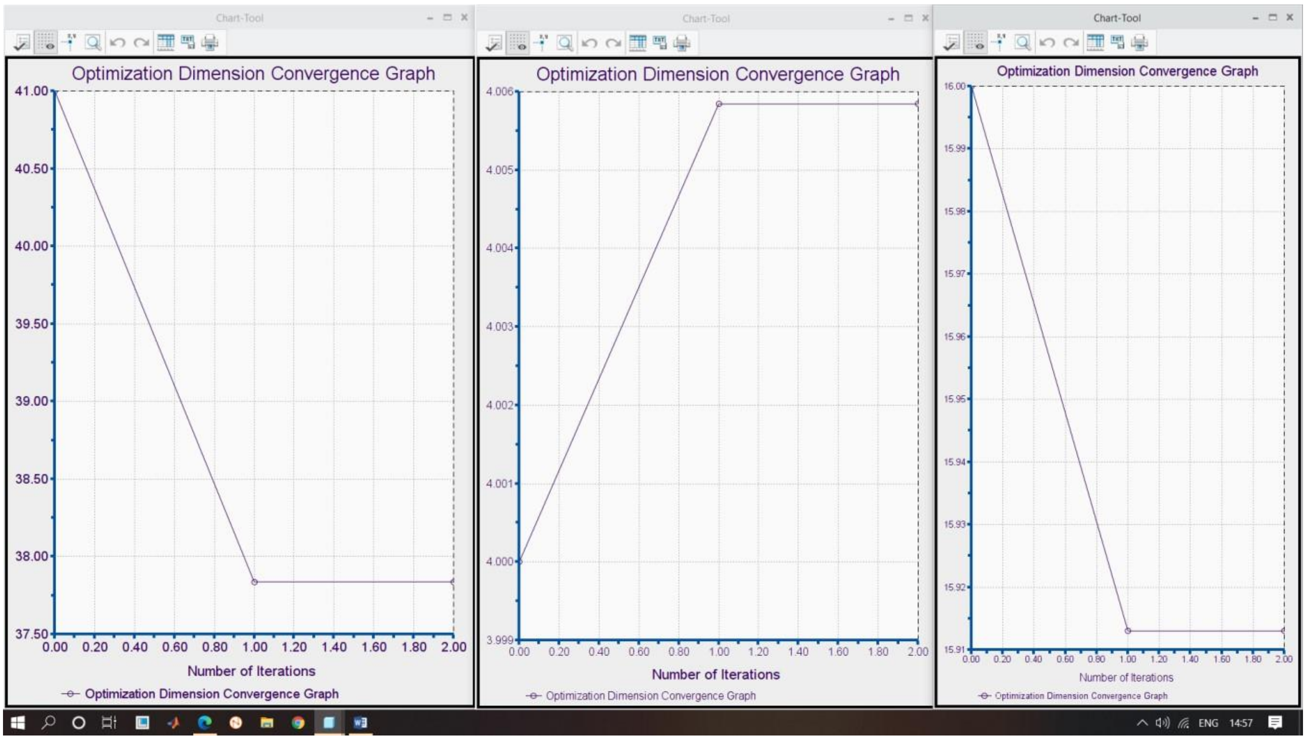


Fig 13. Graphs for sensibility

DIMENSION	MINIMUM(mm)	MAXIMUM(mm)
HEIGHT	30	42
Height of centre of smaller radii	0	7
Larger radii	13	18

Check whether a feasible figure is obtained or not. If not, then change the range or try a bigger range of values .Note down the dimensions and click on reset button and close the dialogue box.

Based on the test we can also now reduce the range for different dimensions for getting better optimisation in less iterations.

B. OPTIMISATION:

OPTIMISATION is done for reducing the mass of the counterweight as much as possible as it will not only reduce the cost of production but for more efficient performance of the engine.

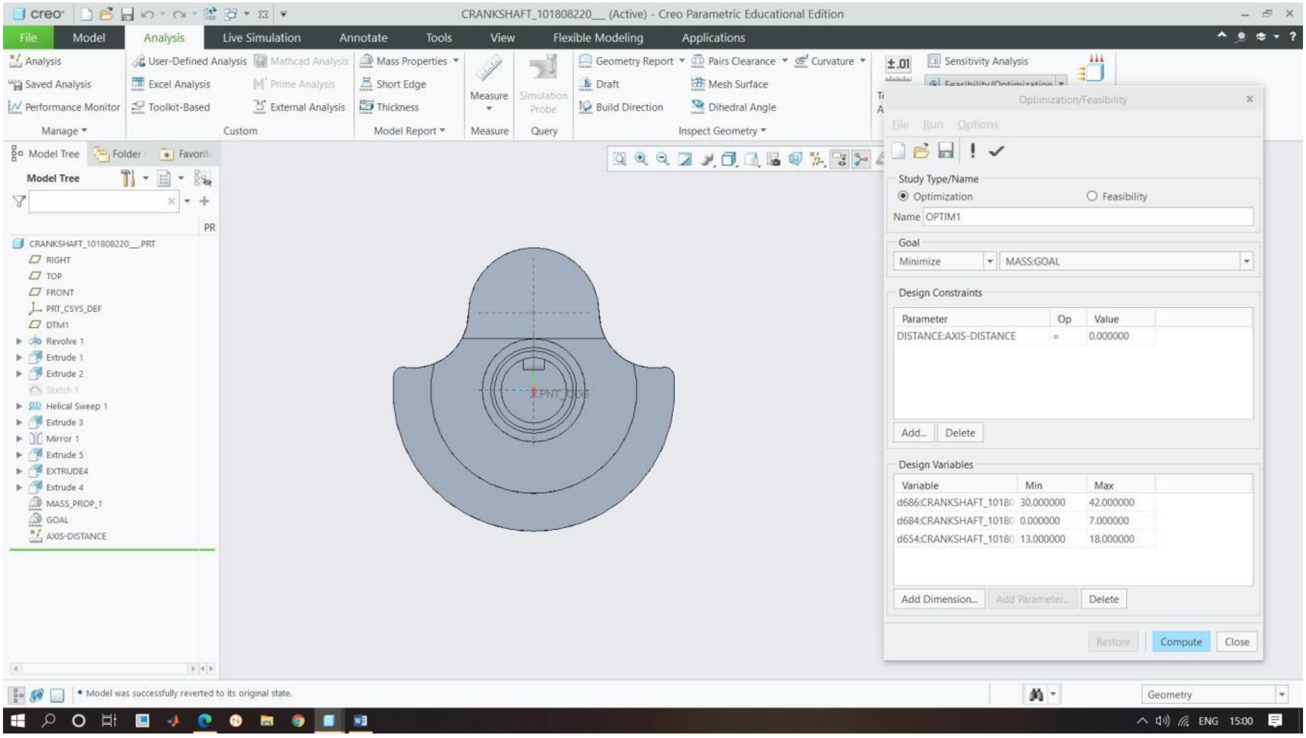


Fig 14. Setting up optimisation

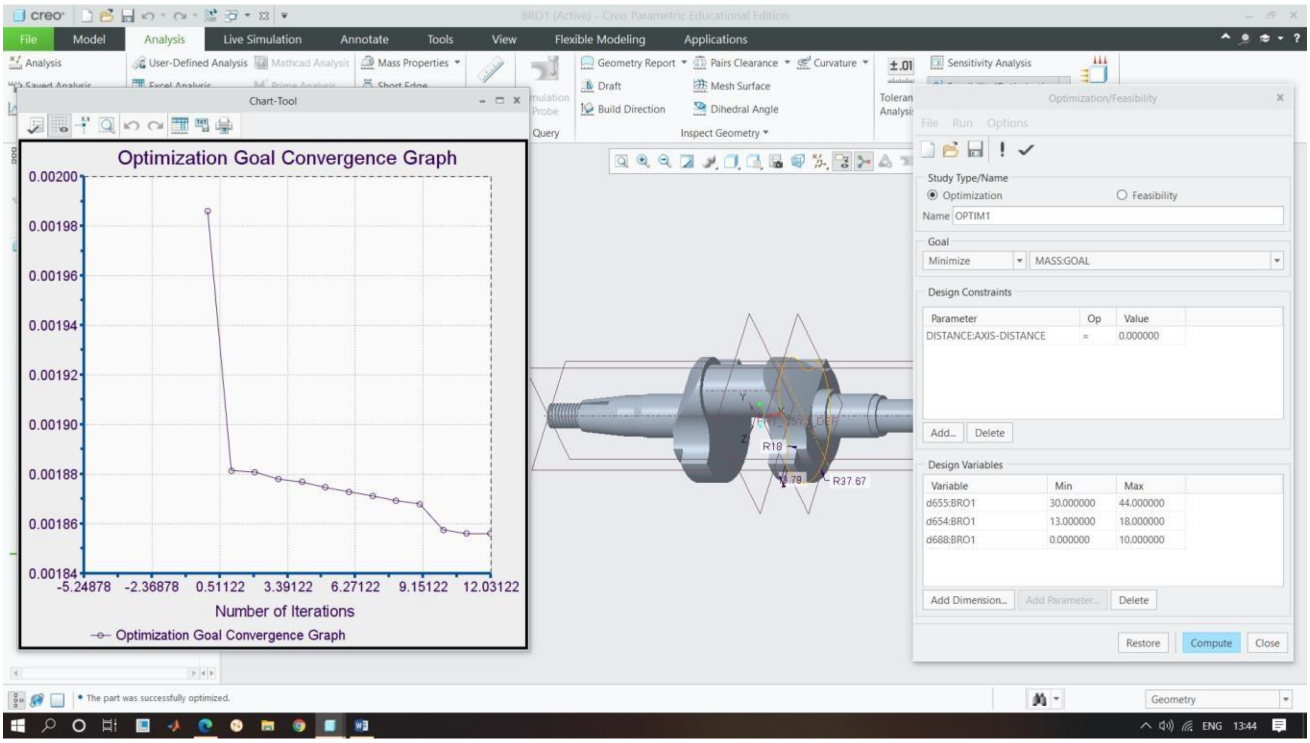


Fig 15. Mass VS no. of iterations

RESULT

1. The final AXIS DISTANCE after optimization came out to be 0 mm along Y and Z.

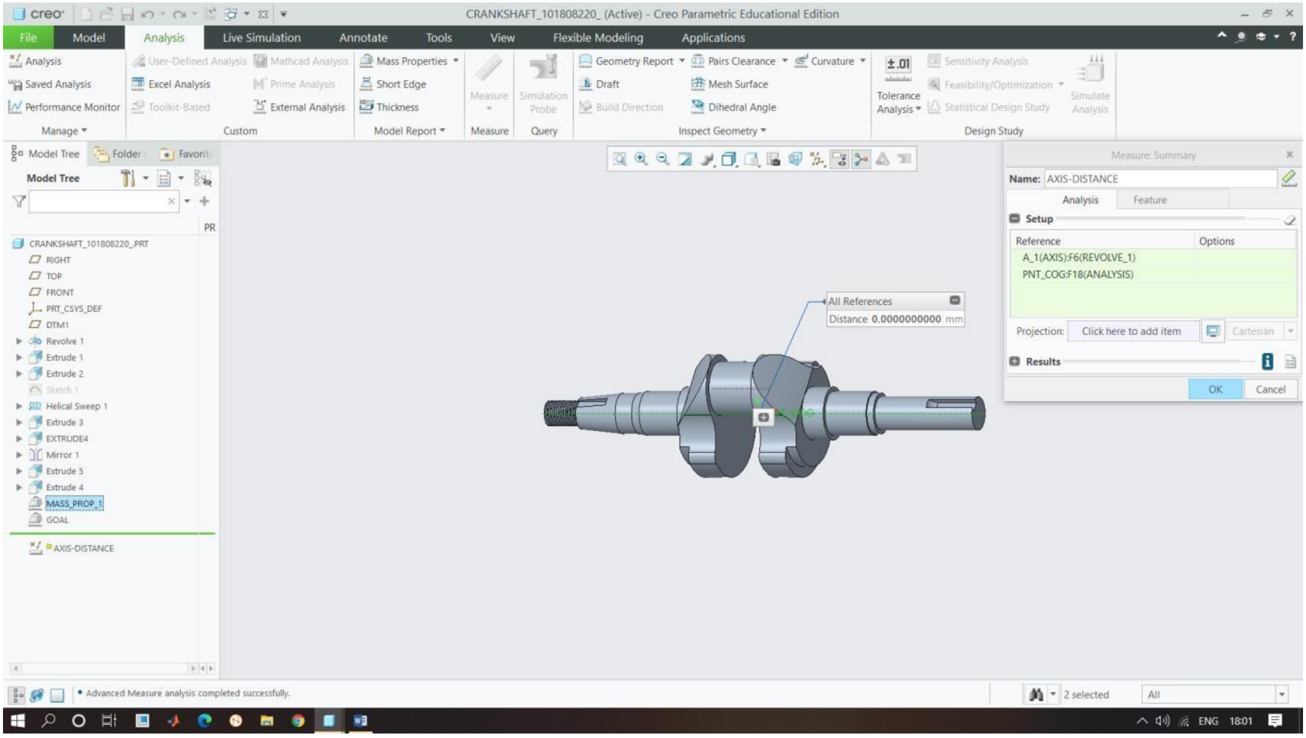


Fig 16. Axis Distance (X Y Z 3.0885413e+00 0.0000000e+00 0.0000000e+00 MM)

2. The changed dimensions are:

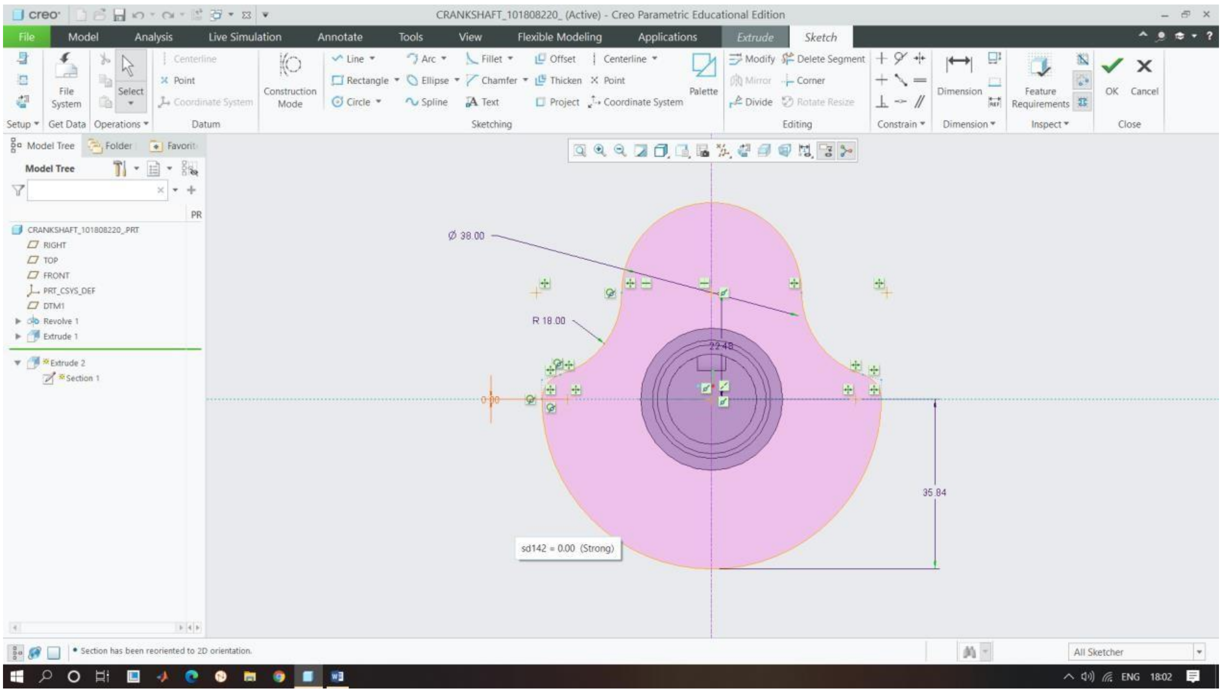


Fig 17. Final dimensions

3. Final mass after optimization is 1.8035333e-03 TONNE.

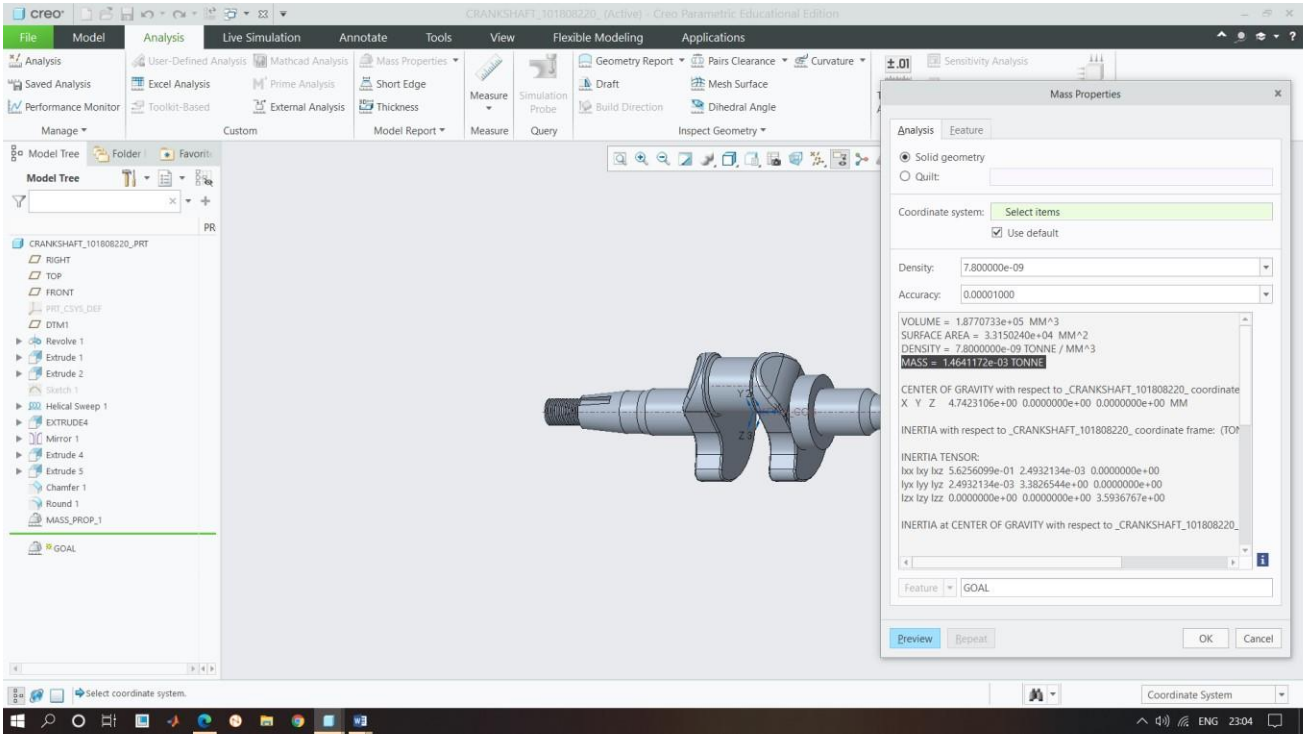


Fig 18. Optimized Mass (1.8035333e-03 TONNE)

CONCLUSIONS

A. During the project, it was concluded that CG of crankshaft is dependent upon the various dimensions of the Counterweight as shown during the Sensitivity analysis. In the Fig 9 and Fig. 10, it can be seen that as the dimension change the AXIS Distance also changes.

B. The objects which have symmetry about the axis of rotation of the crankshaft have no effect on the position of COG.

C. By the end of the project, we were able to minimize both the mass of the crankshaft and location of CG along Y direction.

D. It was observed that since the shaft was symmetric about X-Y plane, CG distance along Z direction was always zero which explains the Point B.

E. Since we were constraint with the thickness of the Counterweights, CG measure Along X axis would never become 0 as the shaft was not uniform.

REFLECTIONS

- The world is leading towards automation. After performing this project I not only learned about CREO parametric 6.0 but also brushed my knowledge about the functioning of HONDA GX160 Engine which is really important for getting in automobile sector and for my branch also.

- Learnings:

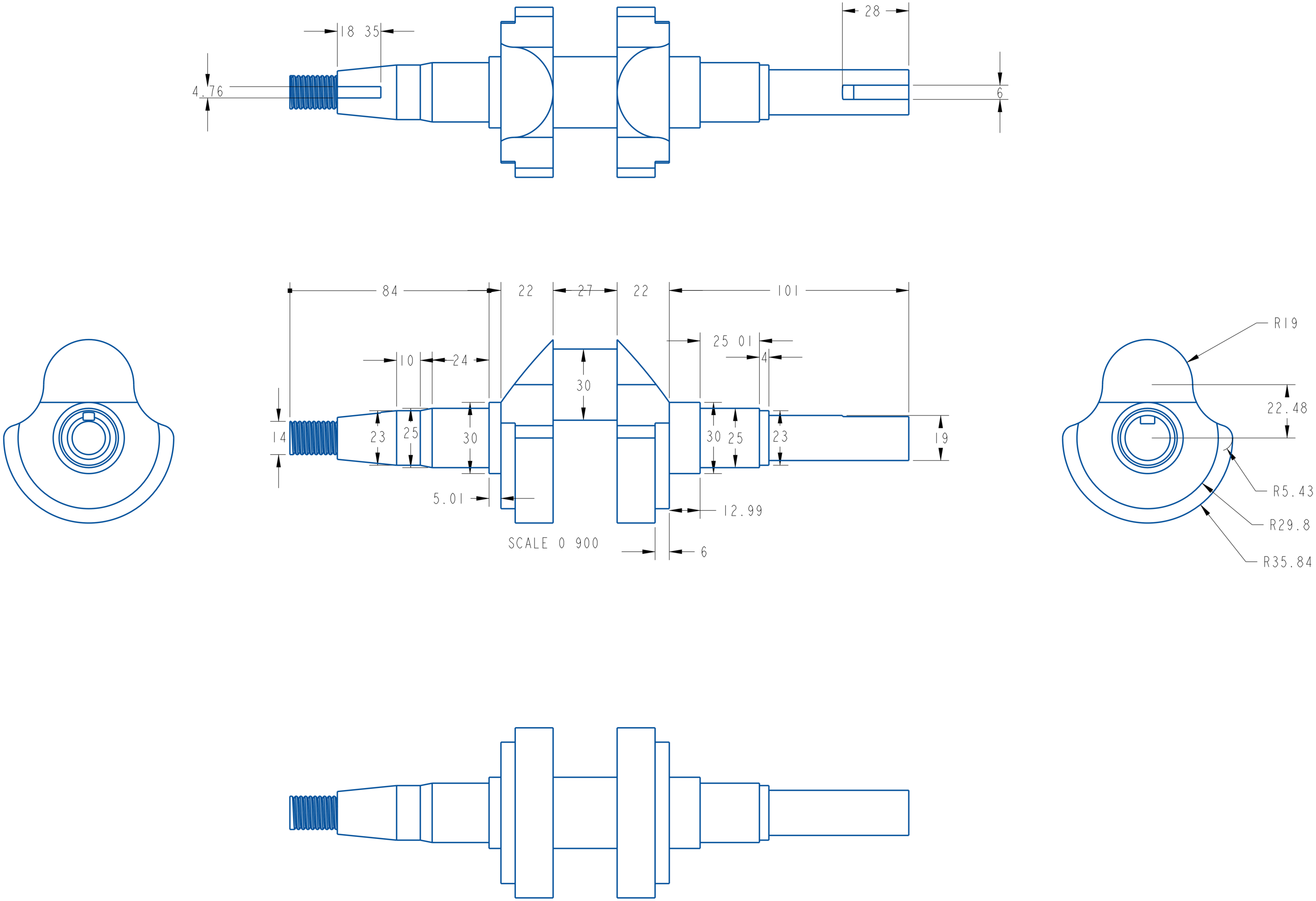
  - Learned to how to use the Helical Sweep command for making threads.
  - About various aspects of dynamics involved in working of crankshaft.
  - Analysis and optimization using powerful CREO parametric 6.
  - Dependency of CG with Dimensions and its effects with vibration and stress.
  - How to think as a designer having zeal to make feasible product.
  - How to write a project report in an industry.

- This project learnings can be implemented in various fields like in industries where we have to make a design which will lower the production cost of the product. While working on some project, it will help me to first make a 3D model and do analysis and feasibility test on it and then decide whether it can be implemented in real world or not. It will save both money and time to be invested.
  It can be also used for thermal and stress analysis in a model. Since by doing changes in according to the various analysis done will result in a durable product design.

- First of all I highly appreciate your initiative to drop the manual drawings since they are no more used in market. The project would have been more effective if there were less constraints given for modelling and more accurate dimensions for gears and all. The students should be given liberty to select the material of the shaft and by doing Thermal and stress analysis on their own with some constraints set.

- There is a feature called TRACE IMAGE in CREO 7 which would have reduced the effort of measure each and every dimension of the shaft.

- If the piston, piston pin and connecting rod is added, it will shift the position of CG greatly. Now we will have to do the analysis on the whole assembly under certain constraints. The conventional methods of connecting rod design consider the centre of gravity (CG) position at 2/3rd distance from connecting rod small end. The connecting rod CG position decides the reciprocating and rotating mass distribution. Analysis is done on connection rod and shaft for minimizing the CG distance. There is no impact of connecting rod along direction parallel to axis. The main aim is to keep the CG near to the axis even if the translation motion of piston. So we will have to change the design of piston and connecting rod also.


18 35
4.76
28
6
84
22
27
22
101
R19
25 01
4
10
24
30
22.48
14
23
25
30
30
30
25
23
19
5.01
12.99
R5.43
R29.8
R35.84
SCALE 0 900
6