ELK ASIA PACIFIC JOURNAL OF MANUFACTURING SCIENCE AND ENGINEERING

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

ELK
Asia Pacific Journals

www.elkjournals.com

OPTIMIZATION OF INPUT WEIGHT OF RINGS IN FORGING, WHILE CONTRIBUTING TO SUSTAINABILITY BY WASTE REDUCTION

Anurag A. Polshettiwar
Student, M. Tech. Project Management
Department of Production Engineering and Industrial Management,
College of Engineering, Pune, Maharashtra, India
polshettiwaraa15.pm@coep.ac.in

M. R. Dhanvijay
Asst. Professor
Department of Production Engineering and Industrial Management,
College of Engineering, Pune, Maharashtra, India.
mrd.prod@coep.ac.in

Bhakti Khot
Customer Project Manager
Project Management Department, SKF India Ltd. Pune.
bhakti.khot@skf.com

Mohan Jagtap
Customer Project Manager
Project Management Department, SKF India Ltd. Pune.
mohan.jagtap@skf.com

ABSTRACT

Manufacturing of bearing rings is done in a series of manufacturing processes viz forging, turning, heat treatment, grinding, and then the bearing is finally assembled with all the components. It is desirable to have an effective utilization of raw material to reduce the waste of bearing manufacturing in whole. This research aims to find out the different waste associated with the manufacturing processes of a bearing and to minimize it. The study includes optimization of the forging die thereby reducing the waste in the forging of bearing rings. By doing this, there is reduction in forging waste which in turn reduces the input weight required for forging the ring. The manufacturer pays the supplier based on the input weight, so reduction in input weight will reduce the cost also. The wastage of 10,875 Kg / Year of bearing steel will reduce. The modification in die will affect different parameters and physical properties. For this purpose forging simulation software was used to analyze the effect of design changes.

Keywords- Forging, Simulation, Waste reduction, Sustainability, Cost reduction

1. INTRODUCTION

SKF provides industry leading automotive and industrial engineered solution through its five technology centric platforms: Bearings and Units, Seals, Mechatronics, Lubrication solution and services. There are different types of bearings such as deep groove ball bearing, spherical roller bearing, tapered roller bearing,

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

and HUB units. The most common elements of bearing are outer ring, inner ring, cage, and rolling element. The bearing rings are produced by forging process as forging gives high strength, aligned grain flow, and better physical properties as compared to other manufacturing processes. However the waste associated with the forging is high. The reduction of waste in forging contributes to sustainability. The material required for bearing rings is high carbon chromium steel known as bearing steel which is costly as compared to normal steel. The manufacturer has to pay the cost on input weight required for the forging. By optimizing the design of forging die it is possible to reduce the waste which in turns would reduce the cost of manufacturing.

To achieve the desired output as stated earlier a detailed study of the processes was conducted. It is preferable to simulate forging die before manufacturing stage. The computer simulation of forging is very important for demanding closed die forging and progressive die forging methods. This simulation enables us to analyze the principles of the forging process and to observe the flow of material in the cavity during its filling.

Simulation software has considerable advantages. It enables the verification of technological parameters and technical preparation of production before making forming tools and beginning the production. It is required to minimize the waste in the bearing ring manufacturing process.

'Beyond zero policy' is the strategy applied to create a positive impact on the environment.

This study is for one of the variants of ball hub bearing. The manufacturing of rings of ball hub is done at supplier end. The type of production at supplier end is batch production. The input weight required for forging an outer ring of is about 500 grams and the final forged ring weighs only 370 gram so about 130 gram material is wasted in the forging process. Reduction in waste creates a positive impact on the environment. And apart from this reduction in input weight reduces bearing manufacturing cost.

2. LITERATURE SURVEY

Milutinovic and Movrin [1] explain forging as a manufacturing process in which a metal workpiece is plastically deformed to desired shape by application of compressive forces is explained. Precision forging is best applied to rotational symmetric parts as it simplifies the process and tool design. Also higher accuracy of the rotational parts can be achieved. With the

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

support of computer aided design tool 3-D simulation of complex forming operations becomes feasible within reasonable time. Modeling in details together with the FEM analyse and process simulation, gives the opportunity to change the parameters such as dimensions, number of stages, preform shape, taper angles, fillet radii, shrinking factor easily and on optimal way.

Geoffrey boothroyd [2] he explains webs are the thin sections with large projected area in the direction of die closure. Webs are often designed into the parts for strength and accompanied by peripheral ribs. If the finished part has through holes to be forged in, then these must be filled with webs at the die parting line and then these webs are removed by piercing at the end. The material in these webs are additional waste material and add to the material cost per part. The appropriate thickness of the webs is dependent on the projected area of the holes to be filled as shown in Fig.3.1 from this the following relationship is obtained.

Web Thickness Tw (mm) = $3.54\ A_H^{0.227}$.......2.1 where A_H is the area of the holes in centimeter square. **(Refer Fig. 3.1)**

Kapustova [3] explains the computer simulation and its uses. This paper focused on analysis of materials as they function in cavity filling during closed die forging. These analyses were completed using simulation software, Superforge, during the production of forging with the shape of a toothed wheel determined for the gear box. The numerical simulation allowed for the optimal forging process, especially from the fold creation elimination perspective. Computer simulation of the forging process is very important for the die forging. This enables to analyse principles of the forging process and to observe plastic flow of material in the die cavity during its filling. Simulation software has considerable advantages- they enables the verification of technological parameters and technical preparation of production before making forming tools and beginning the production.

Mc Bain [4] explain on information of simufact simulation software. Simufact. Engineering GmbH is a global operating software and service company for process simulation in the manufacturing industry. The global competition and new trends like blue efficiency e-mobility and biological engineering requires a new approach in the product design and manufacturing. Companies must change from a geometry oriented manufacturing to a property oriented manufacturing. Simufact. forming

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

provide the possibility to import simulation results from casting simulation to be used as initial conditions for open die forging simulations. With the new material data infrastructure in simufact. Materials properties based on the local concentration of alloying elements can be considered and mixed phases and the resulting material properties computed.

3 METHODOLOGY

It is preferable to simulate forging die before manufacturing. The computer simulation of forging is very important for the closed die forging. This simulation enables us to analyze the principles of the forging process and to observe the material flow in the cavity during its filling.

Simulation of the die forging process consists of two phases-

1. Preparatory phase of simulation – Creation of the geometrical model of workpiece and tools (i.e. AutoCAD, CREO PARAMETRIC etc. choice of process kind, type of depiction 2d/3d, forming temperature)

2. Simulation – Beginning and course of forming process simulation.

Initial process description –

The detailed study of drawing of ball hub was carried out. The initial design of forging die was made by referring books and catalogue and as per the supplier current forging dies by using 3D designing software. These designs are as per the requirement of simulation software.

3.1 DESIGN OF PRESENT FORGING DIE (BALL HUB OUTER RING)

There are certain underlying principles for achieving a practical and economical forging design. The dies are designed by considering the draft for quick removal of the forged part, fillet and corner radius, finish allowance, burning allowance, web and rib thickness etc.

The stock size is calculated by considering the volume of forged bearing ring and the allowances is about 500 grams. **(Refer Fig. 3.2)**

3.2 ANALYSIS OF DATA COLLECTED

After going through the literature survey and the catalogue of forging die design, it is found that the web thickness in forging has a relationship with the projected area .The web thickness should be of Tw (mm) = $3.54\ A_H^{\ 0.227}$ by using this relationship the web thickness for the ball hub variant should be about 6.28 mm. But web thickness found with the present process is about 9 mm, which is more than the recommended. We can reduce web thickness up to 5 mm but it may affect the life and accuracy of the die [2].

3.3 DESIGN OF PROPOSED FORGING DIE (BALL HUB OUTER RING)

The proposed forging die is similar to present forging die except the web portion as it is modified. Initially three different designs of dies are prepared are given in **(Refer Table 3.1)**

Each design is having certain advantages and disadvantages. Modification in the die may affect different parameters like grain flow, input weight, machining cost, and cost of modifications, material saving. Therefore, to find out the optimum design multiple criterion decision making techniques are useful. By using multiple criterion decision making techniques above parameters are analyzed and the optimum design is found out. The weights were assigned by consulting with the expert in the bearing. For the use of multiple criterion decision making technique qualitative data is converted into quantitative data by considering following analogy= High-5, Moderate-3, Low-1. **(Refer Table 3.2)**

3.4 MULTI CRITERION DECISION MAKING TECHNIQUE USING MODIFIED TOPSIS

Multi criteria decision-making (MCDM) or multiple-criteria decision analysis is an important branch of operations research that uses multiple-criteria in decision-making environments. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), is a ranking method of conception and application. The standard TOPSIS methodology aims to select the alternatives which have the shortest distance from the positive ideal solution and the longest distance from the negative ideal solution at the same time. The positive ideal solution maximizes the beneficial attributes and minimizes the cost attributes, whereas the negative ideal solution maximizes the cost attributes and minimizes the beneficial attributes.

The weights are considered as per the importance of parameter and with the help of experts. The normalized matrix as shown in **(Refer Table 3.3).**

By solving above normalize matrix for Modified TOPSIS the results are in bellow **(Refer Table 3.4)**

As per the result of Modified TOPSIS technique Die 2 (Cup) is the optimum design. This die is having advantages like good grain flow, low machining cost, etc. which made its optimum. Computer simulation helps to analyze different

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

parameters which are affected by modifications in dies. The proposed Upper die, Lower die, and Workpiece are designed as shown in **(Refer Fig 3.3)**

4 SIMULATION OF FORGING PROCESS

Simulation software is very useful in optimization of dies. These software's are capable of simulating the whole forging process. And give results quickly so that designers can optimize the die in an efficient manner. It is always better to simulate the forging dies before going to manufacturing of dies. The simulation of forging is done by computer simulation software. The inputs required for the forging process are upper die, Lower die, and Workpiece, these inputs are taken from the CAD files. The process parameters like Workpiece material, Workpiece temperature, Dies Temperature, Friction, Crank speed, etc. is given to the software so that it will give good result of forging. The forging simulation process is shown in **(Refer Fig 4.1)**

The important parameters like Cavity filling, Grain flow, Temperature, Effective plastic strain, Contact pressure, Die contact are compared with the initial design. The comparison table is shown in **(Refer Table 4.1)**

CONCLUSIONS

I. Simulation is vital for finding out the changes in physical properties of forging while optimization of dies.
II. The effective utilization of raw material is possible by reducing waste in the forging process.
III. The wastage of 10,875 Kg/Year of bearing steel will reduce and it helps to prove manufacturers policy of making a positive impact on the environment.
IV. The manufacturer has to pay the supplier based on input weight, so reduction in input weight will reduce the cost of bearing manufacturing. The additional benefit of this modification is on cost, approximately yearly 4, 05,000 Rupees could save. **(Refer Table 5.6)**

REFERENCES

- Mladomir Milutinovic, Dejan movrin "Precision forging-Tool concept and process design". Journal for technology of plasticity, Vol.33 (2008).
- Geoffrey boothroyd "Product design for manufacture and assembly" Textbook. Marcel decan Inc.
- Maria Kapustova "Analysis of drop forging in closed die using computer simulation".2009

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

- Dr. Gabriel Mc Bain, Dr. Hendrik Schafstall, Stenfan Zimmer. "Numerical modelling of Complex Process Chains in the Metal Forming Industry"
- Edward G. Hoffman "Jigs & Fixture"- Delmar Learning Drafting Fifth Edition. (2004)
- Jigs & Fixture Design Manual by Erik Karl Henriksen, Ceneage learning india pvt ltd. Fifth edition (2008)

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

LIST OF FIGURS:

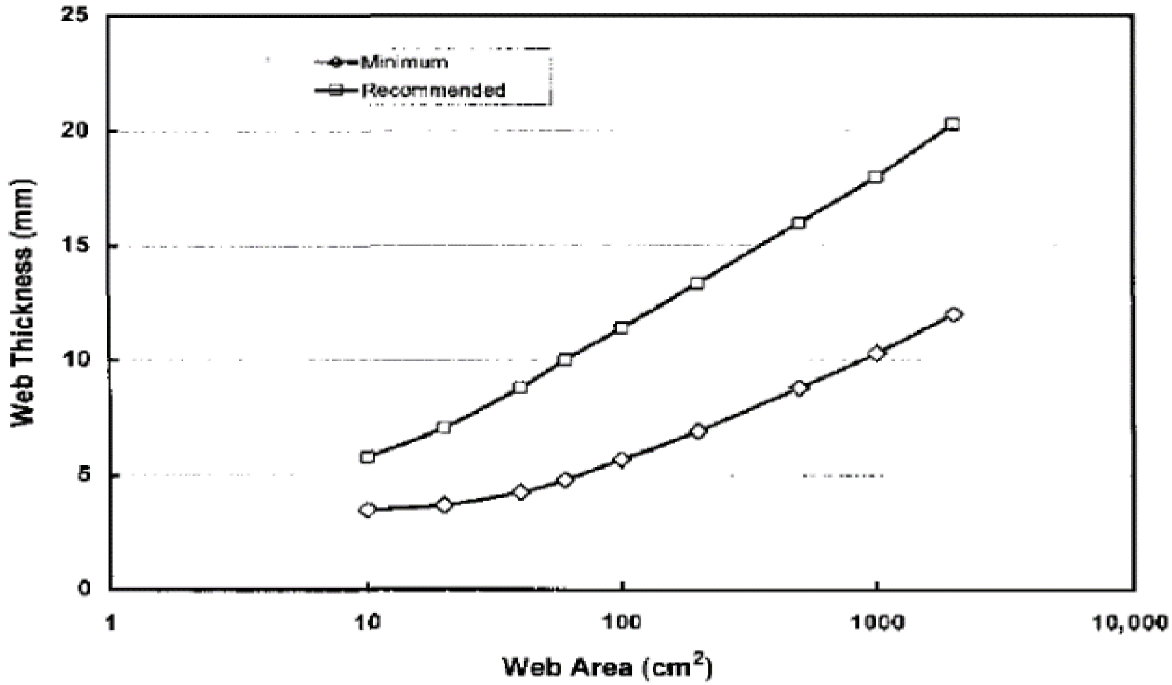


Fig 3.1 Web thickness related to projected area

Fig 3.2 Stepwise present forged part and dies

Fig 3.2 Stepwise proposed forged part and dies

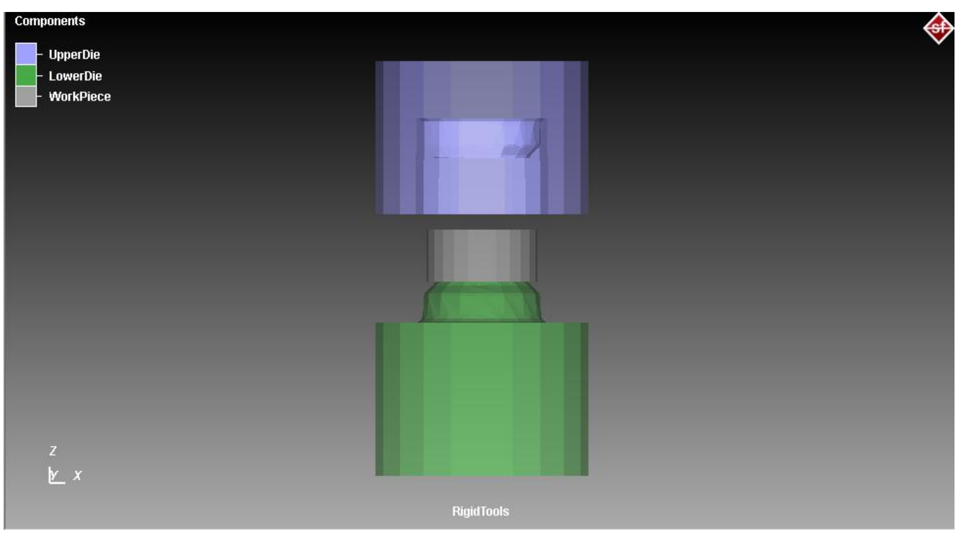


Fig 4.1 Simulation Forging setup

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

LIST OF TABLES:

Table 3.1 Modified web portion designs

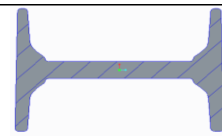
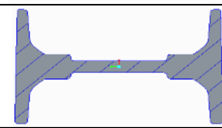
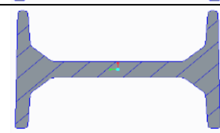
1.	Design with Step	
2.	Design with Cup	
3.	Design with Taper	

Table 3.2 Initial matrix for Modified TOPSIS

Design		**Die1 (Step)**	**Die2 (Cup)**	**Die3 (Taper)**
Parameter	**B/NB**			
Grain flow	Beneficial	1	5	3
Input Weight	Non-Beneficial	450 Grams	475 Grams	465 Grams
Machining Cost	Non-Beneficial	4 Rs	4 Rs	5 Rs
Tooling cost	Non-Beneficial	5	1	5
Material reduced	Beneficial	50 Grams	25 Grams	35 Grams

Table 3.3 Normalized matrix

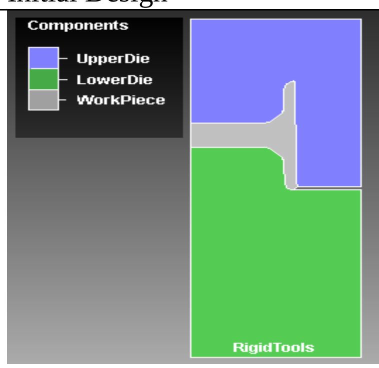
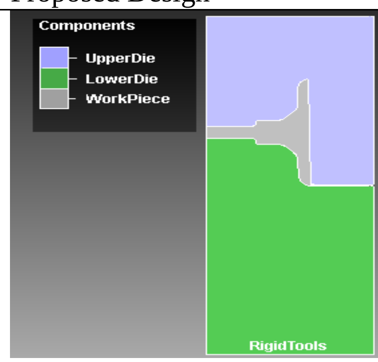
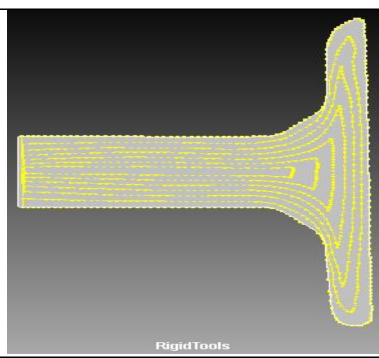
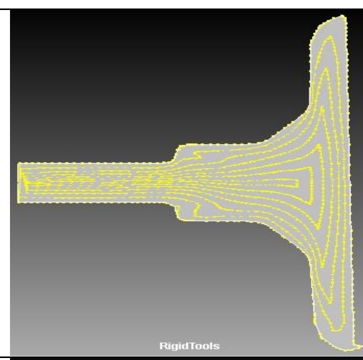
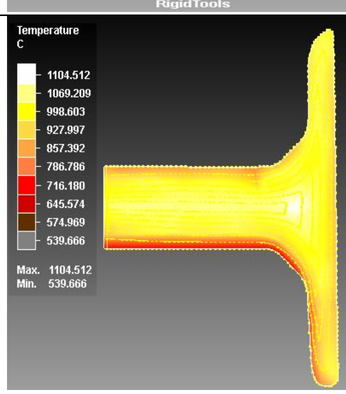
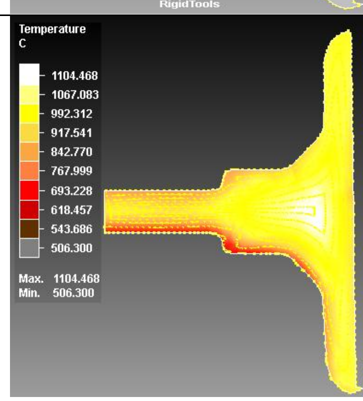
Parameter	**Die 1**	**Die 2**	**Die 3**	**Weights**
Grain flow	0.169	0.845	0.507	0.35
Input Weight	0.561	0.592	0.579	0.25
Machining Cost	0.530	0.530	0.662	0.20
Tooling cost	0.700	0.140	0.379	0.10
Material reduced	0.758	0.379	0.531	0.10

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

Table 3.4Dies and Rank by Modified TOPSIS

DIE	RANK
Die 1	**3**
Die 2	**1**
Die 3	**2**

Table 4.1 Comparison of forging dies

<table>
<tr><td>Parameter</td><td>Initial Design</td><td>Proposed Design</td><td>Remark</td></tr>
<tr><td>Cavity filling</td><td>
</td><td>
</td><td>Cavity filling is good in proposed Design.</td></tr>
<tr><td>Grain Flow</td><td>
</td><td>
</td><td>The grain flow is disturbed at central portion, but in the piercing operation cup portion is pierced out. So the grain flow at groove is uniform in the proposed design.</td></tr>
<tr><td>Temperature</td><td>
</td><td>
</td><td>The Temperature zone at central portion of the proposed design is increased.</td></tr>
</table>

ISSN Online: 2394-0425; Volume 3 Issue 1 (2017)

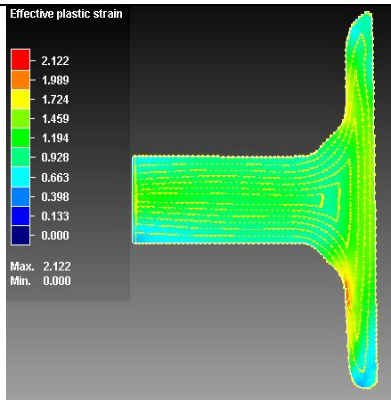
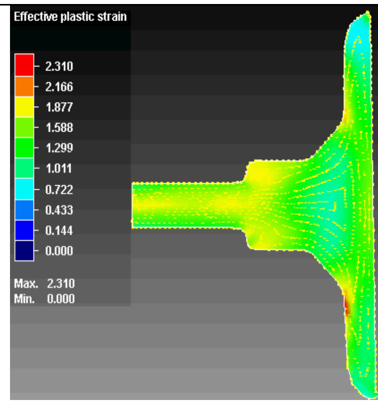
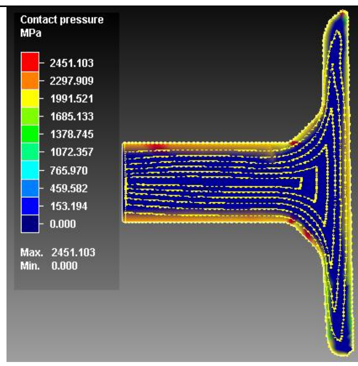
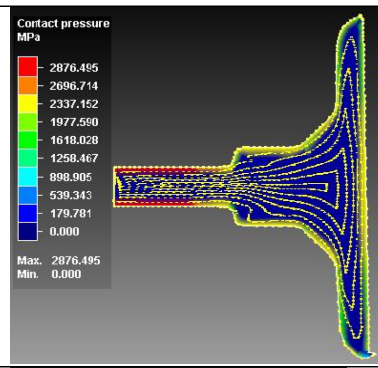
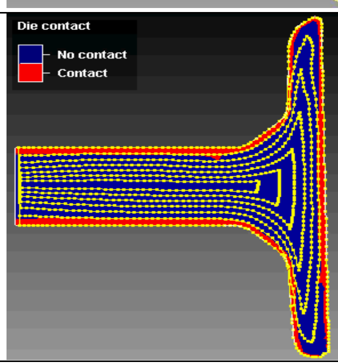
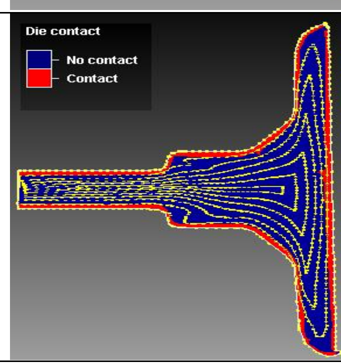
<table>
<tr><td>Effective Plastic Strain</td><td></td><td></td><td>The effective plastic strain is similar in both the design.</td></tr>
<tr><td>Parameter</td><td>Initial Design</td><td>Proposed Design</td><td>Remark</td></tr>
<tr><td>Contact Pressure</td><td></td><td></td><td>The contact pressure on grove position reduced in the proposed design.</td></tr>
<tr><td>Die contact</td><td></td><td></td><td>Die contact is uniform in both the designs.</td></tr>
</table>

Table 5.6 Input weight comparison

Design	**Present Die**	**Proposed Die**
Input Weight for each Ring	500 Grams	475 Grams
Material saving on each Ring	-	25 Grams
Yearly material saving on 4.35 Lakhs bearings	-	**10,875 KG**