A Review on Unfilling Defect Found in Forging Process

Rohan K. Soyaliya[1] V. Parmar[2] Jayendra B. Kanani[3]
[1]M.E. Student [2,3]Assistant Professor
[1,2,3]Atmiya Institute of Technology and Science, Rajkot, India

Abstract— The objective of this paper is to find defects in forging process. Causes for unfilling defects are discussed and remedies for the unfilling defect would help to improve the quality of forging product. It is concluded that proper forging technique, improving die design, proper heating of billet reduce the unfilling defect. Simulation in FEM based software DEFORM 3D helps to detect unfilling defect and using discussed remedies help to reduce rejection rate.
Key words: Forging, Forging Defect, Unfilling, Simulation, DEFORM 3D

I. INTRODUCTION

Forging is the process of shaping heated metal by application of sudden blow or steady pressure and makes use of characteristics of plasticity of material. Traditionally, forging was performed by a smith using hammer and anvil. Using hammer and anvil is a crude form of forging. The smithy or forge has evolved over centuries to become a facility with engineered processes, production equipment, tooling etc.

Some of the forging products are – Crank hook, Connecting rod, Gear, Pinion, Crown wheel etc. In this process starting material has relatively simple geometry; this material is plastically deformed in one or more operation into a product of relatively complex configuration. In forging product, product has been elongated plastically, and usually exhibits better ductility in a direction parallel to that of plastic elongation. Through plastic deformation grains become oriented parallel to elongation. Defects can be defined as imperfections that exceed certain limits. There are many imperfections that can be considered as being defect, ranging from those traceable to the starting material to those caused by one of the forging processes or by post forging operations.

II. FORGING DEFECTS

A. Incomplete Forging Penetration:

Dendritic ingot structure at the interior of forging is not broken. Actual forging takes place only at the surface.

- Cause- Use of light rapid hammer blows
- Remedy- To use forging press for full penetration.

B. Surface Cracking:

- Cause- Excessive working on the surface and too low temperature.
- Remedy- To increase the work temperature

C. Cracking At The Flash:

This Crack Penetrates Into The Interior After Flash Is Trimmed Off.

- Cause- Very thin flash
- Remedy- Increasing flash thickness, relocating the flash to a less critical region of the forging, hot trimming and stress relieving.

D. Cold shut (Fold):

Two surfaces of metal fold against each other without welding completely.

- Cause- Sharp corner (less fillet), excessive chilling, high friction
- Remedy- Increase fillet radius on the die.

E. Unfilled Section (Unfilling/Underfilling):

Some section of die cavity not completely filled by the flowing metal.

- Cause- Improper design of the forging die or using forging techniques, less raw material, poor heating.
- Remedy- Proper die design, Proper raw material and Proper heating.

F. Die shift (Mismatch):

Misalignment of forging at flash line.

- Cause- Misalignment of the die halves.
- Remedy- Proper alignment of die halves. Make mistake proofing for proper alignment for eg. provide half notch on upper and lower die so that at the time of alignment notch will match each other.

G. Scale Pits (Pit marks):

Irregular depurations on the surface of forging.

- Cause- Improper cleaning of the stock used for forging. The oxide and scale gets embedded into the finish forging surface.
- Remedy- Proper cleaning of the stock prior to forging.

H. Flakes:

These are basically internal ruptures.

- Cause- Improper cooling of forging. Rapid cooling causes the exterior to cool quickly causing internal fractures.
- Remedy- Follow proper cooling practices.

I. Improper Grain Flow:

- Cause- Improper die design, which makes the metal not flowing in final interred direction.
- Remedy- Proper die design.

J. Residual stresses in forging:

- Cause- Inhomogeneous deformation and improper cooling (quenching) of forging.
- Remedy- Slow cooling of the forging in a furnace or under ash cover over a period of time.

III. LITERATURE REVIEW

A. Piyush Gulati, Rajesh Kanda, Jaiinder Preet Singh, Manjinder Bajwa

In this paper, methodology of simulation of automobile part is discussed. Firstly modeling of dies in PRO-E software is done, importing it in .STL, set all input parameters, start simulation, check material flow. During this simulation unfilling defect is found.

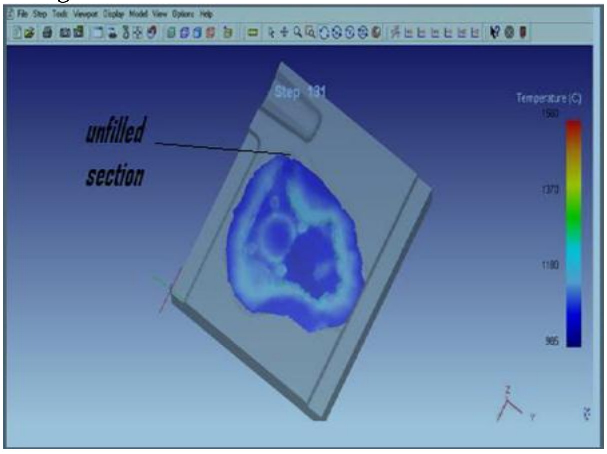

Fig. 1: Simulation of End Plate at 1000 oC

B. Meetinder Singh Sekhon, Dr. Gurinder Singh Brar, Dr. Sukhraj Singh

In this paper, forging defects like cracks, scaling, overlapping, mismatch and underfilling are found to be contributing towards rejection of forged parts. Using Pareto analysis it is found that major defects contributing towards 83% of defect rate are cracks, scaling and low hardness.

C. Mahdi Maarefdoust

In this paper, modeling of industrial gear is done in PRO-E software and analysis is done in SuperForge software. Effect of coefficient of friction and temperature of process was examined. The result show that the effective stress will increase with rising coefficient of friction. With increasing the temperature the press force decreases and effective plastic strain increases.

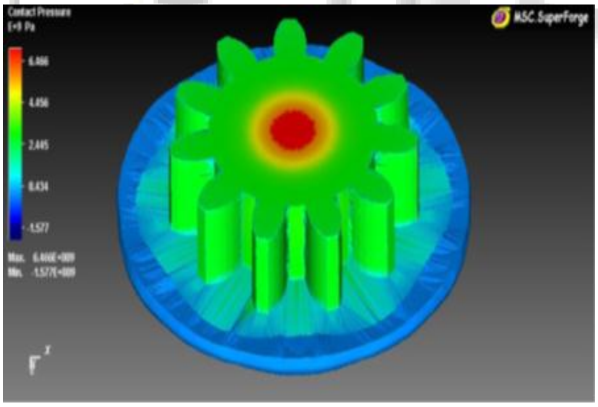

Fig. 2: Contact Pressure

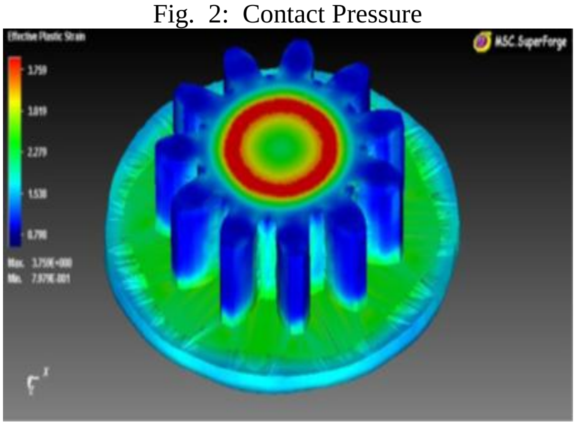

Fig. 3: Effective Plastic Strain

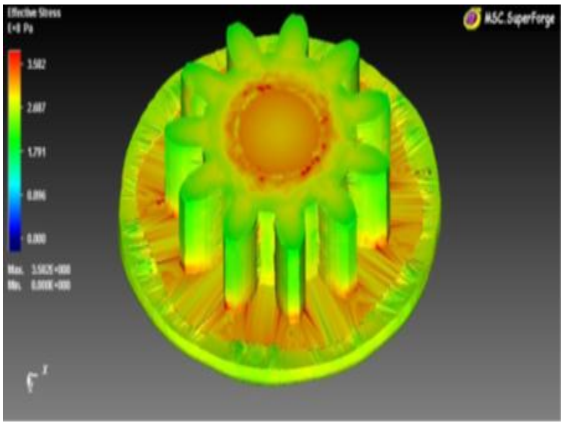

Fig. 4: Effective Sress

Fig. 5: Temperature

Optimum friction in hot forming of steel is between 0.1 and 0.3 according to experiment. Optimum temperature is 1100 oC.

D. Christy Mathew, Justin Koshy, Dr. Deviprasad Varma

In this paper, defects identified in the integral axle arm where unfilling, crack, lap, mismatch. From the Pareto chart it was found that 83.33% of total rejection rate were due to unfilling and lap. The cause and effect diagram was drawn to identify the major causes of these two defects. One of the reason was improper scale removal and secondly poor heating.

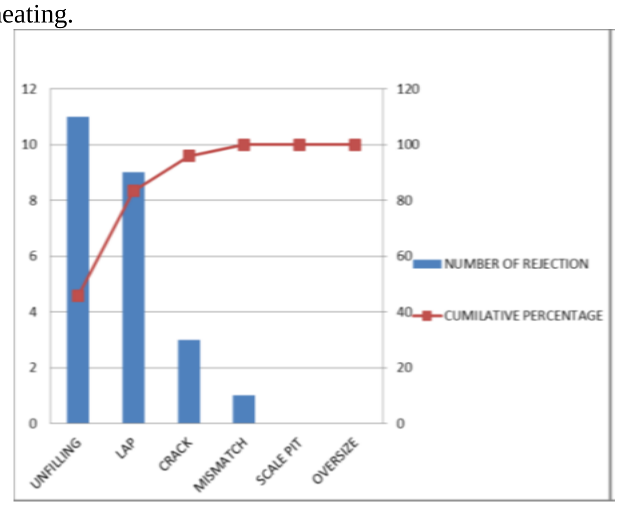

Fig. 6: Defect Analysis Using Pareto Diagram

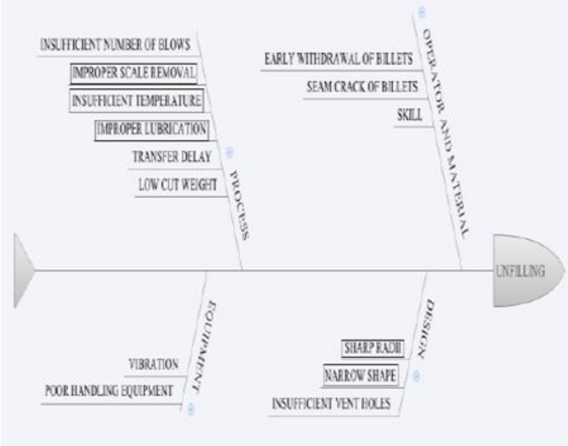

Fig. 7: Cause and Effect Diagram for Unfilling

Pareto diagram constructed data from January ’11 to August ’12 in one of the forging industry.

Major defect found was unfilling. And remedy to unfilling defect is proper heating of billet and improving die design.

E. Aju Pius Thottungal, Sijo.M.T

In this paper, results indicated that rejection rate in the company was more than 5% of total production. Defects in the forged component include lapping, mismatch, scales, underfilling. Remedial action include proper use of antiscale coating, venting process to prevent the underflling, simulation software for determining material flow.

IV. CONCLUSION

Defects like unfilling, crack, lap, mismatch were identified during forging process. Among all, unfilling defect was major cause for rejection rate. It is suggested that simulation to be carried out in FEM based software DEFORM 3D where unfilling defect is identified and during simulation an optimum temperature is to be found out and at that temperature there is no unfilling defect found. And the experiment can be carried out to validate the simulation.

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