Crank Shaft forging design optimisation using computer simulation

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Abstract:

Forging process for a "diesel engine crankshaft" used in power plant, weighing 331 Kgs and 2000 mm length forged out of SAE 4140H steel, is designed and developed with the help of finite element based computer simulation. A commercially available software DEFORM (© Scientific Forming Technology Corporation) is used for the purpose of FEM simulation of crankshaft forging. By adopting the simulation, a single stage forging process was designed, and the underfilling problem observed in the conventional preform design solved by optimizing preform shape. The forging process was optimized to eliminate the intermediate reheating, and preforming / blocker stages of forging. Comparisons are made between the actual forging and the simulation results. The development was done as a collaborative project between ProSIM, Bangalore and Bharat Forge, Pune in India.

Introduction:

The conventional design procedure applied to forging of the crankshaft described above, indicated higher energy and force requirement. Further the forging plan called for a preforming, blocker and finisher operations with a reheating in between. Thus the process was commercially unviable considering the investment in tooling for low volume production.

In view of this, a single stage process (Direct Finish) was to be tried. Such a process could not be directly designed in an optimal way in short lead-time. Computer simulations of the crankshaft forging using DEFORM were adopted for the purpose. A direct finisher process was developed, after multiple simulation experiments using computer simulation tool as virtual forging shop. The hammer manufactured by "Erie" with a capacity of 25000 Pounds is considered for simulation. Two cases of such studies are presented in this paper.

Case 1.

Figure 1 shows the case with a preform which had a round cross section at the flange end. Figure 1a shows the billet positioned in the die cavity. During simulations it was noticed that after 30 blows, reheating was required.

The final shape (flash thickness of 24.3 mm) was achieved after 35 blows. Crankshaft with flash at the end of 35th blow is shown in figure 1b. Underfilling was observed at the ends of the crankshafts as marked in figure 1b.

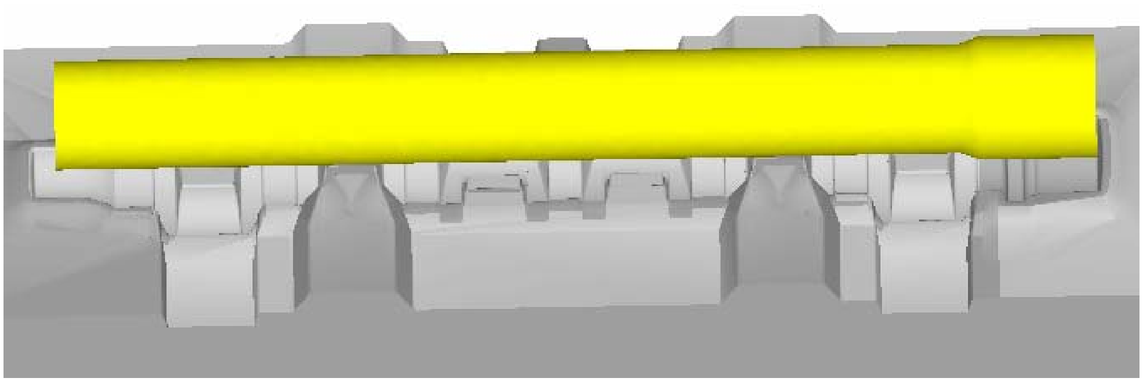

Figure 1a. Die-Preform configuration for Case-1 (preform with circular cross-section at the flange)

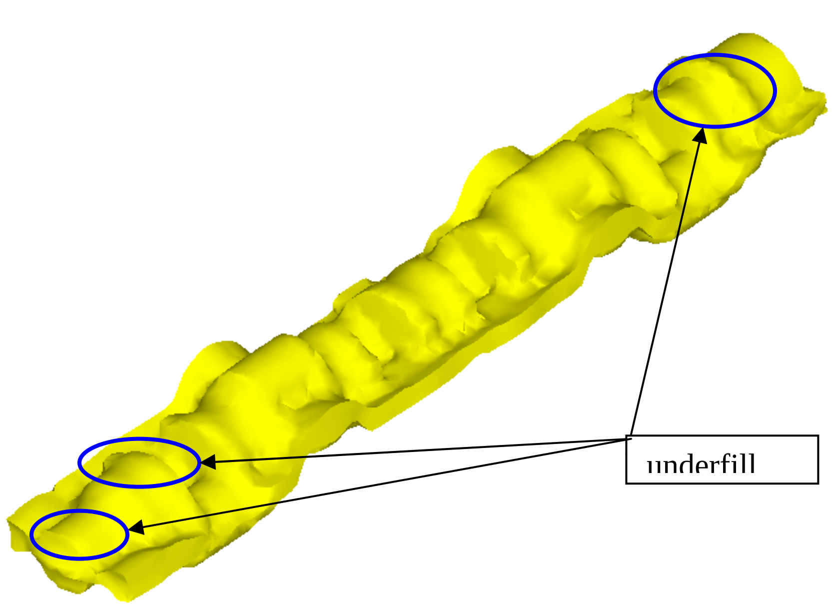

Figure 1b. Crankshaft forged with case-1 configuration perform (end of 35 blows)

Case-2:

To overcome the problem, a preform with a square corner section at the flange end and round section for other area was considered. Further, to overcome the underfill problem the length of the billet was slightly increased. Figure 2a shows the modified billet configuration placed in the die cavity. Forging with this modified billet was analyzed using computer simulation. Figure 2b shows the flash thickness and spread measured on the actual forging compared with the simulation results. Figure 2c shows the actual forging of the crankshaft for the case-2. It is seen that the computer simulation results are well in agreement with the plant measurements.

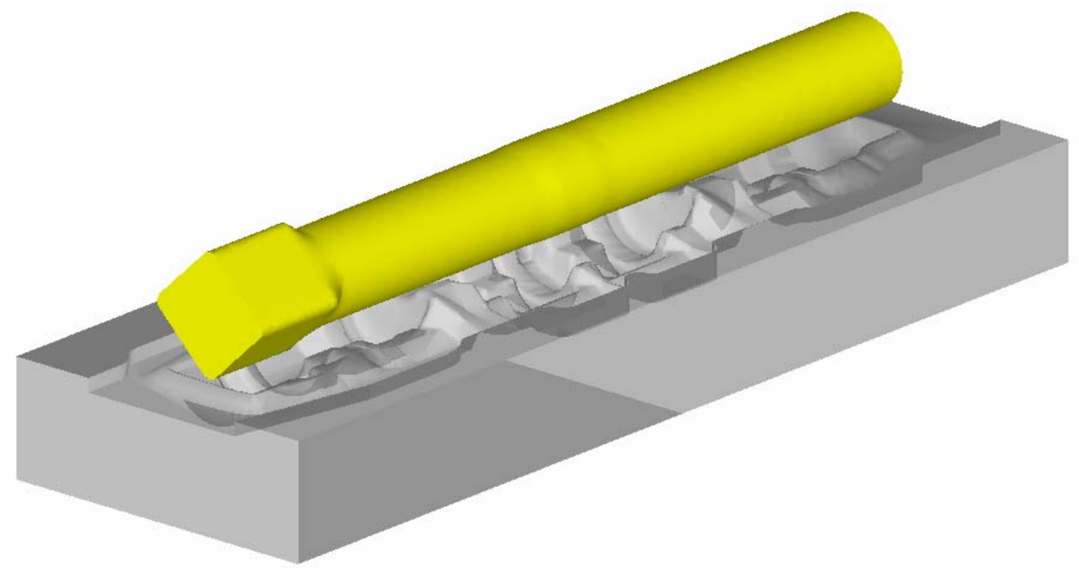

Figure 2a. Die-Preform configuration for case-2 (preform design with rectangular cross-section at the flange)

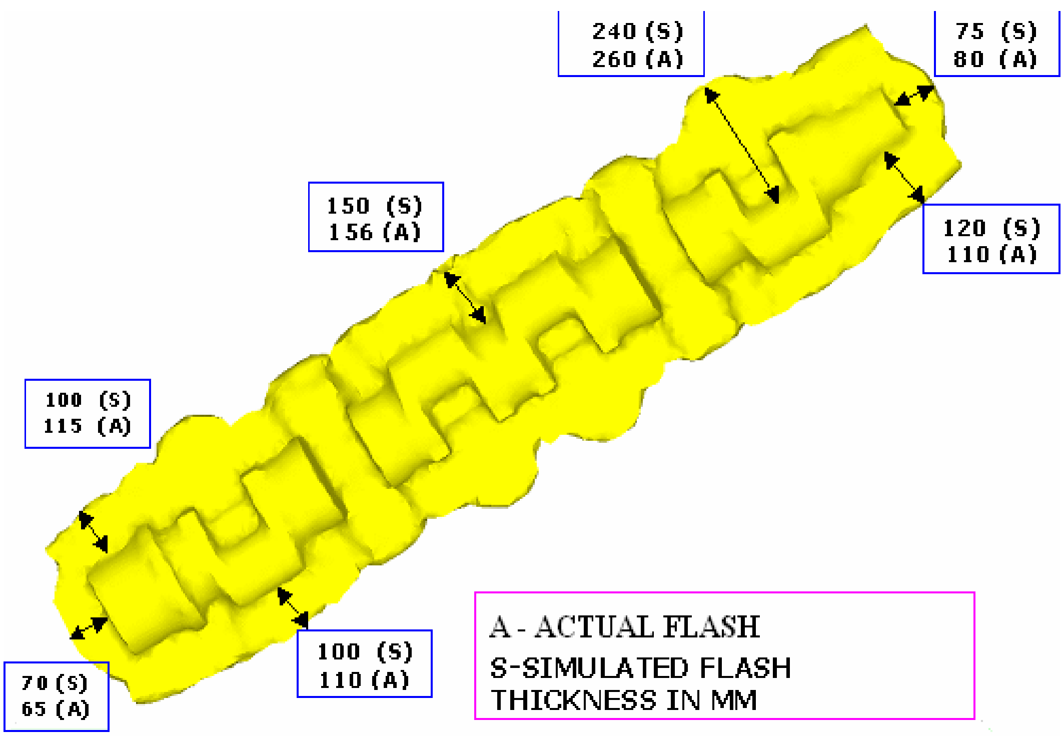

Figure 2b. comparison of flash lengths measured out of forged crankshaft compared with DEFORM FEM simulation.

Figure 2c. Forged Crankshaft

Set up of Computer simulation models:
In order to get useful and reliable information from the computer simulation model, it is important to set up the model as accurately and precisely as possible. These include the die and workpiece geometries, material specifications, process conditions such as work piece temperature, die preheat temperature, lubrication practice, equipment characteristics such as equipment energy and efficiency. Further, high mesh density has to be used in the regions of interest to capture the minute details. Once these issues are taken care of, the simulation results become increasingly reliable.

Conclusions:
Finite element analysis based computer simulation of forging process has been used to optimize the forging process of a 331 Kg diesel engine crankshaft. By carrying out multiple number of forging experiments in the virtual manufacturing, the forging process was optimized to overcome the undefill problem, eliminate blocker stage forging and interstage reheating.

For more details about crankshaft forging contact – shyamtakale@bharatforge.com or shama@pro-sim.com

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