DEFORM® Application #128

Forged Electrical Connector

Background

Gruppo Bonomi is a leader in the European rail market and a reliable partner in the electromechanical and automotive sectors. They design and manufacture products in close relationship with their customers. The company is also a benchmark in the energy market where they produce insulators and accessories for low, medium and high voltage electrical applications.

Case Study

Gruppo Bonomi manufactures electrical connectors at its Montichiari facility in Brescia, Italy. The brass (CDA 110) connector in this study is shaped in two deformation operations: hot forging and cold coining.

The production flowpath is typical for a forged, critical-service product. The billet is first heated in a gas furnace, hot forged on a screw press machine and sand blasted. The forging is then cold formed on a screw press, followed by flash trimming on a hydraulic machine.

Dimensional accuracy and final hardness are critical requirements for the electrical connector. In order to meet specifications, the part must be held to a 0.1 mm dimensional tolerance and a hardness of 55 HB in the wire connection area. The raw material properties and the coining operation are key influencing factors on the final product.

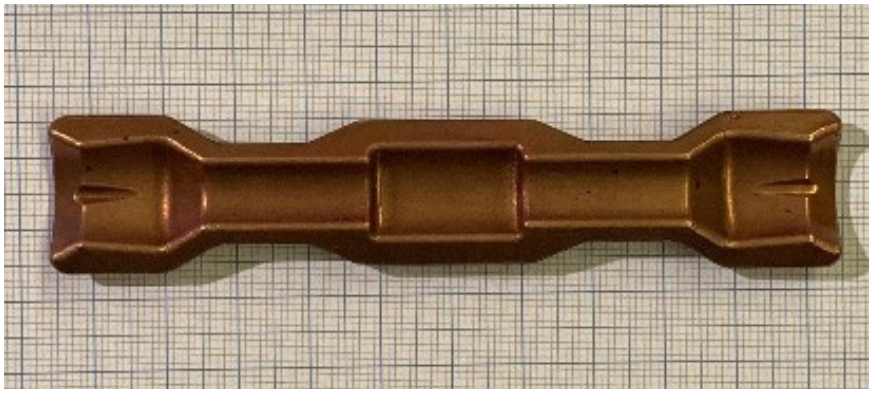
DEFORM®

Design Environment for FORMing

Forging Simulation

The metal forming flowpath was simulated in the DEFORM-3D system. A number of criteria were used to evaluate the influence of the billet geometry. The metrics included the following rules:

1. The die cavity must be completely filled. Under-filled areas are likely to deviate from dimensional requirements.
2. Flash should be produced around the entire flash land. Inadequate flash is generally an indicator of a process that will not be robust. Areas of inadequate flash may turn into underfill if process variations occur.
3. Excessive flash results in lower yields, which lowers margins. It is also associated with high die wear. Bottom line, profit margins will decline.
4. Defect formation is to be avoided. Laps, shear bands or other defects will result in scrap or rework costs.



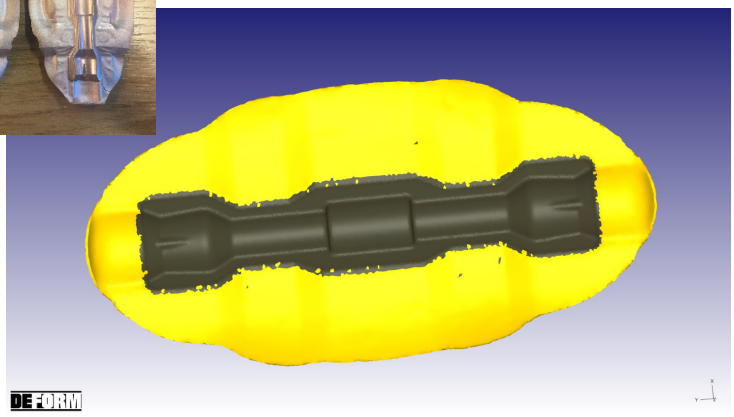
Large Billet

A DEFORM simulation evaluated a large diameter input billet, as shown at the top of the following page. The bar was 12 mm in diameter and weighed 107 g. While the hot forging die cavity filled, excessive flash was observed. The distribution of material in the forging did not allow the part to attain the necessary hardness during subsequent cold coining.

Hot forging generally provided a hardness of 40 HB, but technical requirements had instead asked for 52 HB. The purpose of the cold coining operation was to locally increase hardness to required levels. Coining also increased process robustness for attaining required tolerances. Hot forging and cold coining tolerances were 0.2 mm and 0.1 mm, respectively.

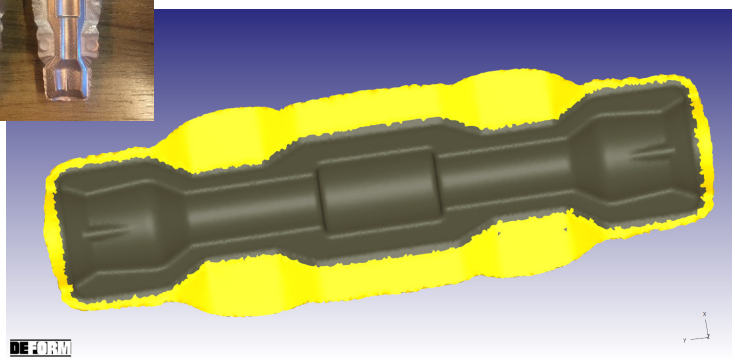
Unfortunately, the area of the part that was to be cold coined was large. This lead to high forming loads. It was determined that the used screw press did not have sufficient tonnage capacity to properly work harden the component.

The predicted scrap, flash and material waste presented a few risks to business financials. Expected profit margins would have eroded if material yield was lower than estimated. Poor tooling life due to excessive flash would have also negatively impacted the company's bottom line.



Small Billet

A second simulation analyzed a smaller, 11 mm diameter billet, with adjustments to bar location and length. Results were overwhelmingly positive and indicated a robust process. The forging die cavity filled without defects. The flash was sufficient for trimming, without being excessive. Controlled dimensions met tolerance. The smaller billet weighed 90 g, which resulted in a material savings of 16% over the large billet. Moreover, calculating a saving of about 20 g of raw material and an annual consumption of 50,000 pcs, the saving were 6,000 €.



Virtual Dimensional Control

DEFORM calculated the connector's final shape, accounting for deformation due to forming, shrinkage due to cooling, residual stress effects and trimming. The customer developed means to import this predicted shape into inspection software for comparison with the nominal CAD model.

Thanks to this new methodology, the customer is able to check whether production parts deviate from the DEFORM prediction. The feedback information allows Bonomi Eugenio to keep the process running near nominal conditions.

Conclusion

The contributions of process simulation in the development of the electrical connector have been well documented. This case study illustrates how DEFORM is highly beneficial in dimensional control and cost reduction tasks.

Tight schedules are the order of the day in the competitive forging industry. Very few manufacturers have the luxury of an increased selling price to compensate for the added costs associated with conservative material sizing, die rework or expensive shop trials.

With profit margins as tight as schedules, it is critical to optimize a process prior to committing cash to the production trials.

DEFORM-3D is an invaluable tool, providing feedback to forging designers early in the development process. The software is equally as useful in troubleshooting and eliminating existing issues with defects and high scrap.

Acknowledgement

The die geometry and process conditions were supplied by Bonomi Eugenio in Brescia, Italy. This case study was developed in partnership with ECOTRE Valente srl, the exclusive distributor of DEFORM in Italy. ECOTRE Valente is a specialist in metallurgy and virtual manufacturing. They are a distributor of simulation software for casting, metal forming and heat treatment applications.

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