Material saving by a combination of rotary forging and conventional processes: hybrid forging for net- shape gear

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Abstract. Increasing efficiency in raw material and energy usage is vital, even more in sectors, such as the hot forging industry, where material accounts for 50% of component price and energy costs are continuously rising. One of the methods to achieve this is to minimize material waste. Traditionally, high-quality gears for the automotive sector are machined to shape from forged preforms which is wasteful of both materials and energy. Attention has now turned to the forging of tooth gears by conventional forging. However, this could require high forging loads and therefore huge press sizes. Some gears may also be difficult to form due to the placement of their teeth. Forging of tooth gears is thus not a straightforward task. In this context, rotary forging is a powerful alternative. It uses incremental deformation locally with the material to achieve near net shape results, minimizing machining. Due to the reduction in contact, it also allows the forging load to be decreased substantially, resulting in smaller presses. This paper shows the development of the rotary forging process in combination with conventional forging to obtain crown gear teeth as a demonstration case. First, the hot conventional forging is shown, based on obtaining the rotary preform by a closed die forging operation. Then, the rotary forging is defined as a semi-finished operation to achieve the forged teeth. The objective is to reduce the initial billet weight, checking that folds and filling defects do not appear. A thermomechanical chained model has been developed based on FEM and experimental tests are carried in a preindustrial environment. The prototypes result in increased yield from raw material (around 15% saving compared to machining) and they can be manufactured with less than 50% of the load required by conventional forging processes. The quality and metallographic requirements are also fulfilled.