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Near net shape technology: An innovative opportunity for the automotive industry

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ABSTRACT

Near net shape is an innovative concept in industrial manufacturing. The main focus of this technology is to produce parts, as near as possible close to their final shape and contour, implementing non-chipping techniques. In this way the manufacturing gives the possibility of a finished product with minimal cutting. Near net shape technology also generates the opportunity to reduce the productive steps for a given process chain. Both the above-mentioned characteristics have the same main goal: achieving cost reduction. This fundamental target incorporates several other advantages, such as: reduction of process variability, quality improvement in the finished product and the possibility to focus the design of mechanical devices on functional features, eliminating technical constraints imposed by the process. Based on these factors and in cooperation with the IWU Fraunhofer Institut of Chemnitz, the authors conducted a research regarding the manufacturing of an innovative automotive gear shaft, produced by applying near net shape processes. The goal of this study is to evaluate whether it is more convenient to produce the part implementing a traditional production chain or an innovative one, based on near net shape techniques. The first step was to locate the available technologies in order to produce the selected part. There are two alternatives: a traditional cutting manufacture, performed with a numerical control turning machine and a near-net-shape technique, characterized only by deformation processes. The next step was to detect the main differential costs between the two opportunities. Comparing technical data and information available in literature, the authors detected the main differential voices of cost: raw material, amortization, manpower and direct setup. In order to make the study more reliable, the authors assumed an actual industrial environment, featured by an annual demand of 400,000 pieces and a product lifetime cycle of 10 yr. The evaluation led to the conclusion that the innovative manufacturing chain is more convenient.

1. Introduction

Today's companies have to face competition that becomes stronger daily. The industry of emerging countries settles continuously new goals in industrial process organization and productive management. In this competitive environment, companies have to look with renovated interest towards the chances offered by innovative industrial techniques. Near net shape technologies represent a significant opportunity to achieve production improvement. The main purpose of this kind of techniques is to produce semi-finished products, as near as possible to their definitive shape and contour, implementing exclusively plastic deformation. In this way, cutting operations are confined to the finishing steps. The research of cost reduction is the background of near net shape technologies implementation. As known, plastic deformation does not produce metallic scrap. The easiest way to achieve an efficient production is to reduce raw material waste. Near net shape technologies ensure several other advantages; first of all, they allow to manufacture complex semifinished products in few productive steps, also characterized by undercuts or particular shapes that cannot be easily manufactured using traditional cutting techniques. To produce a part in fewer steps means to lower the variability of the process, in other words better quality and whole process efficiency. The manufacturing flexibility makes it possible to group in one complex piece more several parts that are traditionally produced independently and then assembled or welded together; the following assembling operations will be easier and faster with reduced possibility of committing mistakes. Thanks to near net shape technologies, designers can plan products focusing on the final purpose of the device, without being forced by technical constraints imposed by the process. To get full benefit from this opportunity, designers must conceive products for near-net-shape technologies since the

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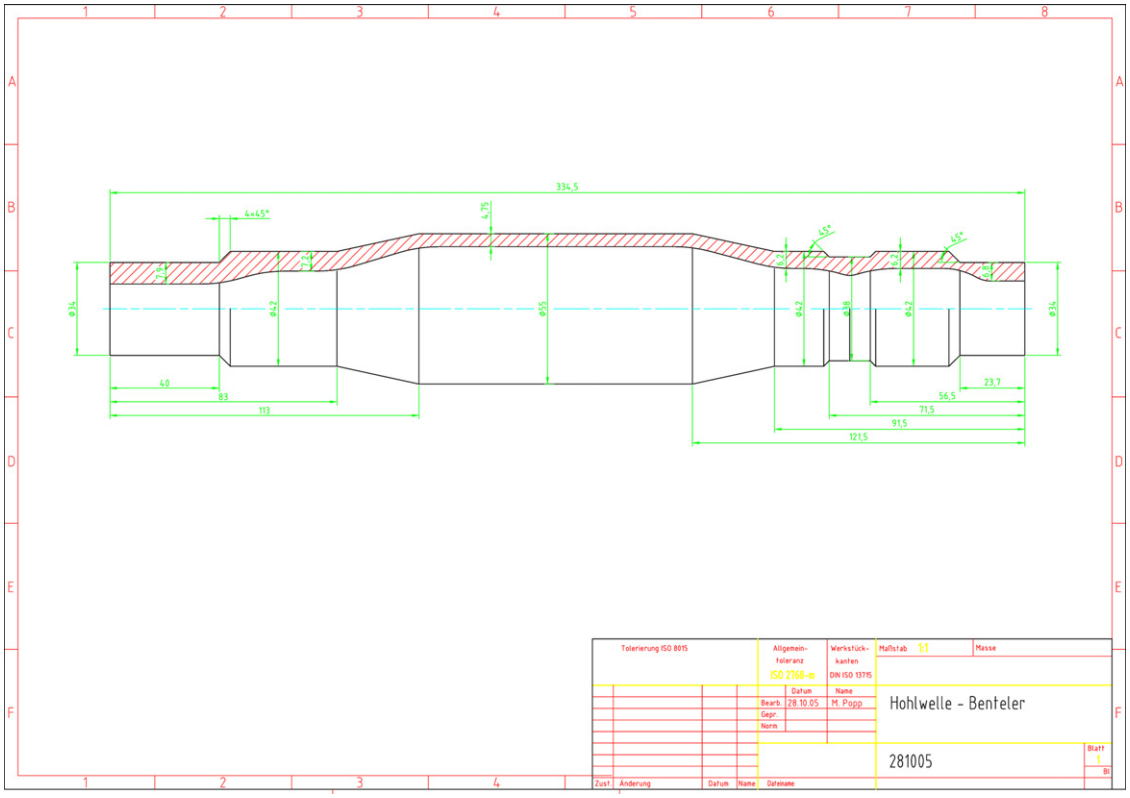

Fig. 1. Drawing of the automotive part subject of the research.

first phases of planning. In cooperation with the IWU Fraunhofer Institut of Chemnitz, in German Saxony, the University of Brescia conducted a research project regarding the industrialization of an automotive part produced implementing a near net shape process. In particular, the authors' main aim was to evaluate whether it is more convenient, under an economical, organizational and industrial point of view, to manufacture the product using either near net shape or traditional techniques. The research project was commissioned to IWU Fraunhofer Institut by a known German automotive company. The mechanical device, which is the subject of the research, is an automotive gear shaft made in structural steel (16MnCr5). Fig. 1 shows a drawing of the part.

The first step that researchers have faced to study which alternative is more convenient was the identification of the available technologies to produce this automotive part. This research was conducted by using available literature, the support of IWU Fraunhofer researchers and the suggestions and indications of machinery suppliers. The result was the identification of two alternatives: the first one is a cutting manufacture performed on a multi-spindle lathe; the second one is to implement a flow forming process in near net shape logic based exclusively on plastic deformation processes.

To assess the compatibility of the research with an industrial and economical reality, an annual demand, and a verisimilar manpower cost are simulated. Economical and technical data of machinery are obtained by the producers. The cost of the raw material is obtained by official LME quotation.

2. Flow forming technology

At the beginning, flow forming was developed for military purposes. With this technology, it is possible to produce cost effectively many single-piece cylindrical components that play an extremely important role in military market. Launch motor casings, nose cones, rocket housing, large cartridge cases and many other military-related components can be produced, with improved characteristics.

The application of flow forming technique to commercial market products is relatively new. By implementing this technology, it is possible to produce tubular, conical or ogival components, characterized by uniform or varying wall thickness. The thickness can be controlled with a very high degree of precision. This offers engineers the chance to design more effective components, saving raw material, without the need for secondary, expensive, chip-making operations.

Flow forming has evolved into a very sophisticated process. The high degree of skill and experience required by early semi-artisans manufacturers has been partially replaced by high-technology machinery, characterized by many numerically controlled axes and high-power spindle motors.

The preformed raw material is placed onto the rotating mandrel. Three radially located rollers provide an axial force that causes a compression of the outside diameter of the working piece, forming therefore the metal into required shape. The inner contour is controlled by the mandrel that has the same geometry of the internal shape of the finished product. Under controlled forces, the metal is compressed above its yield strength point into the plastic deformation zone.

In few words, flow forming offers the possibility to produce finished components with very thin, hard and stable walls. These characteristics are very important, especially if there is a strict requirement about strength-to-weight ratio. For example, it is possible to manufacture thin walled vessels, with improved thermal efficiency, balanced rollers, or cylinders for pharmaceutical applications. Flow forming offers also the chance to produce