Hot forging operations of brass chips for material reclamation after machining operations

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Abstract

The production of chips is an inevitable part of any machining operation. Today, brass chips are commonly recycled through re-melting by the material supplier implying a “loop” where material is sent back and forth between the material supplier and the manufacturing company. The research presented in this paper evaluates a method for compaction and hot forging of brass chips into blanks for subsequent machining into a finished product. A series of experiments have been performed to evaluate the method. The results indicate a possibility of a successful hot forging method for brass chips into machining blanks.

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1. Introduction

Metal cutting chips or swarf are a by-product of all machining operations. In many products, especially thin walled designs, most of the raw material is removed as part of production and never reaches the end customer. When machining parts, it is not unusual that the majority of the workpiece material is converted into chips. Also, it has been estimated that about 80 % of all products have been machined at one point in their manufacturing process [1]. The chips from the cutting process needs to be disposed of in some way, where the most common practice is to

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send the chips back to the materials supplier for recycling. In the recycling process chips are re-melted and thereby new raw material is produced. This implies that materials can be send back and forth between the material supplier and their customers. The energy consumption is higher when re-melting materials compared to reshaping in the solid state due to phase transitions and higher temperatures involved in the re-melting process. If it is possible to re-shape cutting chips to new raw material without melting the material, while maintaining material properties and chemical composition, it can be possible to reduce the energy required for recycling of the material.

In this paper a method of recycling brass chips without re-melting of the material is presented. The fundamental principle of the developed method is to find a relatively simple procedure that is implementable for recycling of materials in-house at Small and Medium Sized Enterprises, SMEs, by using hot forging operations, as a part of their natural manufacturing cycle. Every process step along the way from chips to reusable material will probably be an added cost. Thus, procedures for instance involving controlled atmospheres will likely deter companies not specialized in advanced metal processing from using the method. For those reasons the process steps need to be as simple as possible, yet reliable.

The research in this paper focuses on production of a blank for one product, a 90° pipe bend, used in heating systems. When forging this blank from rod-material the blank weighs 112 g and the finished, machined, part weighs 50 g giving 55 % of material utilization.

Today there is, to the authors knowledge, no process implemented in the industry were brass chips is reclaimed without re-melting, even though Nakagawa et al. [2] developed a method for applying powder forging of high-strength brass chips for the automotive industry in the 1970’s. Due to a drastic reduction in material costs, the production cost of the forged part was found to be 74 % of the cost of the original component. Conclusions from this paper, worth considering in future work, is the effect of large metal flow during the forging process, which improves the strength of the recycled material almost to a comparable level to that obtained using a wrought material. Another essential finding is the importance of shape design of the preform and the forged product to obtain a large uniform metal flow in every section or part of the product. Similar methods, although with less favorable results, have also been reported by Manukyan et al. [3]. According to Philip and Basheerkutty [4], sintering materials containing zinc requires close process control with regards to atmosphere and temperature; otherwise the alloy may lose some of its zinc content. The most significant parameter when sintering is the environment, but tight control of temperature and time is also important.

Similar methods as the one developed in this paper is being used for recycling of aluminum, as described by Kamis et al. [5]. By applying hot forging operations on aluminum chips, billets were produced with nearly the same ultimate tensile strength as the original material from which the chips were produced. According to their study it can be concluded that hot press forging of aluminum chips could be an alternative metal waste recycling process, instead of conventional methods, such as re-melting the waste material.

The purpose of the study presented in this paper is to eventually implement the recycling method at an existing production site, and thereby develop a more sustainable production process. Sustainability is a broad concept containing three domains: economy, society, environment, and their interactions. These three dimensions all contain their own challenges to succeed with sustainable manufacturing. The economic challenges relate to producing new products and services while ensuring development and competitiveness over time. Reducing the environmental impact by promoting minimal use of natural resources and managing them in the best possible way, is a good way to face the environmental challenges of today. The third domain, social sustainability, deals with sustainability challenges by promoting social development and improved quality of life regarding quality of wealth and jobs [6]. Schultheiss et al. [7] have shown that material cost is a large contributor to the total manufacturing cost of brass components. So, if it is possible to increase the material utilization by implementing forging methods on cutting chips, this will likely lead to a more sustainable production by lowering the manufacturing cost and lessen the need for new raw material.

Sustainable manufacturing is a key concept for the future and a great opportunity for companies that want to strive forward. In collaboration with a SME, AB Markaryds Metallarmatur, the forging operations have been performed on site to receive result close to what is possible to achieve in an industrial environment. By forging blanks for subsequent machining operations from recycled brass chips, it is possible to create a circulation of
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