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# Evaluation of the influence of different clamping chuck types on energy consumption, tool wear and surface qualities in milling operations

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**Abstract**

The energy consumption of milling operations is influenced by several interacting parameters. To increase productivity and energy efficiency of related machining tasks, different methods like optimization of machining parameters, new machining strategies and innovative cutting edge geometries for tools are already available. Regarding clamping chucks, only limited information is available on how different chucks influence sustainability of the machining process. Hence, this paper examines the influence of different clamping chucks on the parameters energy consumption, tool wear as well as surface qualities and thereby focusses on important sustainability indicators in machining operations. Therefore, a collet chuck, a Weldon chuck and a precision chuck were evaluated during individual machining tests. Based on the analysis of the gained data, a systematic description of the different influence of each chuck type was carried out and discussed in context of sustainable manufacturing.


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*Keywords:* milling; clamping chuck; energy efficiency; tool wear; surface quality;

## 1. Introduction

Cost savings are an important topic in all economic sectors. The so called Life-Cycle-Costing (LCC) is a process of economic analysis that assesses the total cost of investment over the product lifetime [1]. Especially for small and medium-sized enterprises (SME) the purchase of modern and expensive technologies often does not seem profitable if only calculated with amortization. However, regarding the whole life cycle, the high investment costs are mostly faster amortized.

To ensure competitiveness of the enterprises, precise manufacturing in a short time with high surface qualities is required. For these reasons high investments in modern technologies should not be seen as a burden but as a chance to enhance future competitiveness. The operational costs of machine tools have an annual average of 23 % of the electrical energy [2]. Furthermore, a standard milling machine emits as much $CO_2$ as ten medium-sized cars each year [3]. Due to these facts, an approach like mentioned before is also useful for milling operations. Besides high

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invests for a modern milling machine, operational costs, especially for energy and tools, are a challenge for many SME. Optimized factors in all fields are necessary to keep the costs as low as possible. Different possibilities to increase the overall efficiency of milling operations exist:

- Optimized process parameters, e.g. infeed optimization and computer aided machining strategies [4,5]
- Optimized cutting edge geometry of the tool, e.g. cutting edge preparation [6] or differential helix angle [7]
- Type of chuck [8,9]

All these factors lead to a reduction of the needed cutting power, whereby considerable energy savings are possible. This does not only reduce the energy consumption, it also has an effect on the wear development. Especially a suitable clamping chuck for the current machining operation can increase tool and machine spindle life, which contributes to sustainable machining operations and leads to cost savings in manufacturing processes.

In this paper the behavior of different clamping chuck types while side milling is examined. The test series include a collet chuck (type ER), a Weldon chuck and a precision chuck. Moreover, solid end mills were used for the test series, because up to 80 % of small and medium-sized metal-cutting companies use this type of tool [10].

## 2. State of the Art

A huge development in the field of milling machines for higher productivity and precision has taken place in the last decades. For example higher rotation speed, multi-axis milling, Computerized Numerical Control (CNC), Computer Aided Manufacturing (CAM) as well as High Speed Cutting (HSC) were implemented. [11,12]

The necessity for increased productivity, precise manufacturing, high surface qualities and a long tool and machine life is increasing. Besides the choice of the cutting material, a precise radial accuracy increased by the use of an optimized clamping chuck is needed. Clamping chucks hold the cutting tools in the machine spindle [13]. The listed requirements only can be fulfilled by safe and precise clamping, which has a huge importance, especially for HSC.

A lot of different clamping systems exist on the market, e.g. collet chucks, Weldon chucks or whistle-notch chucks, the shrink technology or a hydraulic expanding chucks are often used. By using new types of precision chucks and innovative technologies, increasing demands on the clamping technology can be fulfilled.

Currently, manufacturers try to reduce the disadvantages by combining the positive characteristics of the different clamping chuck types, e.g. a precision collet and a hydraulic expanding chuck are combined [13].

With highly precise chucks it is possible to reach a long tool life and better surface qualities. Furthermore, cost savings can be achieved. Therefore, manufacturers promote their chucks with slight radial deviations. Studies have shown, that by using a precision chuck instead of a Weldon chuck savings up to one third of the costs per order assuming an order size of 1,000 workpieces are possible, involving all cost factors. In contrast, the direct costs are nine times higher than the one for a Weldon chuck. [14]

Furthermore, it was found that constructive generated damping and overall stiffness as well as a precise radial accuracy of the precision chuck can lead to a one and a half times longer tool life in comparison to shrink chucks [15].

The used toolhoders in this paper, namely a collet chuck (type ER, a), a Weldon chuck (b) and a precision chuck (c), are shown in figure 1.
The collet chuck consists of a front socket, a collet, and a locknut. Weldon chucks have a higher radial stiffness but are less versatile than collet chucks. The standard Weldon chuck has one side-mounted clamping screw. [13] In a precision chuck, the cutting tool is clamped by a worm gear connected to a clamping sleeve [16].

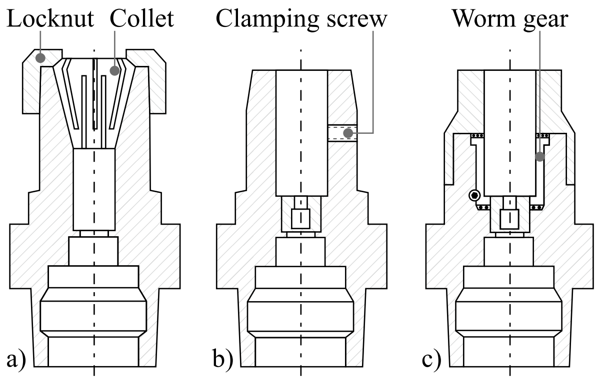


Fig. 1: Considered clamping chucks, based on [9]