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HS-F 1000 increases tool life cycle of cutting tips

Abstract

We compared the performance of the new milling machine HS-F1000 based on a mineral frame design to a conventional milling machine with cast iron frame. Using the HS-F 1000, we found a significantly reduced vibration level compared to the conventional milling machine. At the same time, the HS-F 1000 showed a significantly extended tool life of cutting tips by 25%.

Key words

• **Milling machine** • **Tool life** • **Vibration** • **Cutting tips**

Introduction

Industrial production enterprises are aiming at reducing costs of their processes, which is a particularly challenging task for manufacturers of milling machines. One crucial factor for efficient milling is the tool wear of cutting tips, which significantly affects cutting quality and downtimes of the machine. Furthermore, cutting tips are one of the largest cost factors in maintenance of a quality control laboratory.

The tribologcal process during milling results in wear of the flank and rake face of the milling tip. As matter of course, the wear of the rank face is of practical importance. Usually, the tip wear is divided in three phases: First, there is a rapid formation of an initial wear mark. Second, the wear mark extends slowly and continuously. In the third phase, wear significantly accelerates eventually causing tool fracture.

Figure 1: Milling machine HS-F1000. Especially designed for sample preparation

Milling with a worn or damaged tool usually leads to increased cutting forces, noise, temperature, chatter, and tolerance deviation of surface removal with unfavorable effects on analysis results. In the worst case, the broken tip can cause a severe damage of the complete cutting tool.

Main cause for excessive wear of cutting tips is vibration. In order to increase milling performance and lifetime of cutting tips, the design of the new milling machine HS-F 1000 (Figure 1) was optimized for vibration reduction. We developed shape, mass distribution and material of the machine frame based on finite element calculation. The finite element analysis of the final design revealed a reduction in vibration by the factor 8 compared to conventional milling machines (Figure 2). The perfect damping features of the HS-F 1000 is also due to special mineral composite casting of the frame. Based on this, the HS-F 1000 is applicable for all type of materials leading to brilliant milling results even for extremely brittle pig-iron samples.

In this study, we aimed at examining the tool life of cutting tips using the HS-F 1000. We compared the results of this machine with the performance of a conventional milling machine with gray cast frame.

Methods

We used a milling head with a four cutting items (Sandvik Coromant R200-068Q27-12L) for milling of standard bar material (C60 steel, hardness 45 HRC, diameter of 30 mm). Milling parameters were the same in each trial with spindle speed of 1000/min, milling depth of 8/10 mm, and milling head advance of 800 mm/min. Simultaneously, for each milling operation, we measured vibration velocity (v Peak) of the spindle block using a commercial vibration sensor.

Before each trial, we inserted a set of four new cutting tips (RCTH 1204 MO PL 1010). The milling trial was terminated as soon as all four cutting tips were completely broken (Figure 3). We performed six trials with the HS-F 1000 and six trials with a conventional milling machine with gray cast frame used for sample preparation

For analysis of vibration strength, we evaluated the mean average of the v Peak from the first 50 milling operations of each trial. For analysis of tool life, we analyzed the mean average of milling operations in each trial.

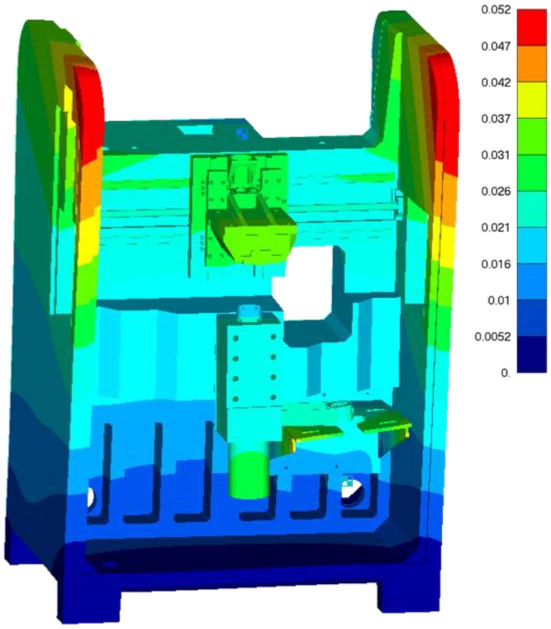

Figure 2: FEA modelling has been used for optimizing the design of the HS- F 1000

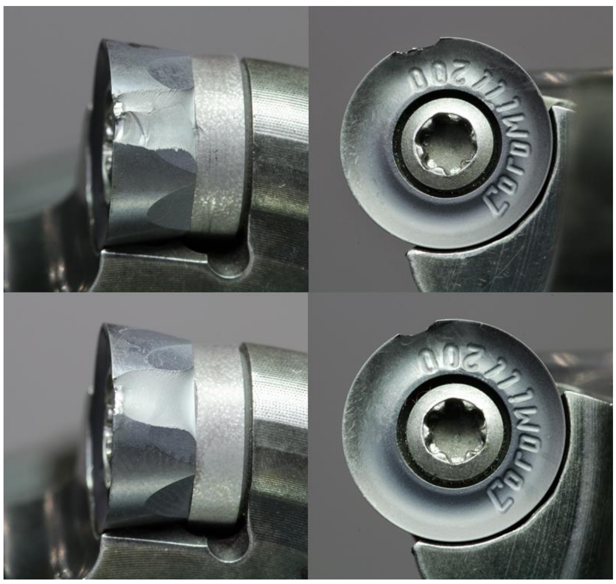

Figure 3: Examples of broken cutting tips with radial (left) and frontal (right) view

Results

The HS-F 1000 showed a significantly reduced vibration intensity compared to the conventional milling machine. The mean v Peak of the HS- F 1000 was 726 ± 41 µm/s, for the conventional machine 2439 ± 121 µm/s (Figure 4, $p<0.001$, student's t-test).

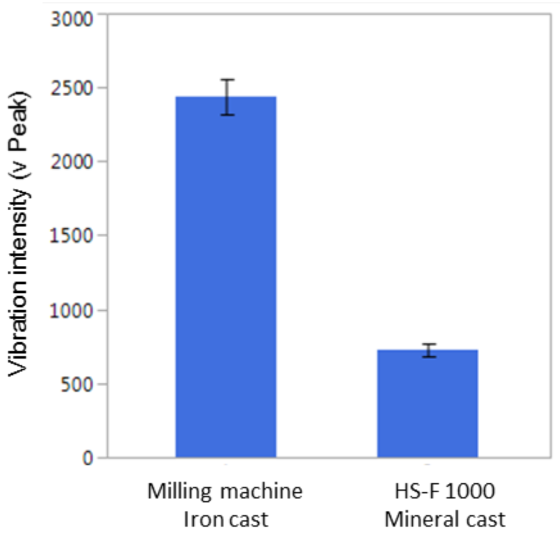

Figure 4: Vibration level of conventional machine compared to HS- F1000

Average number of milling operations in one trial was 413 ± 55 for the HS- F1000 and 328 ± 39 for the conventional milling machine (Figure 5, $p<0.005$, student's t- test).

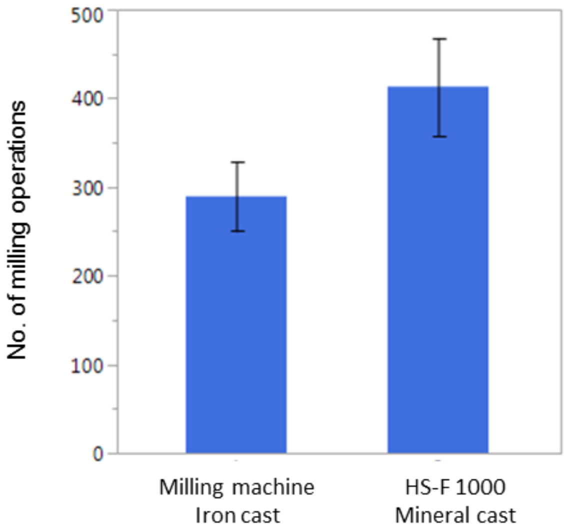

Figure 5: Number of milling operation of conventional machine compared to HS- F1000

Discussion

In our experimental setting, vibration of the HS-F1000 was significantly reduced compared to the conventional milling machine with cast iron frame. These results agree with the theoretical predictions from the finite element analysis and underline the exceptional damping features of the composite mineral used for the frame.

At the same time, the study shows the potential of the HS-F 1000 for extending the tool life of the cutting tips. By milling of standard bar material, we could demonstrate an increase of the service life by 25%. The results of this study are backed by experiences of our customers reporting longer endurance of the HS-F 1000 and less cutting tip consumption in the laboratory.

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