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Innovative Concepts for Grinding Wind Power Energy Gears

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Innovative Concepts for Grinding Wind Power Energy Gears

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

Over the past years wind power energy is gaining higher importance to reduce CO₂ emissions and thus counteract global warming. The development of wind power engines is driven by increased performance which requires larger wind turbines and gear boxes. The quality demands of those gears are increasing while the production cost must decrease. This requires new production methods to grind the gears at low cost and a high quality level. Profile grinding is known as a process to achieve the highest possible quality even for complex flank modifications while threaded wheel grinding is known for high productivity. New machine concepts make it now possible to use both advantages at the same time. The reduction of non productive auxiliary time is a very important key aspect to becoming more productive.

The article will show the newest developments to reduce the overall cycle time. This includes aspects to reduce setup time, idle time, productive time as well as dressing time.

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Productivity in profile grinding

The gears used in wind turbine gear boxes have to transfer high loads which requires hardened material on one hand and an exact geometry on the other hand. Thus, those gears have to be hard finished. Discontinuous profile grinding with dressable wheels is actually the most appropriate process to hard finish gears of large modules ($m > 8 \text{ mm}$; $DP < 3$). Due to the ongoing boom in the wind energy market, the gear box manufacturers are focusing on increasing their capacity and productivity of existing machine tools.

In profile grinding, the total cycle time to grind a gear consists of idle time and main production time. Many approaches to optimize cycle time just concentrates on improving the production time itself without considering the idle time. The idle time, which can cover up to 50% of the total cycle time,

consists of setup time, centering time, dressing time, time for overtravel and pitch movements during grinding as well as on machine measuring time.

Figure 1 shows times for a typical example in profile grinding of large gears. The effective grinding time in rough grinding (41 min) is only 34% or just 17% of the total cycle time (240 min). This example shows a dramatic inefficiency of the process.

The grinding time can be calculated with the specific material removal rate $Q'w$ which represents the productivity of a grinding process. The higher the $Q'w$, the shorter the grinding time. Figure 2 shows the definition of $Q'w$ for discontinuous profile grinding. $Q'w$ is the product of radial infeed Δx and axial feed speed f_a . To reduce the grinding time, $Q'w$ has to be increased either by larger radial infeed or faster axial feed speed or even both. The limiting factor for such an increase is usually the appearance of grinding burn.

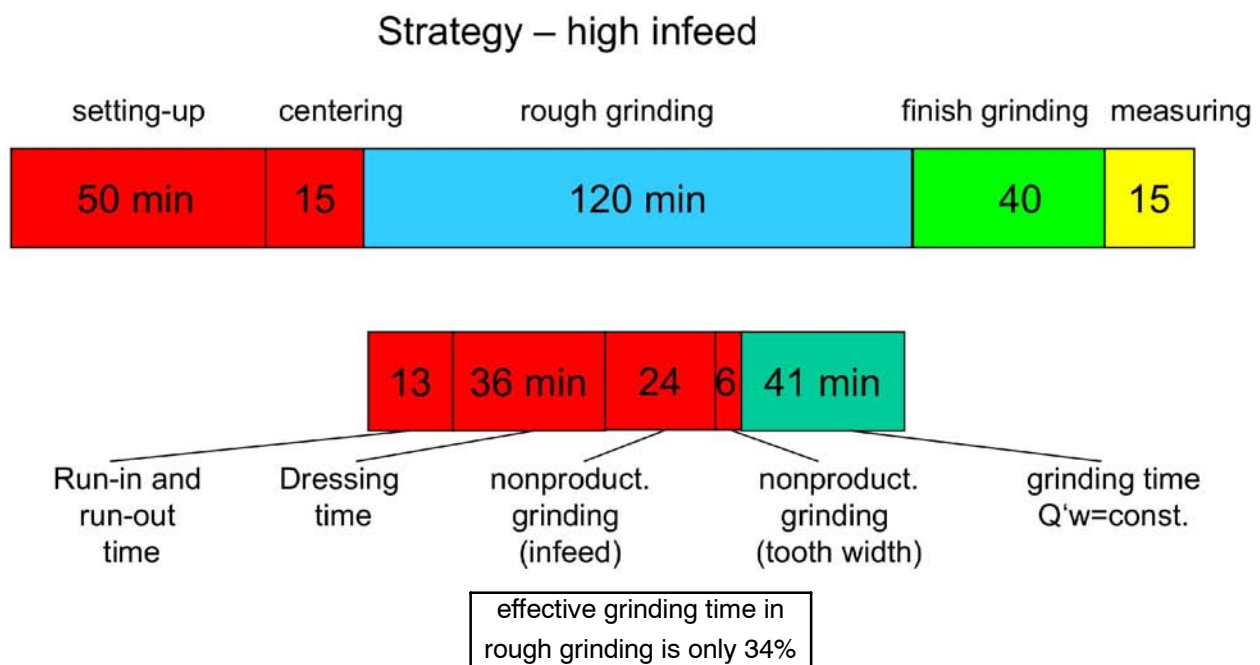


Figure 1. Typical cycle time in profile grinding of large gears

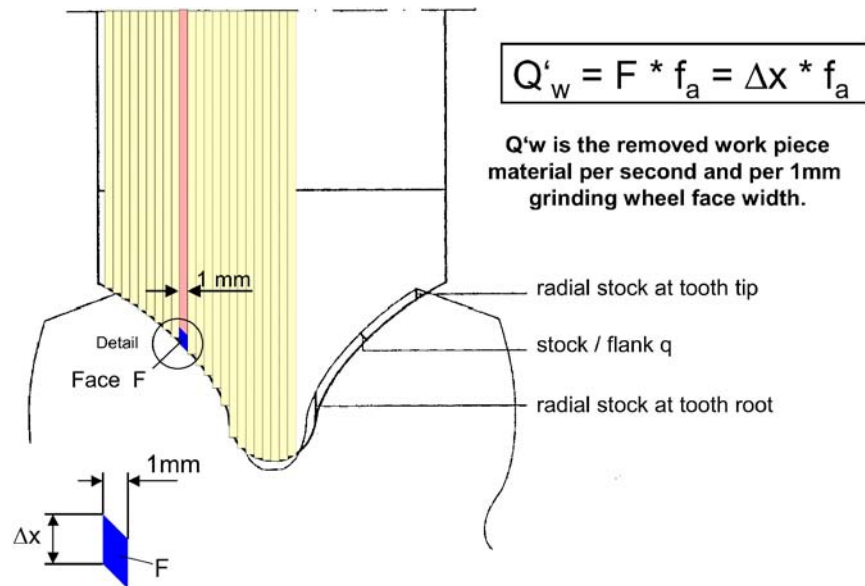


Figure 2. Definition of Q'_w in discontinuous profile grinding

Figure 3 shows the principle relation between the radial infeed Δx and the axial feed speed f_a . As an example, a specific material removal rate of $Q'_w = 10 \text{ mm}^3/\text{mms}$ can be achieved by using a radial infeed of $\Delta x = 0,15 \text{ mm}$ and an axial feed speed of $f_a = 4000 \text{ mm/min}$ as well as using a radial infeed of $\Delta x = 0,05 \text{ mm}$ and an axial feed speed of

$f_a = 12000 \text{ mm/min}$. In principle there are two strategies to reduce the total amount of stock Δx_{total} . One is using high feed speeds and the other one is using a high radial infeed. It is obvious that using a higher axial feed speed for example by a factor of three results in an increase of strokes by a factor of three as well.

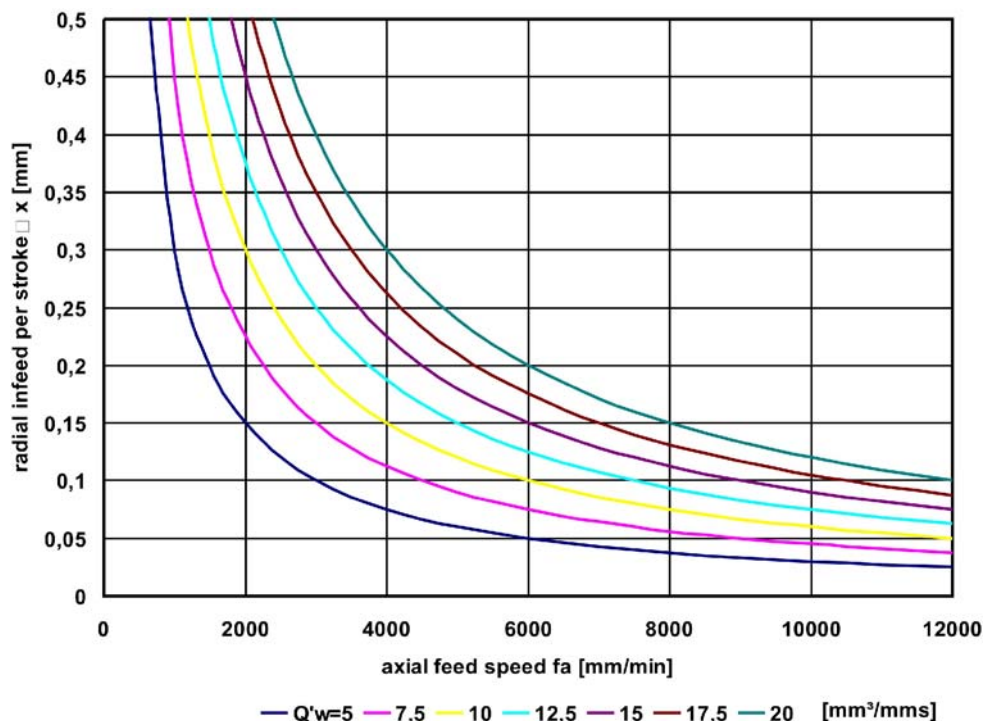


Figure 3. Relation between radial infeed and axial feed speed at constant Q'_w