



## **AGMA Technical Paper**

# **Cubitron™ II: Precision Shaped Grains (PSG) Turn the Concept of Gear Grinding Upside Down**

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# Cubitron™ II: Precision Shaped Grains (PSG) Turn the Concept of Gear Grinding Upside Down

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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

To date, grinding, according to the German DIN Standard 8580, is “machining with geometrically undefined cutting edges” while other machining processes such as turning and milling are classified as processes with “geometrically defined cutting edges”. New abrasive grains, called PSG and developed by 3M, stand this definition on its head. For the first time, grinding wheels made with PSG, called Cubitron™ II, can claim to be made up of “geometrically defined cutting edges” as each and every grain is exactly the same engineered shape. Hence, it might be more appropriate to talk about “micro-milling” rather than grinding. This is borne out by looking at the resulting “flowing” chips which are akin to chips seen in milling operations, just finer.

These free-flowing chips no longer clog up the grinding wheel and, therefore, the grinding wheel remains free-cutting and dressing becomes only necessary due to loss of form rather than loss of cutting ability. In repeated tests, this has shown to drastically reduce the risk of burning and to give consistent and predictable results. Furthermore, tests and subsequent long term trials under production conditions have shown that grinding time can be cut in most cases by at least 50% in comparison to grinding wheels made of standard ceramic abrasives.

Based on more than 100 carefully monitored and documented gear grinding trials, this paper will demonstrate how Cubitron™ II grinding wheels work both in continuous generating grinding of car and truck gears, and in form grinding of large diameter gears for wind generators, for example. Furthermore, the paper will discuss chip formation, filmed with high resolution slow motion; and the benefits of the free-flowing chips in terms of resulting consistent surface finish, superior form holding and extended dressing cycles.

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Since the introduction of ceramic abrasives some twenty years ago, the conventional vitrified bonded grinding wheel has undoubtedly undergone technical improvements, but only in small steps. In this author's opinion, advances in gear grinding technology in the last ten years can be more attributed to improvements in machine tool technology than the grinding wheels themselves. In fact, in some instances such as spiral bevel grinding, it can be argued that grinding wheels have held back advances made in machine tool technology.

Grinding wheels called Cubitron™ II, made of precision shaped grains (PSG), see Figure 1, will change this situation and are challenging machine technology. In fact, some machine tool builders have already adapted to the potential inherent in these new grains by adding spindle power and by adopting their software grinding model.

To date, grinding, according to the German DIN Standard 8580 is "machining with geometrically undefined cutting edges" while other machining processes such as turning and milling are classified as processes with "geometrically defined cutting edges".

Cubitron™ II stands this definition on its head. For the first time, a grinding wheel can claim to be made up of "geometrically defined cutting edges" as each and every grain is exactly the same engineered shape. The secret of the Cubitron™ II wheel's excellent cutting performance lies within its aggressive grain shape. Hence, it might be more appropriate to talk about "micro-milling" rather than grinding. This is borne out by looking at the resulting chips which are fully akin to chips seen in milling operations, just finer.

With any abrasives, the grinding process is a combination of ploughing and cutting during the chip formation stage. Ploughing carries much of the responsibility of the high energy consumption inherent in conventional grinding. The chip formation of conventional grinding takes place in three stages as illustrated in Figure 2. In Stage I, elastic deformation occurs as the grain attempts to penetrate the workpiece material which flows back to some extent, this is then followed in Stage II as plastic deformation (ploughing) and finally, in Stage III, a chip is formed. As the heat generated in grinding is carried away by the chips, it is of paramount importance that the chips are formed as early as possible, and that Stages I and II are as short as possible to avoid heat build-up, and as a consequence, thermal damage to the workpiece.

Precision shaped grains, however, move much quicker into the chip formation Stage III, see Figure 3. This in turn, reduces the risk of thermal damage to the workpiece. While it is difficult to witness the chip formation with direct observation, the resulting chip shapes lead to this conclusion. However, in the actual presentation, a film sequence will be shown, filmed with 400 frames per second, of a dry grinding process in which chip formation can be witnessed.

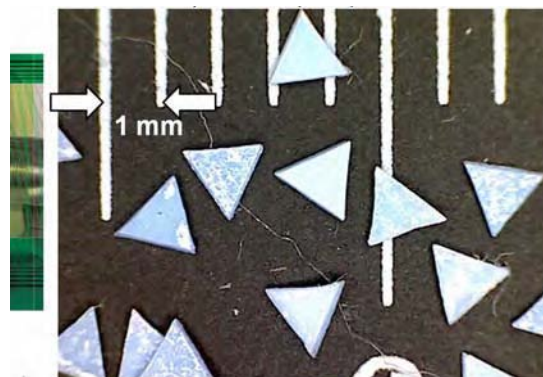


Figure 1. Precision shaped grain (PSG)