High-speed grinding offers great potential for significant advances in component quality combined with high productivity. A factor behind the process has been the need to increase productivity for conventional finishing processes. In the course of process development it has become evident that high-speed grinding enables the configuration of new process sequences with high performance capabilities. By using appropriate grinding machines and grinding tools, it is possible to expand the scope of grinding to high-efficiency machining of soft, ductile materials. In this chapter, a basic examination of process mechanisms that relates the configuration of grinding tools and the requirements for grinding soft materials is discussed.

9.1 Introduction

There are three processes that have become established for high-speed grinding:

- High-speed grinding with aluminium oxide (Al$_2$O$_3$) grinding wheels
- High-speed grinding with cubic boron nitride (CBN) grinding wheels
- Grinding with aluminium oxide grinding wheels in conjunction with continuous dressing techniques

Material removal rates resulting in a proportional increase in productivity for component machining have been achieved for each of these fields of technology in industrial applications. High equivalent chip thickness ($h_{eq}$) values between 0.5 and 10 $\mu$m are a characteristic feature of high-speed grinding. CBN high-speed grinding is employed for a large proportion of these applications. An essential characteristic of the technology is that the enhanced performance of CBN is utilized when high cutting speeds are employed. CBN grinding tools for high-speed machining are subject to certain requirements regarding resistance to wear. Good damping
characteristics, high rigidity and high thermal conductivity are also desirable. Such tools normally consist of a body of high mechanical strength and a comparably thin coating of abrasive attached to the body using a high-strength adhesive. The suitability of cubic boron nitride as an abrasive material for high-speed machining of ferrous materials is attributed to its extreme hardness and its thermal and chemical durability when bonded with the correct composition of glass.

High cutting speeds are attainable with metal bonding systems. One method that uses such bonding systems is electro-plating, where grinding wheels are produced with a single-layer coating of abrasive CBN grain material. The electro-deposited nickel bond displays outstanding grain retention properties. This provides a high level of grain projection and very large chip spaces. Cutting speeds exceeding 300 ms\(^{-1}\) are possible, and the service life ends when the abrasive layer wears out. The high roughness of the cutting surfaces of electroplated CBN grinding wheels has disadvantageous effects. The high roughness is accountable to exposed grain tips that result from different grain shapes and grain diameters. Although electro-plated CBN grinding wheels are not considered to be dressed in the conventional sense, the resultant workpiece surface roughness can nevertheless be influenced within narrow limits by means of a so-called touch-dressing process. This involves removing the peripheral grain tips from the abrasive coating by means of very small dressing in-feed steps in the range of dressing depths of cut between 2 to 4 μm, thereby reducing the effective roughness of the grinding wheel.

Multi-layer bonding systems for CBN grinding wheels include sintered metal bonds, resin bonds and vitrified bonds. Multi-layer metal bonds possess high bond hardness and wear resistance. Profiling and sharpening these tools is a complex process, however, on account of their high mechanical strength. Synthetic resin bonds permit a broad scope of adaptation for bonding characteristics. However, these tools also require a sharpening process after dressing. The potential for practical application of vitrified bonds has yet to be fully exploited. In conjunction with suitably designed bodies, new bond developments permit grinding wheel speeds of up to 200 ms\(^{-1}\). In comparison with other types of bonds, vitrified bonds permit easy dressing while at the same time possessing high levels of resistance to wear. In contrast to impermeable resin and metal bonds, the porosity of the vitrified grinding wheel can be adjusted over a broad range by varying the formulation and the manufacturing process. As the structure of vitrified bonded CBN grinding wheels results in an increased chip space after dressing, the sharpening process is simplified, or can be eliminated in numerous applications.

9.2 High-efficiency Grinding Using Conventional Abrasive Wheels

9.2.1 Introduction

High-efficiency grinding practices using conventional aluminium oxide grinding wheels has been successfully applied to grinding external profiles between centres and in the centreless mode, grinding internal profiles, threaded profiles, flat pro-