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A tool holder for clamping cutting inserts used for turning in a metal cutting operation

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Abstract

Metalworking industry is looking for increase in productivity and maintaining costs per part. One of the most effective methods is the drastic increase of cutting speed by use of Polycrystalline Cubic Boron Nitride (PCBN). The challenge in cast iron machining with ISO/ANSI inserts are high tooling costs and insufficient stability of the insert due to form locked clamping mechanism. The paper presents Beyond shield: an innovative clamping mechanism which provides better rigidity and less movement of the insert, combining with a new designed PCBN inserts shape which results in lower grinding, lower manufacturing time and eventually lower cost.

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1. Introduction

There is a huge market need for machining grey cast iron brake disks and brake drums with high productivity, reliability and lower tooling costs. One way to increase productivity is to increase cutting speeds with Polycrystalline Cubic Boron Nitride inserts (PCBN) [1] despite their high cost. In the past, PCBN cutting tools were difficult to cost-justify, unless they were essential for the machining job. Today, improvements in quality and reliability make these tools, although still costly, competitive in many machining application in the automotive, aerospace, and medical equipment industries. Most rigid machines and tooling setups enable manufacturers to take full advantage of the potential for improved productivity offered by PCBN inserts. [2] Cast Iron machining leads to extremely high mechanical and thermal loads on the tool [3] and today's best performing clamping solution is the form locked clamping system. By having this new cutting tool option, gives manufacturing and tooling engineers an opportunity for cost effective productivity improvement in various machining applications.

The clamping forces on today's form locked clamping mechanism is transmitted by point or line contact. This point contact near the center of the insert leads to very high contact pressure which has resulted in insert breakage. The inserts can still move preventing high speed productivity.

In the form locked clamping system [4], too much of contact pressure is concentrated in the center of the indentation Fig. 1. Over-tightening of the clamp and machining at high speeds have caused the inserts to crack in the center. This leads to work piece and tool damage, which leads to machine shut down and loss in productivity.

Cast iron machining is very aggressive on the tools due to the cast iron chips [3]. These chips flow onto the tool causing wear and destroying the tool very quickly. Usually, it's the insert that wears first, and in some cases, the clamp wears faster than the insert. Clamps need to be replaced often which leads to machine down

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time and loss in productivity. There is also a higher cost per part produced due to clamp replacement costs.

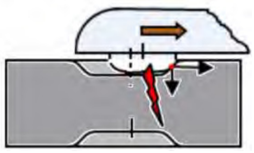

Fig. 1. High contact pressure on existing form locked clamping insert

The real motivation is to create a rigid clamping system that is cost per part competitive in today's dynamic market. The scope would be to produce a lower cost product with the same or better performance as the existing solution.

2. Solution

2.1 Polycrystalline Cubic Boron Nitride Insert

PCBN tools offer the following benefits; (a) machine-hardened cast iron and heat-treated steels, (b) an excellent surface finish that allows eliminate grinding also known as hard turning. Hard turning is turning done on materials with Rockwell C hardness greater than 45 [5]. (c) high productivity rate that can be more than four times higher than that in grinding, (d) great resistance to abrasion which is twice that of ceramics and ten times that of carbide [1] (e) enables dry-machining. 16-20% of the manufacturing cost is from cutting coolant/fluids. Dry machining is becoming important due to the environment and worker's health concerns [6]. These characteristics make it an excellent material to machine cast iron and certain hardened steels.

PCBN cutting tool materials are manufactured by using high temperature and pressure to bond the cubic boron nitride (CBN) crystals together with a ceramic or metal binder [7]. The CBN particles are consolidated in the presence of iron, nickel or cobalt catalysts that promote grain consolidation into a solid mass substrate [3]. They are manufactured as a cylindrical disc. The disc is cut and lapped top and bottom to the required thickness [8]. They are then EDM/laser cut to the required shapes usually to ISO standard sizes Fig. 2 (a).

As the industry is moving towards cost per part, and PCBN material is very expensive, authors came up with a different format to nest these closer so we get more number of inserts per disc Fig. 2 (b, c). This unique shape Fig. 2 (b) provides a 25% increase in the number of inserts per disc due to a material savings of 21% from the former design Fig. 2 (a)

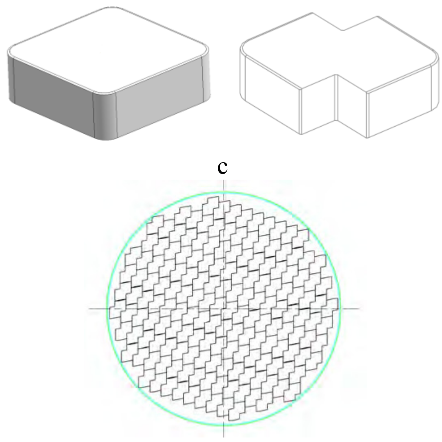

Fig. 2. (a) Standard ISO c style insert; (b) Beyond shield insert; (c) Nesting of Beyond shield inserts on a circular disc

The angles of the nose and the notch should always be supplementary angles to nest them properly in the disc Fig. 3. The distance A is calculated after several FEA analysis to provide the best stability of the insert minimizing failure due to breakage

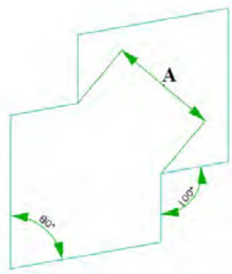

Fig. 3. Beyond shield insert shape

2.2 Beyond shield Clamp

Merchant Circle provides quantitative value for cutting forces in 2D machining [9]. To easily understand the forces involved during metal cutting, A 3D representation of the forces are shown in Fig. 4. Almost 70 % - 80 % of the forces around the insert cutting edge are the tangential force F_t which acts downward onto the insert [10]. This tends to push the insert up on the opposite corner. The rest of the forces are radial force F_r and Feed force F_f which varies depending on the application.