Journal of Materials Processing Technology 209 (2009) 4207–4216

Contents lists available at ScienceDirect

Journal of Materials Processing Technology

journal homepage: www.elsevier.com/locate/jmatprotec

Model of quality management of hard coatings on ceramic cutting tools

M. Soković[a], B. Barišić[b,*], S. Sladić[b]

[a] Faculty of Mechanical Engineering, University of Ljubljana, Ljubljana, Slovenia
[b] Faculty of Engineering Rijeka, University of Rijeka, Vukovarska 58, 51000 Rijeka, Croatia

ARTICLE INFO

Article history:
Received 4 January 2008
Received in revised form 3 November 2008
Accepted 10 November 2008

Keywords:
Hard coatings
Ceramic cutting tools
Quality management
Quality circuits
Tribological system

ABSTRACT

For the development and introduction of new coated cutting tools (*i.e.* new combinations of cutting materials and hard coatings), it is necessary to carry out a number of studies with the purpose of optimizing the coatings composition and processing procedures, and also to test new tools under working conditions. The aim of this paper is to establish a common model for environmentally oriented quality management in the use and development of coated ceramic cutting tools with new coating systems. The paper also presents an investigation of the results of tribological and cutting properties of the coatings deposited with the PVD and CVD techniques on cutting inserts made from (Al_2O_3 + TiC) tool ceramics. Tests were carried out on ceramic inserts, uncoated and PVD or CVD-coated, with gradient, mono-, multi- (nano) layers and multicomponent hard wear resistant coatings composed of TiN, Ti(C, N), (Ti, Al)N, (Ti, AlSi)N and Al_2O_3 layers.

© 2008 Elsevier B.V. All rights reserved.

1. Introduction

The use of coated cutting tools in the machining of various materials now represents state-of-the-art technology. Developments in coating equipment and processes now enable us to produce a wide range of different hard nitride-, carbide- and oxide films and to deposit them on various tool substrates as monolayer, multilayer, or composite coatings. Soković (1997a) clearly revealed that irrespective of whether or not cutting tool materials (HSS, cemented carbides, cermets or ceramics) are coated, the primary concern is to control and optimise properties such as coating adhesion, coating structure, coating thickness, resistance to high temperatures, etc. Therefore, it was taken into consideration that Koenig et al. (1992) had even earlier defined the "*complex composite*" as seen in the coated cutting tool.

The present studies are of importance from two viewpoints: on the one hand, it is considered that the substrate material is important for the production of a highly effective cutting tool, and on the other hand, Navinšek et al. (1991) reported that the maximum performance of hard coatings on different substrates is dependent upon the precision of interface characteristics. For the characterisation of these parameters, modern analytical techniques are used.

* Corresponding author. Tel.: +385 51 651489; fax: +385 51 651465.
E-mail address: barisic@riteh.hr (B. Barišić).

0924-0136/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.jmatprotec.2008.11.026

2. Strategic approach in the development of coated tools

Since the beginning of the nineteen eighties, PVD coating has been used in the large-scale industrial coating of geometrically complex tools (twist drills, taps, etc.) as well as cutting inserts. Hard coating represents a major advance in the performance of these tools. Modern design of coated cutting tools places such rigorous demands on the specified cutting material that such demands can be very often met only by tailoring composite materials for these specific applications. Strafford et al. (1995) particularly argued that the requirements for substrate (bulk) properties, on the one hand, and tool surface properties on the other hand, differ to a great extent, and Weiss (1995) reported the surfaces as having to be specially treated and modified in order to meet the required demands.

The availability of new coating systems and sophisticated coating processes enables us to understand previously unexplained phenomena relating to the performance of coated cutting materials. It is increasingly apparent that the thermo-physical properties of the coatings have a substantial effect upon their performance and operating parameters. Soković (1997b) asserted that the quality of coated cutting (also ceramic) tools often depends on three main parameters, which are shown in Fig. 1.

Despite great advances in the analysis of thin films and coating systems, machinability tests are still needed to demonstrate the performance potential of hard coatings on cutting tools. Dobrzanski and Mikula (2005) reported experimental work that helped to isolate and interpret interface characteristics in comparing between hard coating and substrate, their influence on the parameters in

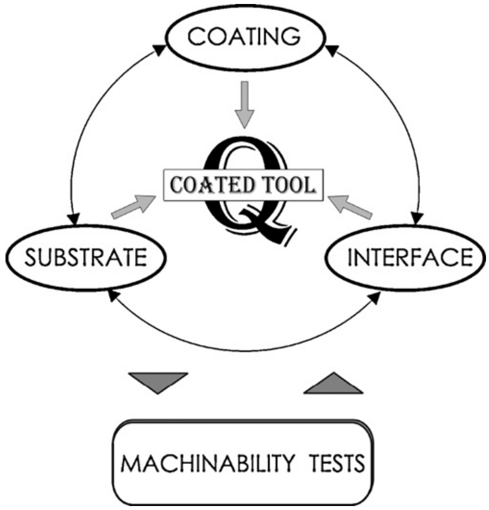

Fig. 1. The interaction of the main parameters on the quality of coated cutting tools.

the machining process, and the resulting forms and causes of tool wear.

3. Quality management in the development of coated tools

The concept of a quality management system when used in the development of coated ceramic tools should encompass all elements of quality assurance and quality control. Patel (1989) proposed that the quality assurance system must undergo a continuous improvement process, which extends from the deployment of preventive quality assurance methods to the application of closed loop quality circuits. Quality assurance methods are frequently effective only when they are integrated into so-called "*quality control circles*".

Quality control circles are quality tools used to achieve the above-mentioned aims in that they effectively enable smooth transition between observation of projected quality in a given process, and concurrent determination of quality for the resulting product at any stage throughout the process of active quality control. The principle behind systematic feedback into various levels of the "*closed loop quality circuit*" is that the use of historical data will prevent the same mistakes from being repeated, for example at the planning stage. Soković (2007) suggests the basic elements for the establishment of the common model of quality management in the development and introduction of hard coatings on ceramic cutting tools, as presented in Fig. 2:

- selection and characterisation of the substrate (ceramics) and coatings,
- processing (preparation) of hard coatings,
- quality control and testing of hard coatings and coated tools (in laboratory and real workshop conditions) and
- industrial applications.

3.1. Step 1: selection and characterisation of substrate and coating

Step 1 in the presented model shows the selection of substrate (a different type of ceramics) and appropriate hard coatings (commercial or new developed) with their characterisations. The first choice in the selection of a substrate is, in every case, a standard type of ceramic (CA, CM, CN, or CR in accordance with the ISO standard 513:2004).

According to the selection of the type of coating, the starting point was the well known commercial monolayer *JOSTiN*® (PVD–RIP) coating (similar to Balzers B coating); in this investigation it is referred to as *Standard Reference Coating—SRC*. For the sake of comparison, some commercial coatings such as titanium carbonitride (TiCN), titanium aluminide (TiAlN) and aluminim oxide (Al_2O_3) were used. Furthermore, in addition to the newly developed gradient/multilayer (TiN + TiAlSiN + TiN), the gradient (TiN + TiAlSiN + AlSiTiN), and the multi (nano) layer (TiN + multi TiAlSiN + TiN) compositions were used. Selection and characterisation of these hard coatings entails the quantitative assessment of the relevant properties by means of physical, chemical, and technological effects. In this phase it is practical to distinguish between characterisations with respect to structure and composition, and characterisation with respect to the other properties.

Hantsche (1990) and Bull et al. (1991) reported that it is not sufficient to characterise only the function and structure of a few atomic layers; Tavares et al. (1997) suggested that the entire modified zone has to be taken into account, and problems with the interface also have to be dealt with. In view of these considerations, a coating system involving substrate–bulk material (*e.g.* cermets, Al_2O_3-based ceramic, Si_3N_4-based ceramics, CBN, etc.), interface, surface coating or modified surface layer, as well as the surface, is very complex. Soković (1998) investigated the complexity of the coating system, shown in Fig. 3, which is influenced by

- *Structure and composition*. One can use a great number of interactions to characterise a surface or a metallographic section. Feeler gauges can be used to study the surface contours, or gases and liquids to study porosity and surface energy.
- *Specific properties*. Measurements of these properties are extremely involved due to the almost infinite number of parameters. This has resulted in a great variety of tests.

  Determining wear resistance alone, which can be classified under abrasive wear, sliding wear, and rolling wear, has led to the development of a great number of tests, which all serve a particular purpose, reflecting the fact that wear resistance is a system property.
- *Bond strength*. The interfacial properties influence the behaviour of coatings under loading, and it is of particular interest to study the strength of the bond between coating material and substrate. Due to the thinness of coatings, this task is very challenging.
- *Coating thickness*. The coating thickness can be measured in many different ways, depending on the properties of coating and substrate.
- *Non-specific testing*. A great number of non-specific tests are available and have evolved during practical work on *coating/substrate* systems. Generally, they will often work very well in assessing the overall quality of a coating and its bonding to the substrate. Notably, the *scratch test* is very widely used to assess the *quality of hard coatings*, but the interpretation of results requires great experience.
- *Testing under service conditions*. Most surface-engineered components are subjected to very special and often complex loading profiles in service, which is particularly the case in corrosive aqueous and gaseous environments and for tribological applications. Soković (1998) proposed the model of transformation of the *technological surface layer* into a "*surface layer in service conditions*" in order to facilitate investigation into the mentioned area. The structure of the model is shown in Fig. 4. In order to obtain data on the actual performance in service, the components have to be tested under closely simulated service conditions.

In the case of a coated cutting tool, it is almost impossible to conduct direct research on events occurring within the coating surface *during the cutting process itself*. Novak et al. (1997) conducted research and found out that what is usually done is an off-line identification of post-process changes on the coating surface (cracks,

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات