

Tool Wear Compensation

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ABSTRACT

This paper describes the principles of a new method to compensate for tool wear when drilling in complex materials such as Carbon Fibre Reinforced Plastics (CFRP), Carbon Fibre Reinforced Plastics / Titanium (CFRP/Ti) and Carbon Fibre Reinforced Plastics / Alloy (CFRP/Al) stacks. A reliable and repeatable hole quality is essential, especially in automatic drilling applications with robots or gantries.

The method combines the unique feature to dynamically adjust the drilling diameter in very small steps in an Orbital drilling End-effector and a new type of software algorithm to predict and compensate for the tool wear in different materials. With this method a large number of holes can be drilled without changing the cutting tool, and a Cpk value of more than 2,5 can be achieved.

INTRODUCTION

Tool wear has always been a big problem when drilling in abrasive materials like CFRP. In some cases just a few holes can be drilled before the cutter has to be scraped or re-ground. Different type of coating and Poly crystalline Diamond (PCD) type of cutters has improved the lifetime but still the process is very expensive and time consuming. Especially in complex stacks with material combinations like CFRP/Ti or CFRP/Al, the process parameters will be a large compromise and even more reduce the lifetime of the cutters. With the Orbital technology a number of these problems can be solved. Especially the unique feature of the Orbital

Drilling technology to adjust the diameter of the drilled hole to compensate for tolerances in tool diameter, tool wear and behavior in different materials is essential.

MAIN SECTION

ORBITAL DRILLING GENERAL BENEFITS - Orbital drilling (Fig.1) is based on machining the material both axially and radially by rotating the cutting tool about its own axis as well as eccentrically about a principal axis while feeding the tool through the material.

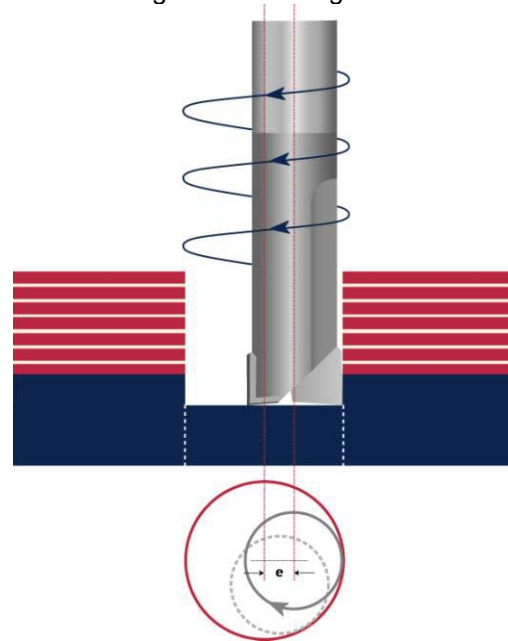


Fig 1 The Principle of Orbital Drilling

Orbital drilling is characterized by a tool diameter that is less than the diameter of the hole; a tool cutting edge that is intermittently in contact with the hole edge; small chip formation; and a low thrust force. These characteristics offer certain benefits. For example small chips in combination with a tool diameter less than the hole diameter allows for efficient chip removal using vacuum, see Fig. 2). Efficient chip removal, in turn, prevents heat build-up and eliminates the risk for matrix melting in composite materials and heat affected zones in metals. In addition, it eliminates the risk for chip induced damage and makes cleaning of structures obsolete.

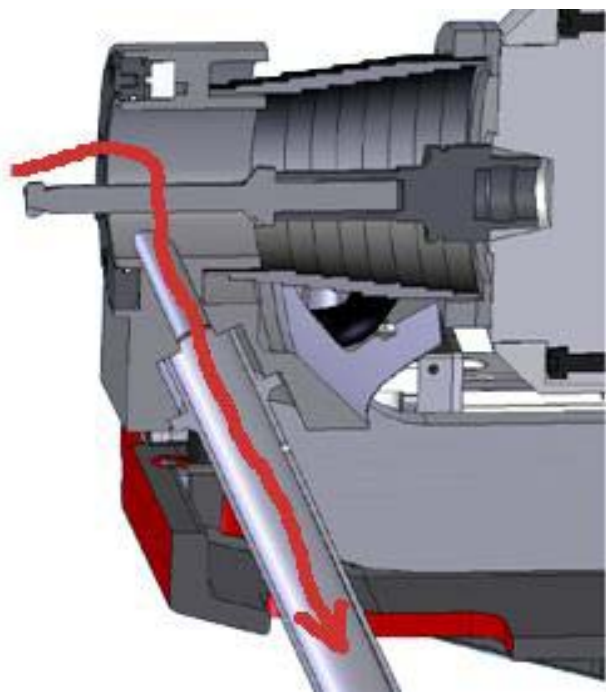


Fig 2 The vacuum system evacuates the small chips

An intermittent cutting edge contact with the part, allows for efficient cooling and makes dry drilling possible. It increases the tool life in dry drilling. Dry drilling is highly desirable as it reduces cost and improves the environment. In some applications, minimal quantity lubrication (MQL) is required to reduce friction. A low thrust force allows for burr-less drilling in metals and delamination-free drilling in laminated composite material. It minimizes the risk for part deflection when drilling in thin structures, and it facilitates automation using light equipment such as industrial robots, which are force-sensitive.

The eccentricity, e , or off-set, is an adjustable parameter. By adjusting the off-set, a tool of one diameter can be used to drill several holes of different diameters. In the more advanced machines this offset adjustment can be dynamically modified during the drilling in very small steps (1-2 μm).

This is achieved by a dual eccentric mechanism (Fig 3) controlled by two servo motors. The speed of the servo motors will determine the “orbital speed” and the phase angle between the motors will determine the current offset (diameter).

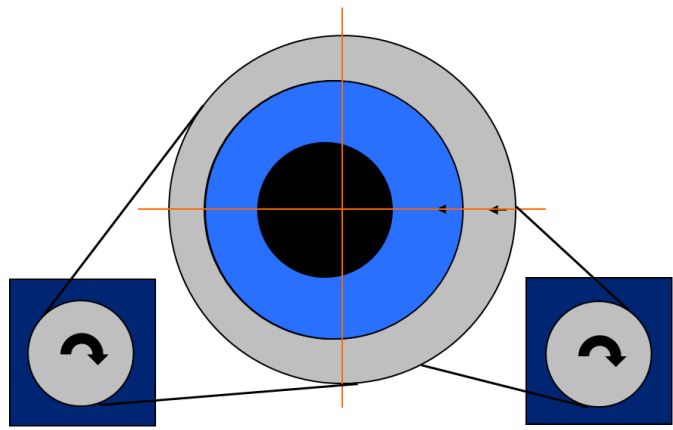


Fig 3 The principle of dual eccenters with dynamic offset adjustment

Orbital Manager

The Orbital Manager is the user interface (HMI) for programming the different drilling recipes. The Orbital Manager includes a database for storing all current and historical data regarding, drilling recipes, cutting tools, machine setup, drilling statistics etc.

Name

IPS 10-14.4

Presser Foot Force

50 %

Orbital Direction

CW

Tool Length

129.7 mm

Machine Parameter Recipe Points

Feed Position (mm)	Offset (mm)	Feed Speed (mm/min)	Orbital Speed (rpm)	Spindle Speed (rpm)	Dwell Time (s)	Tool Air
-1	4	100	300	24700		0 On
4	4	100	300	24700		0 On
30	4	200	300	24700		0 On
38	4	100	300	24700		0 Off
38	0	1000	300	24700		0 On
-1	0	1000	300	24700		0 Off
-1	4,3	100	250	29000		0 Off
40	4,3	100	250	29000		0 Off

Fig 4 The recipe view in Orbital Manager