Characteristics of the Drilling Process

By: Chris Monturo, Miami Valley Regional Crime Laboratory, Dayton, OH

Keywords: machining, toolmarks, drilling, individual characteristics, class characteristics

ABSTRACT

The drilling process is used in the conversion of firearms, obliteration of serial numbers and manufacturing of pipe bombs. When metal is drilled, a variety of marks may be left on the surface being drilled. Understanding these marks may assist forensic examiners in articulating the source and relevance of the marks.

Introduction

The modern drill bit was patented by Stephen A. Morse in 1863. His design incorporates the features of the modern drillbit [1]. A drill is designed to produce holes in objects, metal for the purpose of this paper. Drilling is a fundamental machining process that is typically used to produce initial holes, which may be followed up by reaming, boring, or grinding to provide a final finish size depending on the application. When the drill bit encounters the metal surface it is cutting, various forces produce marks, in addition to the cutting action of the drill bit.

Drill Nomenclature

The drill bit has a variety of features incorporated in its design to provide the efficient and accurate production of holes. Flutes are cut in a spiral fashion along the length of the drill to provide a path for chip removal. Flutes also allow for coolant and lubricant to reach the base of the hole [2]. The land of the drill is the raised area between the flutes. The edge of the lands incorporate a slightly raised area called the margin. The margin allows for clearance of the body of the drill as it cuts a hole (Fig. 1). The lips of the drill are the cutting edges at the end of the lands. The chisel edge of the drill makes initial contact with the material. (Fig. 2) [3].

Mechanics of Drilling

A two flute drill has two cutting edges, called the lips, designed to produce chips. During the cutting mechanism of drilling, four major actions are taking place [4]:

1) A hole is pierced by the chisel edge
2) Chips are formed by the lips (cutting edges)
3) Chips are conveyed out of the hole by the helical flutes
4) The drill is guided in the hole by the margins

Date Received: March 15, 2010
Peer Review Completed: May 3, 2010

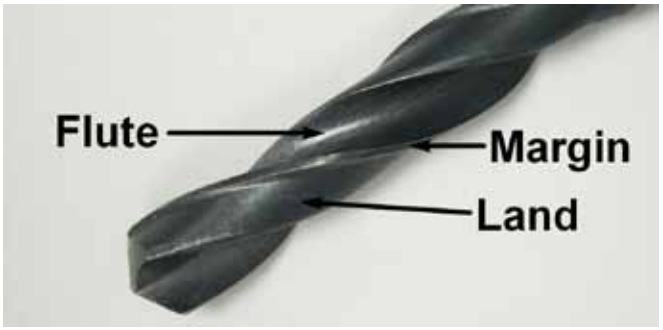

Figure 1: Two flute drill

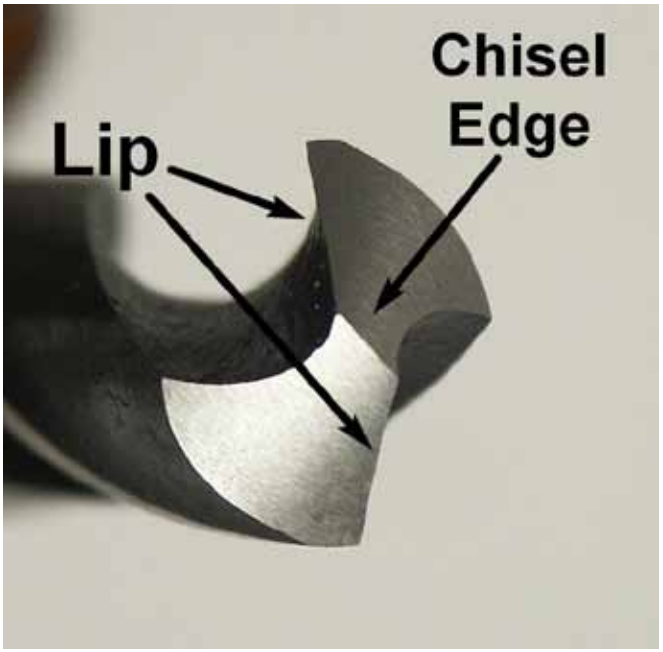

Figure 2: Two flute drill tip

Vibrations in Drilling

The drill bit may be subject to two types of stresses during the drilling action. The first type is lateral whirling vibrations. Lateral vibrations cause side to side movement of the drill bit

in a polygonal shape due to a lobe-shaped motion (Figure 3c).

When a two flute drill bit encounters material, the forces on each flute would theoretically cancel each other out due to their symmetry. However, in practice, there are differences in the grinding of the lips, resulting in unbalanced forces affecting the drill bit [5]. The amplitude of the wandering drill bit is dependant on the deflection due to lateral forces. When the cutting lips engage the metal fully, the hole becomes round and the polygonal shape is no longer present.

The second type of vibration is torsional-axial vibration. When torque is applied to a drill bit it unwinds and elongates. The elongation of the drill bit leads to an increased chip thickness regeneration mechanism in axial direction [6]. The results of torsional-axial vibration produce a sunray pattern in the hole (Figure 3b). The vibration resulting in chatter is in sync with the frequency of the system. Contributors to the frequency of the drilling system are drill material, length, diameter, tool holder, and drill spindle [5]. The occurrence of chatter marks was found to decrease as the spindle speed decreased [7].

Both vibrations can effect the drill bit simultaneously, resulting in whirling and torsional-axial marks (Figure 3d). Occurrence of vibrations is more likely for longer (more slender) drills and increased speed. Conversely, the system may not be affected by vibrational influences and a round drill mark is the result (Figure 3a).

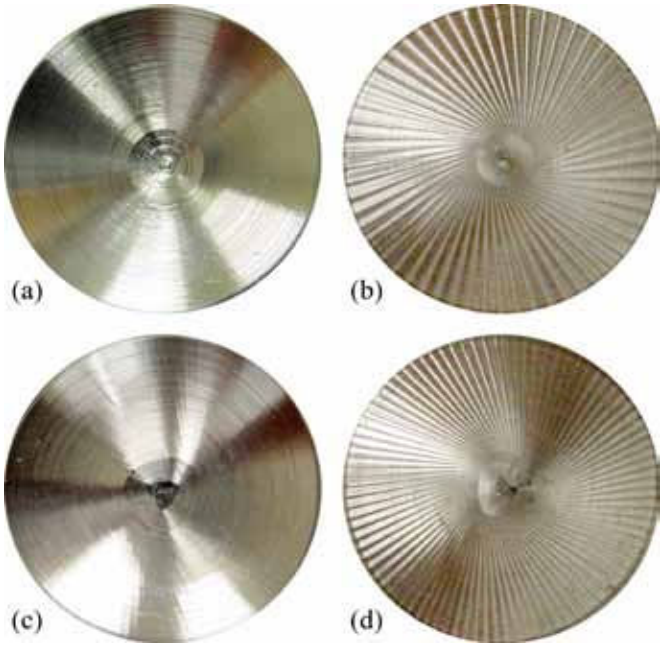

Figure 3: Full hole types generated by a regular twist drill. Photo courtesy of Jochem Roukema.

Summary

The occurrence of whirling (lobed marks) and torsional-axial (chatter) marks can be of limited forensic value. The presence of vibration marks may indicate the condition of the drilling system, but is not specific to a particular drill. However, understanding the source of these marks may assist in an investigation.

References:

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