

Chapter 1

Introduction

1.1 Importance of this Research

Most of us do not consider the economic or design significance associated with the common screwdriver bits that are used in construction and home improvements. In 1997 however, screwdriver bits for power drivers was a \$300,000,000 business worldwide. The complexity of bit design is a result of the necessity for efficient torque transfer between the bit and screw while retaining a geometry that is easy to manufacture and use. The Phillips bit is the most common bit used today. This thesis will look into the problem of testing and design for all bits, but will focus in depth on the Phillips bit and the intricate flute geometries that form the bit.

1.2 Design Focus

When judging the performance of a bit, fracture resistance of the bit and efficiency of torque transfer from bit to the screw are key parameters. Bit wear is also a significant factor. Bit wear changes the mating relationship between the screw and bit, which typically results in an increasing tendency for the bit to disengage from the screw while driving. This disengaging of the bit from the screw is known as cam-out.

1.3 Definition of Cam-out

Cam-out, which is geometrically explained in Section 5.4.1, is the phenomenon which gives a Phillips bit the tendency to slip out of the screw recess when driving or removing a screw. Due to the geometrical mating of the bit and screw, any torque applied to the bit will result in an axial force, which, if not countered by the user, will cause the bit to lose contact with the screw. Most of us have experienced cam-out when using a great deal of torque in attempting to remove a Phillips screw. We find that the bit does not want to turn the screw, but instead

the bit slips out of the screw recess. Most people have learned that if they apply enough downward force on the driver in addition to torque, the bit will not cam-out of the recess and the screw can be loosened. Pressing downward on the screwdriver produces an axial force that overcomes the cam-out force, keeping the bit and screw in contact.

1.4 Current Design Methods

Much effort has been devoted to improving the wear performance of bits. Two major areas that can be studied to improve wear performance are metallurgy and surface geometry. Choosing a high carbon, shock resistant grade of tool steel such as S2 can enhance the wear performance of the bit [Kirkaldy; Becher & Withefered]. Improving the heat treat processes, which is as important as the grade of steel itself, will also increase wear resistance [Becher].

Although not as obvious, bit life can also be improved by optimizing the geometrical design. Since optimizing the geometrical design is a complex task, an understanding of how the geometry is changed through wear must first be reached.

1.5 Future Design Methods

It may be possible to dramatically improve bit wear by developing new bit geometries. The geometry of the bit dictates the force transfer relationship from bit to screw. Therefore optimizing geometry, so that force transfer is improved throughout the life of the bit, should yield a longer lasting bit. Designers wishing to significantly improve bit life will need to focus more effort on the geometrical characteristics of the bit and its interface with the screw. I hope that this work can assist such an effort by deepening the current understanding of the relationship between bit wear and geometry.

1.6 Contributions

This thesis, hopes to improve the approach designers will take by examining three key areas: the test process, evaluation of the tested bits, and understanding and application of the test results.

1.6.1 Testing

In the past, our industrial partner tested screwdriver bits with industrial screw driving rigs that are used in semi-automated assembly. This type of test rigs will not wear the bits as a user would. In fact, these test rigs were able to drive 5000 screws per bit. An average professional user, a typical drywaller, for example can drive only 500-750 screws with one bit using a power driver. In order to design a test rig that will emulate a user, it must be understood what the user does while driving. In studying users, it became clear that they change the angle of the bit with respect to the screw while driving and they vary the axial force applied to the driver. It also became apparent that the actual driver could contribute to the wearing of the bit through vibration. The test rig that was designed incorporated these three variables resulting in a test rig that should replicate the wear a user would produce.

1.6.2 Bit Evaluation

Having the ability to run tests while controlling and isolating axial force and angular offset will help designers understand how these individual factors effect bit wear. None of these efforts however will bear fruit if the changes in the geometry can not specifically be noted. Currently, the bits are compared visually, which does not supply much tangible information on which to base design changes. It is critical that there be a means to take a worn bit and accurately determine and characterize changes in geometry.

Taking a three-dimensional bit and looking at a series of two-dimensional sections stacked together will allow a better understanding of how bit geometry is changing.

1.6.3 Application of Geometric Information

Having tangible information on the geometrical changes of the bit is significant, but that information is incomplete without translating it into bit performance. An understanding of how the geometry will effect the transmission of forces between the bit and screw is crucial. Therefore this thesis will also address the theory behind bit/screw surface contact and how geometrical changes translate into the cam-out forces.