Chapter 7

Conclusions and Future Work

7.1 Conclusions

A great deal was learned from studying bits and how to test and analyze them. Much of that learning will manifest itself as suggestions for future work, which will be detailed in section 7.2. Conclusions are as follows.

7.1.1 Test Rig

Any test machine or test process must go beyond the task of simply using a bit to drive screws into wood, drywall or steel. To truly and accurately test bits a test method must accurately emulate users. This thesis concludes that emulating a user includes three key areas. The rig must have the ability to drive a screw with the driver at an offset angle relative to the screw. It must drive the screws with a varying force within each drive cycle. And it must use the same type of drivers as the users.

7.1.2 Analysis of Worn Bits

It is clear from the work outlined in Chapter 4 that visible wear on the bit does occur. It is also clear that observing the bit in two-dimensional planes advances the understanding of how the geometry is changing. Observing the bit in sections not only revealed the rounding of the bit, but also allowed the geometric change to be defined in terms of lengths and radii.

From the visible changes in the geometry an understanding of the changing dimensions was gained. The changes of those dimensions consequently cause the bit to become less effective because of less efficient force transfer. It appears that the inner and outer radii defined in chapter 4 were not significantly effected over the life of the bit. Figures 4.13 and 4.14 do indicate that the radii of both the flute and the wing tips will increase due to wear.

7.1.3 Laws Governing Surface Contact

As a result of studying the changes of bits during their working life as well as working with designers in the bit industry, it is apparent the potential gains that can be made by simply having a better understanding of surface contact theory. Therefore, it is beneficial for the designers in industry to deepen their knowledge of surface contact laws.

7.2 Future Work

As opposed to using humans as test subjects to wear the bits, as done in the limited sample of bits studied in this work, in the future the rig will allow the bits to be worn through identical test cycles. This will allow the comparison of bits to be more objective, because parameters such as angular offset and variation in axial force can be controlled. This enables their effect on wear to be better understood.

7.2.1 Improving Sectional Analysis

The sectioning work gave a great deal of insight on how to study and define the wear of the bits, however there is room for improvement. Sectioning gives insight to how a bit geometry changes due to wear, however before the process is repeated it should be considered that the process is a time consuming one which requires significant effort and resources. First and foremost, future sectioning work should establish statistical creditability of the findings. The bits used must be initially inspected to ensure that the compared bits are similar in hardness and geometry.

To improve the process, the bit should be encased in a mold material or fixed to a block that would serve as an absolute reference for the orientation of the bits. As the bits were sectioned and photographed for this work their orientation was maintained by numbering the wings of the bit. This was done so that each time the bit was removed and returned to be photographed, the bit was in the same orientation as the previous photograph. However, since the bits were not referenced to a true edge, the photos will vary by a few degrees. This variation prevents the existing photographs from being useful in a study of how the bit is torsionally deformed.

The sectioning process becomes more meaningful when less material is removed during each stage. Ten-one-thousandths-of-an-inch cuts were taken for most of this work. Taking smaller sections will obviously provide better resolution. Using an Electrical Discharge Machine process to section the bit by one or two-thousandths should be considered.

7.2.1.1 Alternate Analysis Methods

As noted in section 4.3, traditional coordinate measuring machines were considered to map the three-dimensional geometry of the bit. Traditional coordinate measuring machines are often used in industry for inspecting three-dimensional part geometry. With this technique, the three-dimensional profile of an object is obtained by probing the object at discrete points and translating the points into an analytical model of the work piece. To translate the measure data set into a model, best-fit algorithms are used. [Ni & Waeldele]. Best-fit algorithms interpret the data into a model, however current algorithms provide little insight when inspecting parts of complex geometries [Tucker, Claudet & Kurfess]. Because of the inaccuracies of inspection and the models created with best-fit algorithms, traditional coordinate measuring systems were not used. Laser digitization however is a technology that should be considered to map the bit geometry in the future.

Laser digitization is a non-contact measurement method that uses optical triangulation to generate two-dimensional profiles and three-dimensional characterizations. Laser digitization can measure thousands of points per second, allowing enough measurement points to be taken to severally reduces the inaccuracies associated with using best-fit algorithms for complex geometries. An ideal laser digitization system for the bit application would have a stationary optical measurement laser and would actuate the bit. Since the bit is symmetrical about its long axis, it should be mounted with that axis in the vertical direction. When actuated it would be in a rotational manner around, and a plunge up and down along, its long axis. This manner of actuation would result in a characterization of the bit based on cylindrical coordinates. Using the digitization setup described should result in accuracy in the one to five ten-thousandths range. A collection of contact information for laser digitization vendors can be found in Appendix C.

7.2.2 Contact Stresses

Normal, sliding and thermal contact stresses and there contribution to wear should be studied. Studying and applying Hertz's equations as well as Blok's flash temperature formulas may give insight to which contact stresses are significantly contributing to bit wear. Once this is determined, the metallurgical bit design can be focus on combating either the normal, sliding and/or thermal wear.

7.2.3 Areas to Pursue

In the area of bit design there are several tasks that could be pursued. Initially the findings made in this thesis should be expanded upon. An in-depth study should continue to look into how the flute and wing tips round and what effect this has on the bit's performance. Using a technique known as bluing could be used to further study how the bit's contact point is changing over the life. Bluing consists of coating the bit with a colored film. When the bit and screw are in contact, the film is removed exposing the bit contact surface. The exposed bit surface indicates the section of the bit at which the contact occurred. This process repeated over the life of the bit may assist in tying together how the contact changes in correlation with rounding of the bit's geometry.

One additional area to consider when re-examining the geometric changes of the sectioned planes due to wear would be a change in the area of the section. The decrease in the area of a section may better indicate the loss in performance of the bit.

Finally I would suggest that all bits could be redesigned to optimize their performance in both the areas of mating ease and torque transfer. For example an improved hex head bit design, which is one of the few current bits that does not produce cam-out, could keep the efficient torque transfer properties it currently has while adding a tapered geometry at the bottom to improve insertion.