Measuring the Surface Area of Fasteners

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New product provides a easy way for companies to identify the surface area of threaded and nonthreaded fasteners, especially as changes in wood preservative treatments act to accelerate metal fastener corrosion in wood.

Accurate identification of the surface area of threaded fasteners is essential for understanding the behavior of fasteners in numerous applications. For example, the surface area of a threaded fastener is needed to properly calculate its corrosion rate. Following the voluntary withdrawal of CCA (chromated copper arsenate) from residential use, alkaline wood preservatives such as ACQ (alkaline copper quarternary) and CuAz (alkaline copper azole) are being increasingly used.

These new alkaline-based preservatives are more corrosive than CCA, but little is known about their corrosion rates on threaded fasteners in contact with the treated wood. This is in part due to the fact that up until now no general analytical expression of the surface area of threaded fasteners existed so previous corrosion rate calculations were imprecise.

With increasing environmental regulations, it is likely wood preservatives will be modified on a more frequent basis, requiring a revaluation of the corrosion potential of all fasteners in these new treatments. Currently, the corrosion of fasteners in preservative-treated wood requires a time-consuming evaluation process that only results in relative comparison of metals and metallic coatings. For fastener manufacturers that are developing new coating systems, this can be costly and time consuming. Electrochemical techniques offer a screening method that has the advantage that it is both rapid and quantitative. Recent work at the **US Forest Service Forest Products Laboratory** has shown that these techniques can be extended to polymer-coated fasteners **(Figure 1).**

A critical parameter is the determination of the fastener surface area. Until lately, the use of electrochemical test methods has been limited to simple geometries for surface area determination. Researchers at the **USDA Forest Service** understood this and developed a method to evaluate the surface area of threaded fasteners for the corrosion performance, but would like to make it available for inclusion in the fastener industry's product development and inspection control.

Fig. 1 — l-r: Electrochemical test cell, polymer-coated fastener after exposure to wood extracts and electroplated fastener after exposure in solid wood.

Optical Technology for Determining a Fastener's Surface Area

Our product uses an optical method and apparatus that determines the surface area of a threaded fastener from high-contrast digital images **(Figure 2).**

Generally, this optical method and apparatus works by acquiring a digital image of the fastener, separating the image of the fastener into regions and then determining the corresponding surface area for each region using the analytical expression developed by the researchers **(Figure 3).** The surface area of the three regions are then summed in order to determine the surface area of the fastener. This method is versatile enough to also determine the surface area of non-threaded fasteners.

For threaded fasteners, the key characteristics that are needed to determine the surface area from the acquired images include the root diameter, the thread crest diameter, the thread length, the thread width at the root diameter and the thread transitions (i.e., location between fastener tip and constant shank region). **Figure 4** highlights these key fastener characteristics.

In short, the general approach is to acquire a high-contrast image, break the complicated fastener geometry into smaller

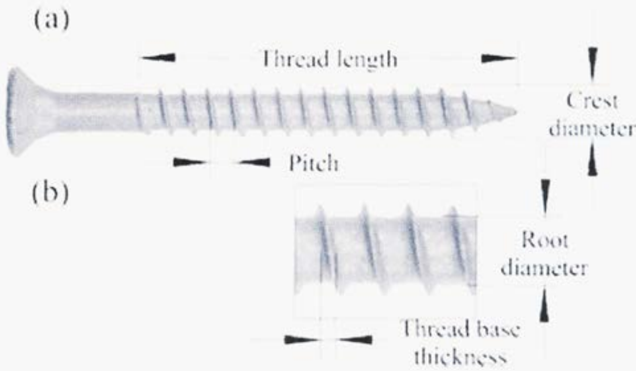

Fig. 2 — High-contrast image with key fastener characteristic identified.

Fig. 3 — Fastener sub regions.

defined segments with known analytical solutions, calculate the surface area of each individual segment and add the individual segments to determine the total surface area of the threaded fastener. This method has been successfully used to determine the surface area of threaded fasteners used in recent experiments to determine the corrosion rates of fasteners in different preservative environments.

In order to demonstrate the efficacy of the surface area algorithms, the surface area of a No. 10 (2.54 cm) wood screw was calculated. The parameters of the No. 10 wood screw are specified by *ASME.8* and these parameters were used to generate a geometric model to test the algorithm (as seen in **Figure 5).**

The mathematical and actual image seen in **Figure 5** are remarkably similar and lend validation to the developed expression.

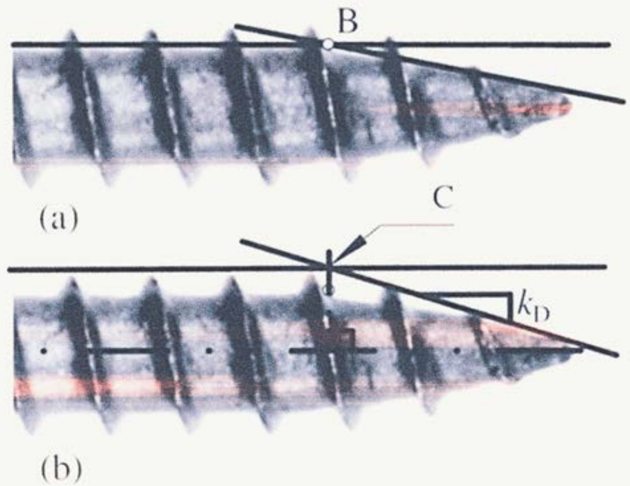

Fig. 4 — Determination of key parameters using machine vision.

Applications

This research development makes it possible to calculate the surface area of a threaded fastener, which has significant benefits for numerous applications and industries including the following:

Alternative Wood Preservative Treatments and Fastener Corrosion Rates. This product will allow for more accurate determination of corrosion rates for threaded fasteners that are in contact with treated wood. Corrosion of threaded fasteners can lead to rust and instability in the structures where alternative wood preservatives like **ACQ** are used. Thus, this product helps provide more accurate predictions for the replacement rate of fasteners currently in use.

Metal Plating of Fasteners. This product will help metal plating companies determine the surface area of a threaded fastener prior to plating. This will allow for a more accurate determination of the applied coating thickness.

General Fastener Manufacturing. The algorithm presented can also be easily incorporated into existing manufacturing equipment. This will give manufacturers and testing laboratories greater manufacture control by allowing products to be tested and changed so that problems could be solved prior to production. It will also help reduce costs and improve product quality.

Conclusion

This new product provides an easy way for companies to identify the surface area of threaded and nonthreaded fasteners. The product provides a necessary and useful tool for manufacturers and testing laboratories, especially as changes in wood preservative treatments act to accelerate metal fastener corrosion in this wood.

The inventors are looking for collaborators to further develop and commercialize the technology, which has been published as a patent application (see *U.S. Patent Publication* No. US-2008-0126008).

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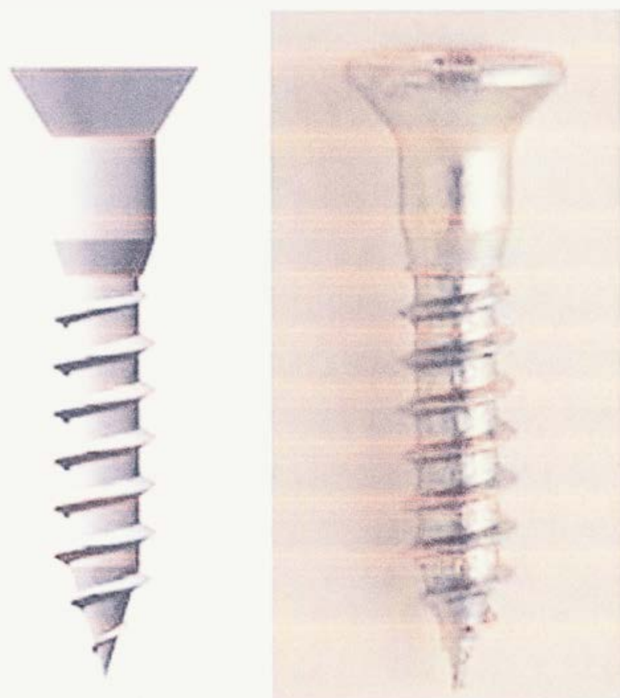
Fig. 5 — Mathematical image of actual No. 10 wood screw.

Company Profile:

*The **Forest Products Laboratory (FPL),** located in Madison, WI, USA, promotes healthy forests and forest-based economies through the efficient, sustainable use of wood. Since 1910, researchers have used science and technology to conserve and extend our Nation's wood resources. Current research emphasis areas at FPL include biorefining and bioenergy, nanotechnology, advanced structures, advanced composites and underutilized woody biomass. As the national research laboratory of the USDA Forest Service, FPL researchers often work in partnership with academia, industry, tribal, state, local and other government agencies.*

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