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In this installment the author discusses tests devised for evaluating hardness, how hardness is actually defined, and the evolution of testing methods over time.

Hardness is not a single, clearly defined, physically changeable value, but a complex combination of diverse concepts. In gears we need to know surface hardness, hardness depth, hardness at depth, and case depth. What is hardness? The relative abilities: 1) of different substances to penetrate one another; 2) of materials to take and keep a cutting edge, and; 3) to resist abrasion and wear. Some surface may fill one or even two of the requirements, but not three. Eric Oberg in his 1914 book "Heat Treatment of Steel" defined hardness as the property resisting penetration. According to the stress that the metal is subjected to the hardness could be tensile, cutting, abrasion, and elastic. Dana defined mineralogical hardness as "The resistance offered by a smooth surface to abrasion." Hardness means little unless it is allied with a testing method and scale.

From the beginning of the production of hardened steel, testing was nothing more than scraping with a flint, a piece of steel, or even a diamond. Machinery in 1915 would report "All steels are tested by file… the file test by an expert is very reliable and some feel more confidence... than on any testing instrument." Oberg states that "the test by filing is not to be despised as it is easily applied. But the file is an instrument inadequate to the requirements of the modern metallurgist... for two reasons: First, the alloy steels seem to possess the property of being able to resist a file, a piece of manganese self-hardening tool steel may in reality be softer than a specimen of pure carbon steel, yet resist the attacks of the file equally well... the hard manganese resist the file while the iron substratum remains soft." The second objection was that the file offered no reliable

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means of comparison. The AGMA today still proposes the file method using blocks of known hardness for comparison being particularly useful for on-site inspection.

The first hardness scale was developed by the German mineralogist Friedrich Mohs in 1820. Based on a sequence of 10 clearly defined substances arranged in their ability to indent or scratch those lower down on the list. They ranged from diamond to talcum. Hardened tool steel ranged between 7 and 8. It was imprecise and not a quantitative measurement, but it is still used as a comparative method today. In 1865 Tschernoff's work on the heat treatment of steel used a file for hardness comparison. In a report by Martel in 1893 to the French Commission of Material Testing, the first useful procedure for the dynamic testing of hardness was provided. Four years later Foeppl advancing Réaumur's work by measuring the contact area of two semi-cylindrical bars when pressed together and dividing this area into the load to evaluate their hardness. In 1908 Brown and Sharpe adopted the new Shore method for quality automotive gears. Packard used Shore's scleroscope to study past gear performance to devise a hardness specification. Their forging and gear suppliers Wyman and Gordon, B&S, and Gleason were obliged to use Shore's method. The scale used was almost identical to the previously used sclerometer.

The popular Brinell system was named for the Swedish engineer Dr. J.A. Brinell, for which he received the Grand Prize at the 1900 Paris Exposition. Originally the steel ball was 10 m.m. (0,394") and the pressure 3,000 kg (6,614 lbs). In the U.S. in 1910 a 0.875 "ball was used with a pressure of 10,000 lbs. When a steel sphere of D m.m. is pressed into the surface by a force F at a depth H, then the Brinell number is F/D-H times the reciprocal of pi 0.3183. Small portable instruments were almost instantly available.

While working in a ball bearing factory, Stanley P. Rockwell invented the Rockwell hardness test in 1916, which was further improved by Charles H. Wilson in 1919. The scale indicated the penetration depth of a hard steel or diamond cone. The American Society of Heat Treating published Rockwell's "Testing of Materials for Hardness" in August 1922. In the U.K. Smith and Sandland developed a new indentation test in 1925.

The "Vickers" tested materials too hard (48 HRC) for a Brinell test. By using a diamond indenter any material could be tested and placed on one continuous scale. The method was introduced into the U.S. in 1927. Also in England, Edward G. Herbert of the company by that same name introduced the "Cloudburst" method in 1929 that bombarded the metal piece with hardened steel balls at a controlled velocity and height. Other methods such as the pendulum, Knoop, and Meyer are also used.

ABOUT THE AUTHOR:

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