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Short communication

Evaluation of ASTM G65 abrasive —Spanning 13 years of sand

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ABSTRACT

Standardized testing requires consistency of all testing parameters including consumables. One of the more common American Society for Testing and Materials (ASTM) tests to evaluate abrasive wear resistance is the ASTM G65-04 Standard Test Method for Measuring Abrasion Using the Dry Sand/Rubber Wheel Apparatus. The specified abrasive is nominally 100% silica (SiO_2), sieved to 50/70 mesh. To quantify the consistency of the commercially available silica abrasive used in the ASTM G65-04, five lots of the abrasive were compared using five material characterization tests. The five lots of the abrasive, purchased from U.S. Silica Co., were manufactured in March 1997, July 2007, August 2008, June 2009 and October 2009. The five tests used to compare the different lots of abrasive were the ASTM G65-04 wear test, Uncompacted Void Content (ASTM C1252), chemical composition, size (sieved size distribution) and particle shape (visual).

It was found that there was only one instance of significant difference in the characterization tests among the five lots of abrasive. One lot had a significantly different amount of void content among the individual particles but demonstrated similar results to the other lots in wear rate, chemical composition, size distribution and particle shape.

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1. Introduction

The consistency of standardized wear testing consumables, besides being of paramount importance, usually initiates lively discussions among tribologists. By definition consumables for standardized test procedures should not vary. However, given a multitude of uncontrollable conditions, perfect consistency is not possible. First there is the geological nature, which is anything but consistent – from the provenance of the geological deposit to currently active natural forces (wind, temperature, water infiltration). Likewise, the second input into a consumable is the processing by man-made systems, which is fraught with human foibles. Economic demands, changes in processing technologies, organizational changes and even human lifespan can drastically alter the final "unchanging" product. Given the various forces attempting to alter consumables, it is appropriate to be concerned about how these consumables can affect future data intended to be compared with past data using the same testing standard. This research focused on silica, a naturally occurring mineral that is quarried and then processed to ASTM standard requirements.

The ASTM G65-04 wear resistance test is one of the more common low-stress abrasion standardized tests [1]. The consumable list consists of the rubber wheel and silica sand. The wheel has chemical composition and hardness requirements (chlorobutyl with a specific composition and pressure cure, Durometer Shore A 60) and the abrasive is AFS 50/70 silica (rounded quartz grain, not to exceed 0.5 wt% moisture). Although silica sand can be crushed and sized to a consistent dimension, the original deposit or deposits need to be large enough and accessible for many years in order to supply an unpredictable demand. In addition, consistent processing (crushing, conveying, transporting, sizing, cleaning) will be necessary to produce a consistent product in terms of size, angularity and sharpness. Other than "rounded" there are no requirements or specifications in the G65 standard on angularity, sharpness or aspect ratio.

There have been several methods developed to characterize the geometric aspects of particles. Particle attributes that have been measured include edge detail, surface texture, size, thickness, color, aspect ratio and roundness [2]. Some use computerized Fast Fourier Transform techniques on photographs of particles [3]. The particle shape evaluation method chosen for this work, the Uncompacted Void Content test (ASTM C1252) [4], is an established, simple and affordable method of particle shape characterization. In addition to the particulate geometry characterized by Uncompacted Void Content (ASTM C1252), the silica was analyzed using four other methods including the ASTM G65-04 wear resistance test, chemical composition analysis by X-ray fluorescence, particle size distribu-

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Table 1
Sand lot identification numbers and corresponding manufacturing dates.

Sand lot no.	Lot date
1	March 03, 1997
2	July 02, 2007
3	August 19, 2008
4	June 10, 2009
5	October 07, 2009

tion analysis by sieve and particle shape analysis by SEM (scanning electron microscopy).

2. Experimental

2.1. Materials

The test abrasive was obtained from U.S. Silica Co. in Ottawa Illinois over the course of thirteen years (1997, 2007, 2008 and 2009 – Table 1). It was received in 23 kg (50 pound) bags that were unopened prior to testing for this project. Samples for the Uncompacted Void Content and chemical composition tests were taken from the top of the freshly opened bags. Further samples were taken from each lot for particle size analysis, particle shape analysis and wear resistance testing. The sand was tested in the as received condition. No additional tests were conducted on sand that had been used for the ASTM G65 wear resistance tests.

2.2. ASTM G65 Dry Sand/Rubber Wheel wear resistance test

The ASTM G65 standard established the laboratory method of determining the relative abrasion resistance of various materials. The test involves abrading a rectangular sample (25 mm × 76 mm with thickness between 3.2 mm and 12.7 mm) with standardized silica sand abrasive (AFS 50/70). The sand is introduced between a vertically oriented rubber wheel rotating at a specific speed (200 rpm) and the specimen, which is held against the wheel at a specified normal load. The rotating rubber wheel pulls the sand into the contact area, abrading the surface of the specimen. Wear rates are reported as volume loss, e.g. cubic millimeters. In this study the controlled variables for ASTM G65-04 Procedure A were: AISI 1090 steel standard wear specimen, 30 pound load, 200 rpm, rubber wheel, sand flow and 6000 revolutions. The test machine was manufactured by Dieter Detroit. A schematic of the testing equipment is shown below (Fig. 1).

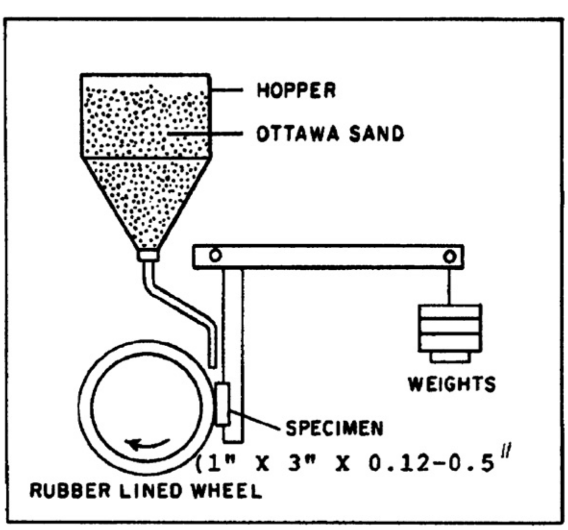

Fig. 1. Schematic of ASTM G65 test equipment [1].

Four AISI 1090 steel specimens were prepared according to the G65 specification. Specifically, two 75 mm long pieces were band-sawed from a 25 mm × 25 mm bar of 1090 steel. The two pieces were heated at 900 °C in air for 30 min, removed from the furnace, placed on a refractory brick and air-cooled. Each piece was cut lengthwise producing four 75 mm × 25 mm × 12 mm wear test specimens. The specimens were milled flat and parallel and then surface ground before testing. At least 1.5 mm was removed from the surfaces exposed to the air in the furnace to remove decarburized layers. A minimum of six Rockwell C scale hardness tests (HRc) were conducted on the surfaces prior to wear testing to verify compliance to the 24–26 HRc G65 specification, resulting in a 24.5 HRc average. The four blocks were used multiple times. Between uses, the wear scar was removed by surface grinding under coolant. Hardness was measured after grinding and confirmed that no change occurred due to grinding. Before wear testing, specimens were cleaned in acetone in an ultrasonic bath for 3 min and then forced-air dried.

2.3. Standard Test Methods for Uncompacted Void Content of fine aggregate as influenced by particle shape, surface texture and grading (ASTM C1252 – Method A)

According to ASTM C1252, the Uncompacted Void Content standard "provides an indication of (an) aggregate's angularity, sphericity and surface texture compared with other fine aggregates tested in the same grading." It is a particle shape test that provides relative information of similarly sized abrasives and an ideal method for the quantifying geometric aspect (size, angularity, aspect ratio) differences for multiple and identical lots of particles, in this case AFS 50/70 silica.

The C1252 equipment was fabricated according to the ASTM standard, which consists of a standardized funnel attached to a reservoir, a calibrated cylinder and a stand to hold and align the funnel and cylinder. A measured amount of aggregate (190 g) is metered through the funnel into the cylinder located 115 mm below (Fig. 2). The aggregate fills the cylinder and excess spills to the sides. The aggregate in the cylinder is struck level with a spatula and then weighed. The specification requires mass measurements

Fig. 2. Uncompacted aggregate void measurement equipment.

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