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Solid biofuels — Determination of grindability — Hardgrove type method for thermally treated biomass fuels

Biocombustibles solides — Détermination de la broyabilité — Méthode de type Hardgrove pour les combustibles de biomasses traitées thermiquement

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Foreword

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This document was prepared by Technical Committee ISO/TC 238, *Solid biofuels*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 335, *Solid biofuels*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Grindability characteristics are of fundamental importance during solid biofuel preparation for energy conversion processes, requiring a predictable particle size distribution. Particles that are too large or too wide in their distribution may result in feeding problems as well as un-burnt fuel passing through the conversion process. Also, in case of processing of biomass for pre-treatment, consistency in particle size determines the yield of such pre-treatment as well as the quality of the final solid biofuel.

The effectiveness of combustion in a pulverized fuel furnace depends strongly on the reactivity and particle size distribution of the pulverized fuel among other factors. For coal, the Hardgrove Grindability Index (HGI) test was developed to characterize the relative grindability of a particular quality of coal relative to a pre-determined standard quality of coal (ASTM D409). The HGI test is an empirical batch method that simulates the continuous grinding and crushing operation of a ball, table or tube type of industrial coal pulverizer, herein also called coal mill. The HGI value is an indication of the degree of grinding required to reach a particular particle size necessary for effective combustion.

Manufacturers of coal pulverizers for preparation of pulverized coal for combustion in coal burning plants provide curves that show the relationships between the HGI for coal, coal mill capacity in terms of tonne/h and coal mill power in kW. This is done as part of the boiler contract and guarantees. It also serves as a first indication as to how to operate a mill when pulverizing different coals with predetermined standard properties. A HGI of 50, which is standard industry convention, implies that 100 % capacity in tonnes per hour (as indicated) can be reached for the coal at a fineness of 70 % less than 75 microns and 99,5 % less than 300 microns. If a coal has a HGI of less than 50 it implies some level of pulverizer capacity loss while on the other hand, a HGI higher than 50 indicates some level of pulverizer capacity gain. The HGI method is internationally accepted and quoted as part of the specification of coal for international trade.

Grindability may also be applied to thermally pre-treated compressed biomass materials, such as pellets, for pulverization in coal mills. Pre-treatment methods for biomass fuels such as torrefaction, steam treatment or hydro-thermal carbonization (HTC) upgrade the properties of biomass making it more effective as a fuel. With increasing interest in the use of such pre-treated biomass fuels for direct co-firing applications in conventional pulverized coal boilers, this method herein describes a laboratory procedure for determination of the grindability of pre-treated biofuels for powder fuel preparation.

The HGI determination is subject to many limitations, including the fact that measurements can be insensitive to the heterogeneous properties of coal that arise from different mineral contents, maceral constituents and levels of maturity. Three relevant adaptations are applied to the standard HGI method in order to extend its applicability to thermally pre-treated biomass fuels. The adaptations and their justification are as follows:

— Amount of sample used for the test determination.

— Particle size used as basis for defining grindability.

— Reference materials for establishing the calibration curve.

0.1 Amount of the sample used for test determination

Coal pulverizers are volumetric devices but with the densities of coals being fairly similar, the capacity of these devices is expressed in mass units per hour. In contrast different biomass materials have different densities. Therefore, the sample amount was changed to the volume (75 ± 0,5) cm^3 of input material, which approximates the bulk volume of the standard reference coal samples with a particle size between 1,18 mm and 600 µm.

0.2 Particle size used as basis for defining grindability

The standard HGI test for coal uses the mass of particles passing a sieve with an aperture size of 75 µm as criteria for determining the grindability and the resulting HGI value. The furnace volume is designed from the knowledge of coals to be utilized so as to provide an adequate residence time for complete combustion. Combustion efficiency depends in part on fuel particle size especially for pulverized coal

furnaces. As the combustion efficiency also depends on the reactivity, which is linked to volatile matter content of fuels, the particle size for high-volatile fuels, such as thermally treated biomass, would not necessarily need to meet the strict fineness requirements for coal powders. Therefore, a sieve with an aperture size of 500 µm is used for determination of grindability of thermally treated biomass. This adaptation also has positive implications on the repeatability of the determination.

0.3 Reference materials for establishing the calibration curve

In the standard HGI test for coal, four references coals are needed for calibrating a HGI mill. This enables reproducibility of the results across different labs. For the thermally treated biomass grindability index determination, this is the very first step. The thermally treated biomass grindability index is an index for materials originating from biomass. The sieving behavior of biomass materials differs fundamentally from that of coals due to the difference in the sphericity of the coal particles. Biomass materials, including thermally treated biomass, are more fibrous and have lengthy dust particles compared to coals. Thermal treatment processes, such as torrefaction, modifies the property of biomass by making biomass more like charcoal. Woody charcoal is a product of slow pyrolysis, which degrades the fibrous nature of the biomass. This consequently improves its grindability as well as the sphericity of the pulverized fuel.

The adapted grindability method uses wood pellets (ISO 17225-2:2021 A1 class pellets) and wood based charcoal (ISO 17225-1:2021, Table 14) as calibration reference materials. These biomass reference materials will be given assigned Thermally Treated Biomass Grindability Index (TTBGI) values as a result of the procedures described in Annex A. The materials are available commercially for the determination.

Solid biofuels — Determination of grindability — Hardgrove type method for thermally treated biomass fuels

1 Scope

This document describes a method for determination of grindability of graded thermally treated and densified biomass fuels such as classified in ISO/TS 17225-8, for the purpose of preparing fuels with a defined particle size distribution for effective combustion in pulverized fuel boilers. The grindability characteristics determined by the test method provide guidance as to the pulverizing mill performance when utilizing such fuels.

Apart from pelletized materials as described in ISO/TS 17225-8, the method can also be applied to non-compressed or non-densified thermally treated biomass as specified in ISO 17225-1:2021, Table 14 and Table 15.

The results created with this method are not relevant for large wood chips, since limitations apply for large pulverizing coal mills, which are typically not used for grinding materials such as chips.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3310-1, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*

ISO 14780, *Solid biofuels — Sample preparation*

ISO 16559, *Solid biofuels – Terminology, definitions and descriptions*

ISO 17827-2, *Solid biofuels — Determination of particle size distribution for uncompressed fuels — Part 2: Vibrating screen method using sieves with aperture of 3,15 mm and below*

ISO 18134-1, *Solid biofuels — Determination of moisture content — Oven dry method — Part 1: Total moisture — Reference method*

ISO 18134-2, *Solid biofuels — Determination of moisture content — Oven dry method — Part 2: Total moisture — Simplified method*

ISO 18135, *Solid Biofuels — Sampling*

ISO 21945, *Solid biofuels — Simplified sampling method for small scale applications*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16559 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/