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Additive manufacturing — Qualification principles — Test methods for metal casting sand moulds

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Foreword

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Introduction

Additive manufacturing (AM) technology, which enables a part with a complex shape to be made without a master mould, has been applied to fabricate advanced sand moulds for metal casting. AM-made sand moulds have advantages in that it is possible to make cast parts not only with more precise dimensions, but also with thinner and complex shapes; therefore, application fields in the foundry industry are expanding.

The difference between sand moulds and general mechanical/structural parts is that sand moulds are never used as final products. In other words, a sand mould is crushed after each casting process when its role ends. Therefore, sand moulds do not require long-term-stable properties, but specific properties for the casting process, such as having stiffness with a good balance between sufficient mechanical strength and crushability, as well as gas permeability and physical thermal properties for a hot environment. The test methods and dimensions of specimens are standardized in existing documents for conventionally made sand moulds, and they are applicable to AM-made sand moulds. However, these standards do not cover all aspects of sand moulds made by AM, where uneven properties due to location in a build space and variations in process conditions between build cycles, as well as anisotropy due to a layer-by-layer process also can have a significant effect of the properties of the sand mould.

This document provides practices for sampling specimens of AM-made sand moulds, for application in parallel with existing test methods for the mechanical and physical properties of a metal casting sand mould made in a conventional way. In this document existing standards for testing tensile strength, transverse strength, gas permeability and thermal expansion are cited in terms of applicability to test pieces extracted from sand moulds made with AM. In addition, examples of test reports for two typical applications, where this document can be applied, are presented. One is for purchasing AM-made sand moulds and the other is for verifying the performance of an AM machine for sand moulds.

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Additive manufacturing — Qualification principles — Test methods for metal casting sand moulds

1 Scope

This document specifies test methods for metal casting sand moulds produced using additive manufacturing technologies, with mechanical and physical properties including, but not limited to, tensile strength, transverse strength, gas permeability and thermal expansion.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their contents constitute 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 17295, *Additive manufacturing — General principles — Part positioning, coordinates and orientation*

ISO/ASTM 52900, *Additive manufacturing — General principles — Fundamentals and vocabulary*

ISO/ASTM 52901, *Additive manufacturing — General principles — Requirements for purchased AM parts*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/ASTM 52900 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/

4 Standard practice for sampling specimens of AM-made sand moulds

4.1 Factors causing uneven properties in an AM-made sand mould

An AM machine for sand mould controls joining/curing position and process, based on 3D model data and process parameters to build qualified sand mould parts stably. However, due to machine positioning error, joining condition errors, e.g. laser power or binder volume fluctuations, and variations in the environment, e.g. temperature and humidity, the parts built can have dimensional errors, and properties change depending on location in the build space during the build cycle. Moreover, even when the same 3D model data, feedstock and process parameters are applied, the parts built can have different properties in different build cycles and manufacturing lots, during production over a long period. A conventionally made sand mould is usually made using binder-premixed sand with an embedded master mould made of a material such as wood, resin, or metal; then, the entire sand mould is cured uniformly. In contrast, sand moulds made by AM are formed by incrementally joining or curing the sand particles, mostly commonly using a BJT or a PBF process, and this can cause non-conformities at different locations in a build space and anisotropy due to a layer-by-layer joining/curing process.

Hence, major factors requiring attention when monitoring production quality control for AM-made sand mould are:

— location in a build space;

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