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Industrial furnaces and associated processing equipment — Method of measuring energy balance and calculating energy efficiency —

Part 11: Evaluation of various kinds of efficiency

Fours industriels et équipements associés — Méthode de mesure du bilan énergétique et de calcul de l'efficacité —

Partie 11: Évaluation de différents types d'efficacité

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Contents

Page

Foreword ..... **v**

Introduction ..... **vi**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Symbols **4**

5 Boundary and energy (enthalpy) **7**
5.1 Configuration of the area of evaluation 7
5.2 Classification of boundary 7
5.3 Classification of energy (enthalpy) 8
5.4 Calculation of energy (enthalpy) 11
5.4.1 Energy input to the heating chamber (E_{h}) 11
5.4.2 Energy required for process (E_{pr}) 12
5.4.3 Sensible heat of exhaust gas at the outlet of combustion chamber 12
5.4.4 Sensible heat of exhaust gas at the outlet of heat recovery equipment 13
5.4.5 Sensible heat of exhaust gas at the inlet of heat recovery equipment 13
5.4.6 Recovery heat ($E_{h,re}$) 13
5.4.7 Thermal energy loss (E_{l}) 14
5.4.8 Electrical energy loss in electroheating ($E_{l,eh}$) 15
5.4.9 Energy consumed in auxiliary equipment (E_{aux}) 15
5.4.10 Energy consumed in generation of utilities ($E_{u,gen}$) 16
5.4.11 Electrical generation loss ($E_{l,eg}$) 16
5.4.12 Fuel equivalent energy of electricity ($E_{fe,el}$) 16
5.4.13 Recycled energy (E_{rcy}) 16

6 Efficiency based on enthalpy **16**
6.1 General formula 16
6.2 Examples of typical efficiencies 16
6.2.1 General 16
6.2.2 Overall efficiency in accordance with ISO 13579-1 17
6.2.3 Heat efficiency on the whole calorific value basis 17
6.2.4 Heat efficiency on the supplied calorific value basis 17
6.2.5 Available heat ratio 17
6.2.6 Combustion efficiency 17
6.2.7 Effective waste heat recovery ratio in combustion furnace 18
6.2.8 Waste heat recovery ratio as performance indicator of heat recovery equipment 18
6.2.9 Ratio of waste heat of combustion exhaust gas to calorific value of fuel 18
6.2.10 Converted available heat ratio where waste heat recovery is not considered 18

7 Efficiency based on exergy **18**
7.1 General 18
7.2 Boundary 18
7.3 Classification of exergy 18
7.4 Calculation of exergy 19
7.4.1 Exergy input from electrical source ($EX_{h,el}$) 19
7.4.2 Exergy of fuel ($EX_{h,fuel}$) 20
7.4.3 Exergy of exothermic reaction ($EX_{react,exo}$) 20
7.4.4 Exergy of sensible heat of fluid at the inlet ($EX_{s,fluid}$) 20
7.4.5 Exergy in energy required for drying and evaporation ($EX_{pr,ev}$) 21
7.4.6 Exergy required for endothermic reaction for heated material ($EX_{pr,re}$) 21
7.4.7 Exergy in given enthalpy to product ($EX_{pr,en}$) 21
7.4.8 Exergy of exhaust gas ($EX_{ex,oc}$, $EX_{ex,or}$, $EX_{ex,ir}$) 21
7.4.9 Recovery exergy ($EX_{h,re}$) 22

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7.4.10 Exergy in required for heating jigs and other substance ($EX_{l,j}$) 22
7.4.11 Exergy in heat loss from furnace structure ($EX_{l,fs}$) 22
7.4.12 Exergy in energy required for heat storage of furnace structure ($EX_{l,hs}$) 22
7.4.13 Exergy in given enthalpy to atmosphere gas ($EX_{l,atm}$) 22
7.4.14 Exergy consumed in electroheating ($EX_{l,eh}$) 22
7.4.15 Exergy consumed in auxiliary equipment (EX_{aux}) 23
7.4.16 Exergy consumed in generation of utilities ($EX_{u,gen}$) 23
7.4.17 Exergy of recycled energy (EX_{rcy}) 23
7.5 Efficiency 23
7.5.1 General formula 23
7.5.2 Examples of typical efficiencies 23

8 Designation 24
8.1 General 24
8.2 Individual item block 25
8.3 Type of operation 25
8.4 Energy source 25
8.5 Example 25

9 Measurement 26

10 Evaluation report 26

Annex A (informative) **Example of energy efficiency evaluation 27**

Annex B (informative) **Comparison of enthalpy efficiency and exergy efficiency of continuous reheating furnaces 37**

Annex C (informative) **Procedure for estimation of energy saving effect of combustion furnaces 46**

Bibliography 60

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 244, *Industrial furnaces and associated processing equipment*.

A list of all parts in the ISO 13579 series can be found on the ISO website.

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Introduction

The Kyoto Protocol of the UN Framework Convention on Climate Change defines a system for emission reduction called the Clean Development Mechanism (CDM). In order for the industrial furnace manufacturers industry to address global warming based on the Kyoto Protocol, it is necessary to have fair guidelines to make use of CDM.

ISO 13579-1 to ISO 13579-4 focus on evaluating the overall efficiency of industrial furnaces and associated processing equipment (TPE) system, including electrical energy consumption as fuel equivalent energy, to help the industry facilitate implementation of CDM.

However, these documents do not define and specify efficiencies of each specific component of TPE (e.g. heat recovery equipment, heating chambers, etc.), which are directly related to and available for energy-saving measures. With this in mind, this document has been developed to specify and provide the following information:

— definitions of the various kinds of efficiency of TPE using designation systems and by defining energy balance boundaries within the TPE based on its elements;

NOTE The definition for TPE efficiency varies according to region.

— evaluation formulae of energy reduction factors, which are available for actual energy conservation based on the energy balance measurements.

In addition to these evaluations in terms of enthalpy, this document also deals with energy efficiency based on exergy, i.e. efficiency based on availability of fuel energy, for the following reasons.

— The whole amount of "energy" in the "closed" terrestrial system is preserved due to the conservation law of energy while "exergy" inherently decreases. The term "energy" related to energy crisis or energy issue is "exergy". Therefore, it may be said that controlling the degrees of a decrease in exergy (or dissipation of available energy) is the essence of the energy crisis. As such, exergy is one of the indexes to evaluate the energy efficiency of TPE.

— It enables a fair comparison among heating furnaces with different heating conditions or heated materials as a result of a common thermodynamic viewpoint.

— Improvement in exergy efficiency leads to essential efficiency-enhancing measures in energy usage.

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Industrial furnaces and associated processing equipment — Method of measuring energy balance and calculating energy efficiency —

Part 11: Evaluation of various kinds of efficiency

1 Scope

This document specifies classifications and designations in the methodology of energy efficiency evaluation of industrial furnaces and associated processing equipment (TPE), including energy efficiency in terms of exergy as well as enthalpy.

This document does not apply to the following types of TPE:

— blast furnaces, basic oxygen furnaces, coke ovens;

— furnaces that generate gases to be used as fuel (including by-product gases);

— special atmosphere gas generators;

— industrial furnaces that are designed for chemical plants or petroleum plants;

— installations where heating or combustion is performed in an open space;

— installations that combust solid fuel;

— waste incinerators.

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 13574:2015, *Industrial furnaces and associated processing equipment — Vocabulary*

ISO 13579-1:2013, *Industrial furnaces and associated processing equipment — Method of measuring energy balance and calculating efficiency — Part 1: General methodology*

ISO 13579-2:2013, *Industrial furnaces and associated processing equipment — Method of measuring energy balance and calculating efficiency — Part 2: Reheating furnaces for steel*

ISO 13579-3:2013, *Industrial furnaces and associated processing equipment — Method of measuring energy balance and calculating efficiency — Part 3: Batch-type aluminium melting furnaces*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13574, ISO 13579-1 and the following apply.

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

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

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— IEC Electropedia: available at www.electropedia.org

3.1 General terms

3.1.1
boundary
enclosed section that is defined for an energy balance evaluation of object(s)

Note 1 to entry: The energy efficiency evaluations are possible once a boundary is set.

3.1.2
product
item processed in a TPE, including auxiliary material

EXAMPLE Auxiliary material loaded in scrap melting process in addition to the main material (i.e. scraps).

Note 1 to entry: Product does not include by-products formed in the thermo-processing, e.g. formation of oxidized substance such as iron-scale and aluminium oxide.

Note 2 to entry: Product does not include the accessories, e.g. jigs or fixtures that are heated simultaneously with product.

[SOURCE: ISO 13574:2015, 2.134, modified]

3.1.3
energy balance analysis
grouping of energy values into either input energy or output energy, by measuring and calculating provided energy, including by exothermic reaction and outflowing energy, which also includes by endothermic reaction to/from the boundary

Note 1 to entry: The total energy input and the total energy output inherently balance.

3.1.4
energy efficiency
efficiency defined as *specific energy output* (3.1.5) divided by *specific energy input* (3.1.6)

Note 1 to entry: Energy efficiencies are expressed in percentages. Specific energy output and specific energy input are defined in this document.

3.1.5
specific energy output
specific energy defined in this document as effective energy output from the boundary for calculation of an index of efficiency of TPE

EXAMPLE Enthalpy accumulated in product through a TPE process.

3.1.6
specific energy input
amount of supplied energy defined in this document as energy brought to the boundary for calculation of an index of efficiency

3.1.7
available heat
calorific value which is required in a heating chamber of a furnace under specified operating or equipment conditions

Note 1 to entry: Available heat is a form of specific energy output defined in 6.2.5.

Note 2 to entry: “Available energy” in exergy terms has a different concept.

Note 3 to entry: See A.2.5.

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3.1.8
available heat ratio
index of efficiency defined as *available heat* (3.1.7) divided by the calorific value of fuel

Note 1 to entry: This term is one of the significant indexes of a combustion furnace.

3.1.9
fuel equivalent energy of electricity
amount of primary energy which is equivalent to the calorific value of fuel input consumed in electrical generation

3.1.10
fuel equivalent energy conversion
conversion of electrical energy consumption to *fuel equivalent energy of electricity* (3.1.9)

Note 1 to entry: The factor for calculation, which is generally available, is not considered loss between the power receiving station to the TPE's power receiving terminal.

Note 2 to entry: The unit kJ/kWh is generally used.

Note 3 to entry: The value for fuel equivalent energy conversion varies depending on governments or regions.

Note 4 to entry: It should be indicated when the conversion is conducted.

3.1.11
energy performance indicator
amount of energy that is consumed per specific production unit of utilities or per specific output of auxiliary equipment

3.1.12
exergy
maximum work which can be extracted under the ambient temperature of a place, which is generally defined as

$$EX = \Delta H - T_0 \Delta S$$

where

EX is the exergy (maximum work);

ΔH is the change in enthalpy;

T_0 is the ambient temperature, in Kelvin;

ΔS is the change in entropy.

Note 1 to entry: There are chemical exergy, pressure exergy, mixing exergy and thermal exergy in a combustion system. But pressure exergy and mixing exergy are negligibly small.

3.1.13
exergy loss
difference between exergy that flows in to and flows out from the targeted *boundary* (3.1.1)

3.1.14
furnace structure
sum of furnace walls, cooling water equipment, furnace opening, etc.

3.2 Balance table

NOTE See Table A.3 and Table A.7 as examples.

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3.2.1
energy balance table
table on which breakdowns of energy input and energy output are listed

3.2.2
efficiency evaluation table
reorganized table from an *energy balance table* (3.2.1) to categorize energy groups such as *specific energy input* (3.1.6) or *specific energy output* (3.1.5) to calculate an efficiency index while maintaining the energy balance

4 Symbols

4.1 Symbols for energy/exergy

Symbol	Definition
E_{aux}	energy consumed in auxiliary equipment per tonne of product
$E_{available}$	available heat per tonne of product
$E_{available\ I}$	available heat of the baseline, in MJ/t
$E_{available\ II}$	available heat after energy saving measure, in MJ/t
E_{ex}	sensible heat of exhaust gas per tonne of product
$E_{ex,ir}$	sensible heat of exhaust gas from fuel at the inlet of heat recovery equipment per tonne of product
$E_{ex,oc}$	sensible heat of exhaust gas from fuel at the outlet of combustion chamber per tonne of product
$E_{ex,or}$	sensible heat of exhaust gas from fuel at the outlet of heat recovery equipment per tonne of product
$E_{exrm,ir}$	sensible heat of exhaust gas from raw materials at the inlet of heat recovery equipment per tonne of product
$E_{exrm,oc}$	sensible heat of exhaust gas from raw materials at the outlet of combustion chamber per tonne of product
$E_{exrm,or}$	sensible heat of exhaust gas from raw materials at the outlet of heat recovery equipment per tonne of product
$E_{fe,el}$	fuel equivalent energy of electricity per tonne of product
E_{h}	energy input to the heating chamber per tonne of product
$E_{h,el}$	heat energy by electroheating per tonne of product
$E_{h,fuel}$	calorific value of fuel per tonne of product
$E_{h,fuel\ I}$	energy consumption (calorific value of fuel) of the baseline, in MJ/t
$E_{h,fuel\ II}$	estimated energy consumption after energy saving measure, in MJ/t
$E_{h,re}$	recovery heat per tonne of product
$E_{h,reex}$	recovery heat from sensible heat of exhaust gas per tonne of product
$E_{h,repr}$	recovery heat from sensible heat of product per tonne of product
E_{l}	thermal energy loss per tonne of product
$E_{l,atm}$	energy loss by atmosphere gas per tonne of product
$E_{l,eg}$	electrical generation loss per tonne of product
$E_{l,eh}$	electrical energy loss in electroheating per tonne of product
$E_{l,exrm}$	energy loss by exhaust gas from raw material
$E_{l,fs}$	energy loss from furnace structure per tonne of product
$E_{l,j}$	energy required for heating jigs and other substance per tonne of product
$E_{l,hs}$	energy required for heat storage of furnace structure per tonne of product
$E_{l,other}$	other energy loss per tonne of product
$E_{l,uc}$	energy loss by uncombusted content per tonne of product
E_{p1}	enthalpy of product at the time of loading into the boundary per tonne

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