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**Machining process - Test methods for essential energy
efficiency data**

机械加工过程 能效基础数据检测方法

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Machining process - Test methods for essential energy efficiency data

1 Scope

This document specifies the test and calculation methods for essential energy efficiency data in the machining process.

This document applies to the test of essential energy efficiency data in the machining process of metal cutting machine tools during machining.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the version corresponding to that date is applicable to this document; for undated references, the latest version (including all amendments) is applicable to this document.

GB/T 4863, General terminology of machine-building technology

GB/T 6477, Metal-cutting machine tools - Terminology

3 Terms and definitions

Terms and definitions determined by GB/T 4863, GB/T 6477, and the following ones are applicable to this document.

3.1

machining process

The part or entire process for a machine tool to complete the machining of a workpiece.

3.2

standby

The state where the general power supply of the machine tool is turned on, and all other systems of the machine tool used to support machining, except the spindle and the feed system, are running.

3.3

idling

The state, in standby, where the spindle system or feed system of the machine tool is turned on, and the spindle system or feed system is in the state where there is no cutting load.

3.4

cutting

The running state where the machine tool is cutting and machining the workpiece.

3.5

standby power

The input power when the machine tool is in standby (3.2).

3.6

idling power

The input power when the machine tool is in idling (3.3).

3.7

cutting power

The input power when the machine tool is in cutting (3.4).

3.8

material removal power

The power increased for the machine tool to remove material.

3.9

energy consumption in standby period

The energy consumed by the machine tool in standby (3.2).

3.10

energy consumption in idling period

The energy consumed by the machine tool in idling (3.3).

3.11

energy consumption in cutting period

- 2) Idling power test: Turn on the machine tool spindle system or feed system, and record the tested power value; the stable operation time in idling stable is greater than 3/f, and the idling power is based on the partial power data after stable operation in the idling state or the average value of all power data; the idling power test should include all the idling states involved in the machining process.
- 3) Cutting power test: Record the input power value of the machine tool in the whole process from when the machine tool touches the workpiece to when the tool leaves the workpiece surface. The cutting power is based on the average value of the input power in the whole process. At the same time, the workpiece information, tool information and cutting parameters corresponding to the cutting process should be recorded.

5.2.2 Energy consumption test

Install an electric energy tester at the power input end of the machine tool. After the machine tool is turned on, record the energy consumption values corresponding to the start time and end time of each running state of the machine tool.

5.3 Calculation

5.3.1 Power data

The material removal power is calculated according to Formula (1).

$$P_{mr} = P_c - P_u \quad \dots\dots\dots (1)$$

Where:

P_{mr} – material removal power, in kilowatts (kW);

P_c – cutting power, in kilowatts (kW);

P_u – Idling power, in kilowatts (kW).

5.3.2 Energy consumption data

5.3.2.1 Energy consumption in standby period

Energy consumption in standby period includes the energy consumption of a single standby period and the total energy consumption in standby period. The energy consumption in a single standby period is the energy consumption value at the end of a single standby process minus the energy consumption value at the start, which is shown in Formula (2); the total energy consumption in standby period is the sum of the energy consumption of each single idling period, which is shown in Formula (3).

$$E_{st}^i = E_{st,end}^i - E_{st,start}^i \quad \dots\dots\dots (2)$$

$$E_{st} = \sum_{i=1}^{Q_{st}} E_{st}^i \quad \dots\dots\dots (3)$$

Where:

E_{st}^i – the energy consumption of a single standby period of the i^{th} standby process, in kilowatt-hours (kW·h);

$E_{st,end}^i$ – the energy consumption value at the end of the i^{th} standby process, in kilowatt-hours (kW·h);

$E_{st,start}^i$ – the energy consumption value at the start of the i^{th} standby process, in kilowatt-hours (kW·h);

E_{st} – the total energy consumption in standby period, in kilowatt-hours (kW·h);

Q_{st} – the total number of standby processes.

5.3.2.2 Energy consumption in idling period

Energy consumption in idling period includes the energy consumption of a single idling period and the total idling energy consumption. The energy consumption of a single idling period is the energy consumption value at the end of a single idling process minus the energy consumption value at the start, which is shown in Formula (4); the total energy consumption in idling period is the sum of the energy consumption of each single idling period, which is shown in Formula (5).

$$E_u^i = E_{u,end}^i - E_{u,start}^i \quad \dots\dots\dots (4)$$

$$E_u = \sum_{i=1}^{Q_u} E_u^i \quad \dots\dots\dots (5)$$

Where:

E_u^i – the energy consumption of a single idling period of the i^{th} idling process, in kilowatt-hours (kW·h);

$E_{u,end}^i$ – the energy consumption value at the end of the i^{th} idling process, in kilowatt-hours (kW·h);

$E_{u,start}^i$ – the energy consumption value at the start of the i^{th} idling process, in kilowatt-hours (kW·h);

E_u – the total energy consumption in idling period, in kilowatt-hours (kW·h);

Q_u – the number of idling processes.

c) Tool information

Tool material: hard alloy.

d) Processing sequence

The processing sequence is as follows:

- right end of the machine;
- cylindrical turning $\phi 47 \text{ mm} \times 110 \text{ mm}$;
- cylindrical turning $\phi 44 \text{ mm} \times 105 \text{ mm}$;
- cylindrical turning $\phi 41 \text{ mm} \times 100 \text{ mm}$;
- chamfer C1.

A.1.2 Test cycle

The test cycle is all the running processes of the CNC machine tool from startup to shut-down.

A.1.3 Test condition and instrument

A.1.3.1 The test environment is normal temperature and normal pressure.

A.1.3.2 The test instrument is a power analysis instrument that integrates the functions of a power meter, an electric energy tester and a stopwatch, and its accuracy level is 0.1.

A.1.3.3 Install the power analyzer according to the method in 5.2.1; the test frequency is 20 Hz.

A.1.4 Power test

A.1.4.1 Standby power test

The operation sequence of the machine tool is shown in Table A.1. The standby is the state after the cutting cooling system runs stably; the standby power is based on the average value of the power data measured when the cutting cooling system runs stably for 2 minutes. The measurement results are shown in Table A.1.

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