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Study on the clamping force measurement and partial load regulation technology of injection molding machine

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ABSTRACT

Tie bars are the most important parts of injection molding machine, and the partial load of tie bars will directly affect the product quality. According to the measurement of strain and stress of the tie bars, the partial load rate of tie bars was calculated, and the influence of different types of thread shape and template (mold) parallelism on the partial load rate of tie bars were analyzed. Experiments reveal that the partial load rate is changed within 0.8%–3.8%, and the partial load rate gradually decreases with the increase of the clamping forces. Besides, different types of the thread of tie bars have little influence on the partial load rate, while the parallel degree of the template (mold) has great influence on the partial load rate of the tie bars. Further experiments show that the partial load rate is located in 0.79%–1.81% when the parallelism of template (mold) is good, and the partial load rate of tie bars between 8.59%–11.46% when the parallelism of template (mold) is poor. Finally, the partial load adjustment system of tie bars were also designed to make the force of tie bars more uniform and the partial load rate can be reduced by detecting the partial load rate of the tie bar and using the closed-loop control.

Introduction

The molding clamping unit is one of the most important parts of injection molding machine, which directly affects the dimensional accuracy and the quality of products. The optimized clamping force and uniform load on four tie bars are important indexes to evaluate the performance of the injection molding machine [1]. The uniform load of tie bars ensures quality of products, plays a protective role and extends the life of the mold and injection molding machine. Current molding clamping units are inherent with several limitations [2–4], for example, the nonparallel template (mold) caused the nonuniform load of the tie bars, and the unstable clamping force may cause tie bars fracture. Therefore, several efforts are needed to relieve the above limitations [5–9]. Firstly, the accuracy should be optimized and enhanced for the measurement of the clamping forces; secondly, the partial load needs to be optimized and adjusted for uniform clamping force of the tie bar.

The measuring of clamping force is to convert the stress of tie bar into strain according to the principle of strain electrical measuring, and electrical measuring method is to change non-electricity (force, stress, temperature, etc.) into electricity by the sensing element according to the amplification and processing of the measurement circuit, which can be reflected in the instrument reading device of a measuring method. Finally, the stress of the parts, mechanism and working condition can be analyzed [10].

Traditional measurement method is by using embellishment strain gauge to measure the strain and calculate clamping force of tie bars [11,12]. The traditional measurement method has many disadvantages such as the strain gauge paste difficultly and the strain gauge can be used only once which not only takes long time to prepare the paste work, but also requires critical measurement environment.

The values of the experiments were presented as follows: according to measuring the strain and stress of the four tie bars, the stress and partial load rate of the tie bars are shown in real time, when the partial load rate exceeds a certain value, the device will alarm, at the same time, the partial load adjustment system start work to adjust separately the stress of every tie bar to ensure the stress of the four tie bars within the reasonable limits, so as to

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improve the injection molding machine performance and ensure the quality of plastic product. The analysis of the influence of thread types and parallel degree of template (mold) on the stress and partial load rate of the tie bars, determine the influence of thread types and parallel degree of template (mold) on the stress and partial load rate, the values of this were that to avoid the uneven load caused by the uneven template, provide the basis for the design of the template parallelism.

Stress measurement of tie bar and method of partial load calculation

Experimental device and apparatus

The clamping force measurement technique used in this paper is magnetic force measurement, the measuring device is called magnetic enclosed type clamping force measuring device (QE-1008, SENSORMATE, Switzerland). The structure and installation of the magnetic measuring device are shown in Fig. 1, as shown in Fig. 1(a), the measuring device consists of steel shell, strain gauge, magnet, rubber pad, adjusting bolt, adjusting nut, connecting line, etc., the strain gauge is placed between the two magnets in stainless steel foil, it stands absolutely in axial line on the surface, strong magnetic force through the bolt, nut and a rubber cushion make the strain gauge firmly affixed to the surface of the tie bars, so as to produce a strong interaction with friction between the surface of strain gauge and steel foil and tie bar, the pressing force of the strain gauge can be adjusted by turning on the nuts of the magnets. Each measuring case is connected respectively with the input of the digital display device, the deformation variable is converted into the change of electric quantity, after the measurement circuit amplification and processing, the measured strain value is then displayed directly in “microstrain” or “kN” or “t”. The measuring device is a whole one, when the experiment is ended, the measuring device can be removed by force which exceed the magnetic force, so the measuring device and its application is reproducible.

Template (mold) parallelism will directly affect the deflection of the tie bars. According to mechanical principle, nonparallel template (mold) will directly affect the horizontal direction pulling force of the tie bars. Terminal of the tie bars are thread structure were fixed on template by the nut, and the thread types are trapezoidal thread and triangle thread. In order to investigate the influence of parallel degree of template (mold) and thread types on the stress and partial load rate of the tie bars, the two model machine T300 with different thread and T250 with different parallel degree of mold were used in the experiment.

Experiment procedure

As shown in Fig. 1(b), four tie bars are fixed on the front template, movable template and back template through the nut under the action of the cylinder. The hydraulic cylinder imposes force on the clamping unit, and the clamping unit imposes pull to

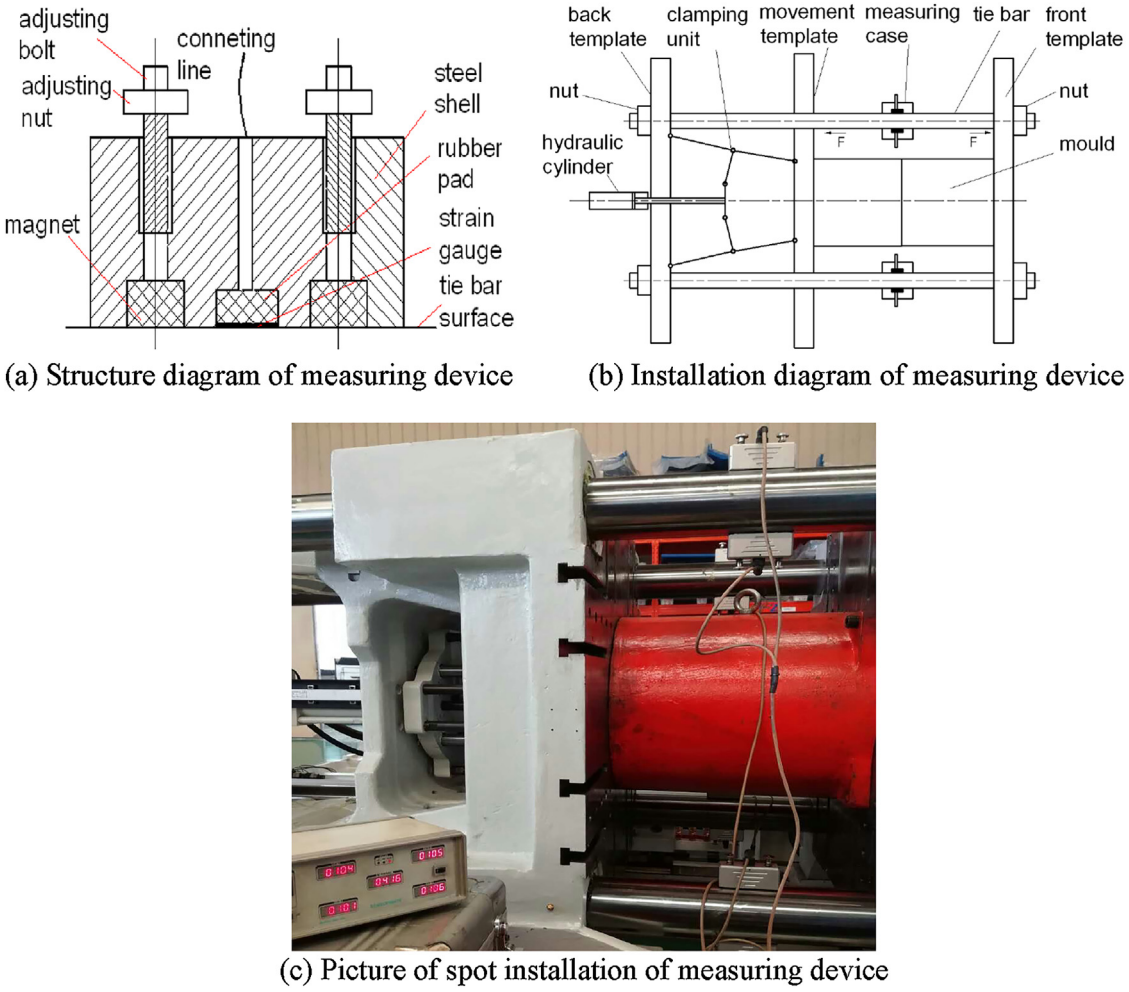

Fig. 1. Structure and installation of the magnetic measuring device.