Apparatuses for investigating polymer crystallization under high cooling rate and fast flow

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Introduction

Non-equilibrium phase transition has important implications in both industrial production and physics Research. Polymer crystallization induced by fast flow and under fast cooling rate are ordinary examples of non-equilibrium phase transition.

In the recent months, two stretching rheometers for various applications combining fast cooling unit were designed, produced and assembled in order to achieve a new experimental route for investigating polymer crystallization under both high cooling rate and strain rate in one system.

Description of Apparatuses

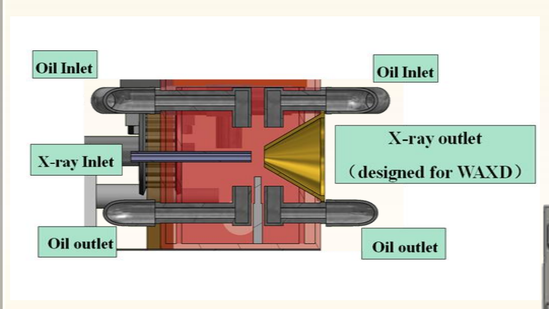

Fig. a Oil bath cooling and stretching rheometer with movable chambers. After eliminating thermal history and stretching heating chamber is divided into two pieces driven by servo motor and then oil bath set to design temperature rises over sample for cooling.

The apparatus focus on cooling rate for better perform of liquor as cooling media and temperature jump between heating chamber and oil bath. The temperature and flow of oil provided by professional temperature control device is precisely controlled to get any route of temperature change wanted.

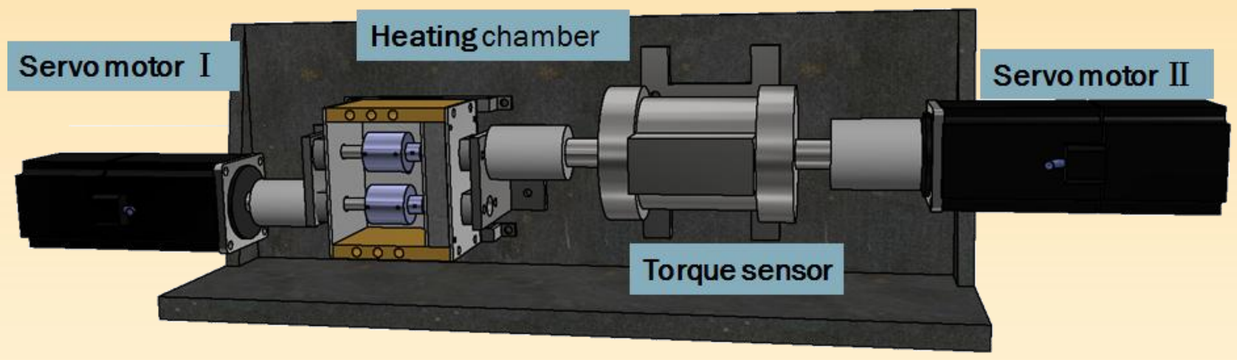

Fig. b Dual-motor rheometer with gas cooling tube. Two motors are applied instead of gears to decrease transmission error and power penalty. Hollow rollers with bigger radius are also outfit to achieve higher speed and acceleration while rotational inertia keeps almost the same. Indoor temperature or subzero nitrogen is applied for cooling.

With low rotational inertia and devices with precise transmission, the rheometer has the starting performance almost the same as motor idling, which is able to achieve fairly high strain rate making flow-induced crystallization study under stronger flow possible.

performance parameter

The dual-motor rheometer provide strain rate higher than $120s^{-1}$. With large flow indoor temperature nitrogen over 100L/min, cooling rate on the face of sample is around 600℃/min, recorded by disposable home-made temperature data collection device.

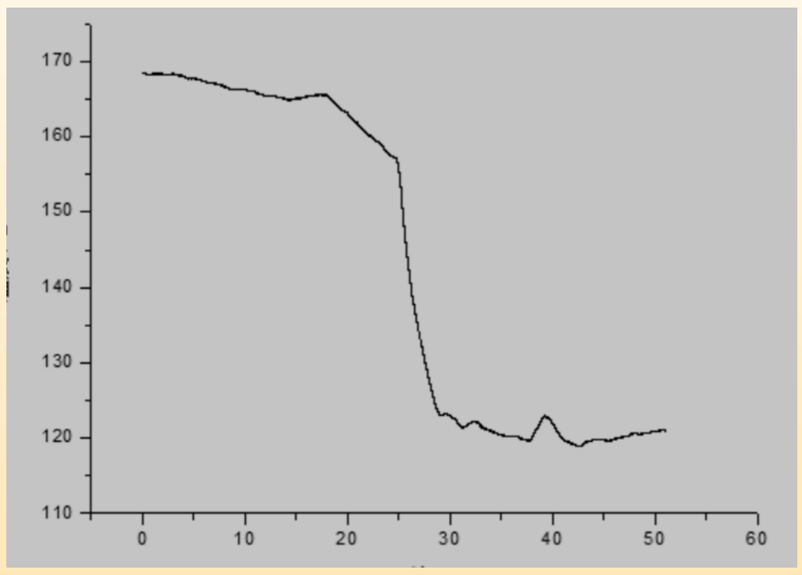

Fig. c Temperature decreasing with time, the highest cooling rate is around 10℃/s while temperature changed from 170℃ to120℃.

outlook

Quantum cascade laser (QCL) and infra-red thermograph with Super fast time-resolved detector are about to combined with the quality of high strain rate and cooling rate.

The performance of oil bath cooling and stretching rheometer remains examined which is expected to get better results on cooling rate for cooling media and temperature jump function.

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