Technology Offer

Catcher for stabilization of high-viscosity extrusion jets (Ref.-Nr.: 0105-6614-BC)

The offered invention relates to a device that reduces free-jet instabilities inherent to high-viscosity extrusion injection, facilitating delivery of protein microcrystals for serial diffraction X-ray crystallography.

Advantages

- Continuously stabilizes the position and speed of a viscous jet, even if the jet is subjected to strong, intermittent, physical forces
- Functions for most high-viscosity carrier media
- Optimal settings can generally be found within a minute or two of manual adjustment
- Simple, compact, robust

Applications

- High-viscosity extrusion experiments, especially experiments at synchrotrons
- Time-resolved HVE measurements

Background

In serial diffraction X-ray crystallography measurements on biological samples (for instance, protein crystals) that require a lipid environment, the biological samples are embedded in a lipidic cubic phase (LCP). The high viscous LCP containing the biological samples is injected into a pulsed X-ray beam by means of a nozzle, and a diffraction image is obtained by diffraction of the X-ray on the biological sample. The diffraction of the X-ray on the biological sample may be disturbed if the jet containing the biological samples is not stable. For example, if the free end of a vertical jet oscillates, the biological samples move into or out of the X-ray beam. In order to stabilize the free end-oscillations of the jet, a stationary solid 'catcher' plate is positioned such that the jet after being irradiated by the X-ray beam attaches to and coils up on the plate. This prior-art method reduces the sideways motion of the jet but does not eliminate it, as the jet material piles up on the stationary plate and the accumulating pile electrostatically repels the jet, displacing the jet relative to the X-ray beam.

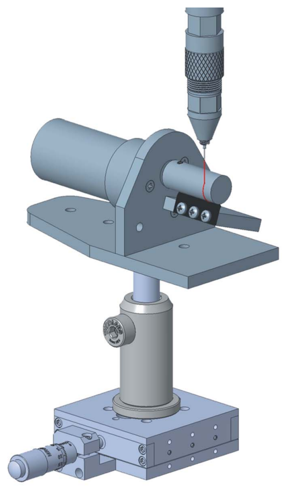

Fig. 1: Drawing of a rotating rod catcher

Technology

The innovative catcher presented here employs a moving rather than a stationary catcher surface. The jet once again adheres to the catcher but, rather than piling up, is carried away by the moving surface. A scraper shears the deposited material off the catcher surface. The speed of the moving catcher surface is set such that jet material is carried away at approximately the same rate at which it arrives. As a result, a steady-state dynamical system is established, in which the jet flows steadily from the nozzle to the attachment point on the moving catcher surface, to be carried away as an attached ribbon on the catcher and then removed by the scraper. In this dynamic steady-state equilibrium, the attachment point of the jet on the collector is fixed in space, with the jet

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traversing a fixed path from the nozzle to this point. The jet is effectively pinned by these two endpoints. Moreover, there is no pile-up of charged viscous jet material on the collector at the attachment point.

In preferred embodiments of the innovative catcher jet material collection is based on rotary motion, for instance, by collection on a rotating cylinder, or a rotating flat disc, or a looped conveyer belt. The drawing of an innovative rotating catcher that collects the jet material on a rotating cylinder is given in Fig. 1. The overall height of the catcher assembly is 16 cm. A variable-speed DC gear motor rotates the cylinder of appropriate diameter about a horizontal axis. The jet (colored red) streams vertically downwards from above to contact and adhere to the rotating cylinder near its top. By varying the DC motor drive voltage, the rotational speed of the motor is set to carry the arriving jet material away at approximately the same speed with which it arrives. Residual speed mismatch between jet and cylinder surface is accommodated automatically, so that collection of the jet material on the cylinder surface is relatively insensitive to speed mismatch. The attached ribbon of jet material rotates with the cylinder to arrive at a rubber blade, which scrapes it off the cylinder. Optimal setting of the rotational speed, of the separation of the cylinder surface from the nozzle, of the horizontal offset of the nozzle relative to the cylinder axes can be found in a minute or two of manual adjustment. The rotating catcher, as shown in Fig. 1, was used in measurements at beamline ID29 of the ESRF synchrotron, Grenoble, to stabilize injection of different protein microcrystals ranging in size from 2 to 40 um

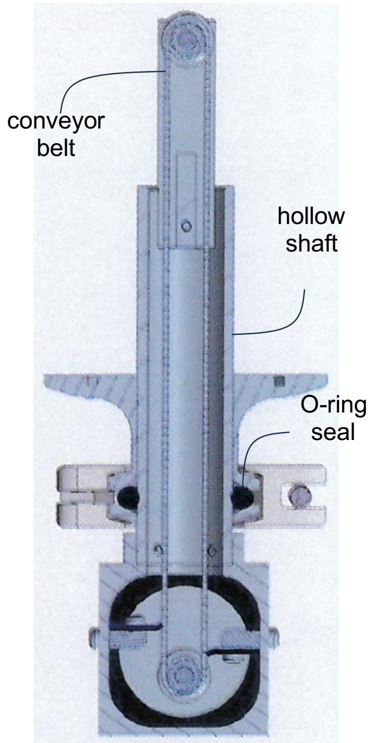

Fig. 2: Cross-sectional view of a conveyer-belt catcher

Fig. 2 shows a cross-sectional view of an innovative catcher that is designed for use in a vacuum chamber and employs a miniature (commercially available) timing belt to convey the deposited jet material from the deposition point. As seen in the cross-sectional view, the cylindrical housing of the timing belt slides through a clamping O-ring-seal at the bottom of a custom vacuum nipple that mounts on the bottom of the vacuum chamber. This sliding motion allows the distance of the belt from the nozzle tip to be varied. A second sliding connection near the top of the cylindrical housing allows for tensioning of the timing belt.

Patent Applications

PCT application filed

Other Publication

R. Bruce Doak et al, *Dynamic catcher for stabilization of high-viscosity extrusion jets*, J. Appl. Cryst. (2023), 56, 903-907

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