EFFECT OF FEED PROPERTIES AND LOCAL DRYING KINETIC ON PARTICLE MORPHOLOGY IN SPRAY DRYING

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International Fine Particle Research Institute

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INTRODUCTION

Spray drying is a widespread drying technique used in a variety of industries. The process conditions have a great influence on the quality of the final product. In this study, the influence of temperature and concentration of maltodextrin solution on the moisture content and bulk density of powders obtained by co-current spray drying was investigated. It has been shown that there is a relationship between the temperature and concentration of the solution and the moisture content and bulk density of the product. In addition, conditions were identified under which the process could not be carried out. In order to fully analyse the effect of the feed properties on the morphology of the powder, the study needs to be complemented by measurements of the particle size distribution and microscopic images.

Spray drying experiments

The dried material is an aqueous solution of maltodextrin prepared from starch and moderately saccharified by reducing the sugar content by 12.4% in terms of glucose (DE12) (Nowamyl S.A., Poland). The specific heat of the dry maltodextrin is 2472 $J \cdot kg^{-1} \cdot K^{-1}$ and the density corresponds to 1568.2 $kg \cdot m^{-3}$.

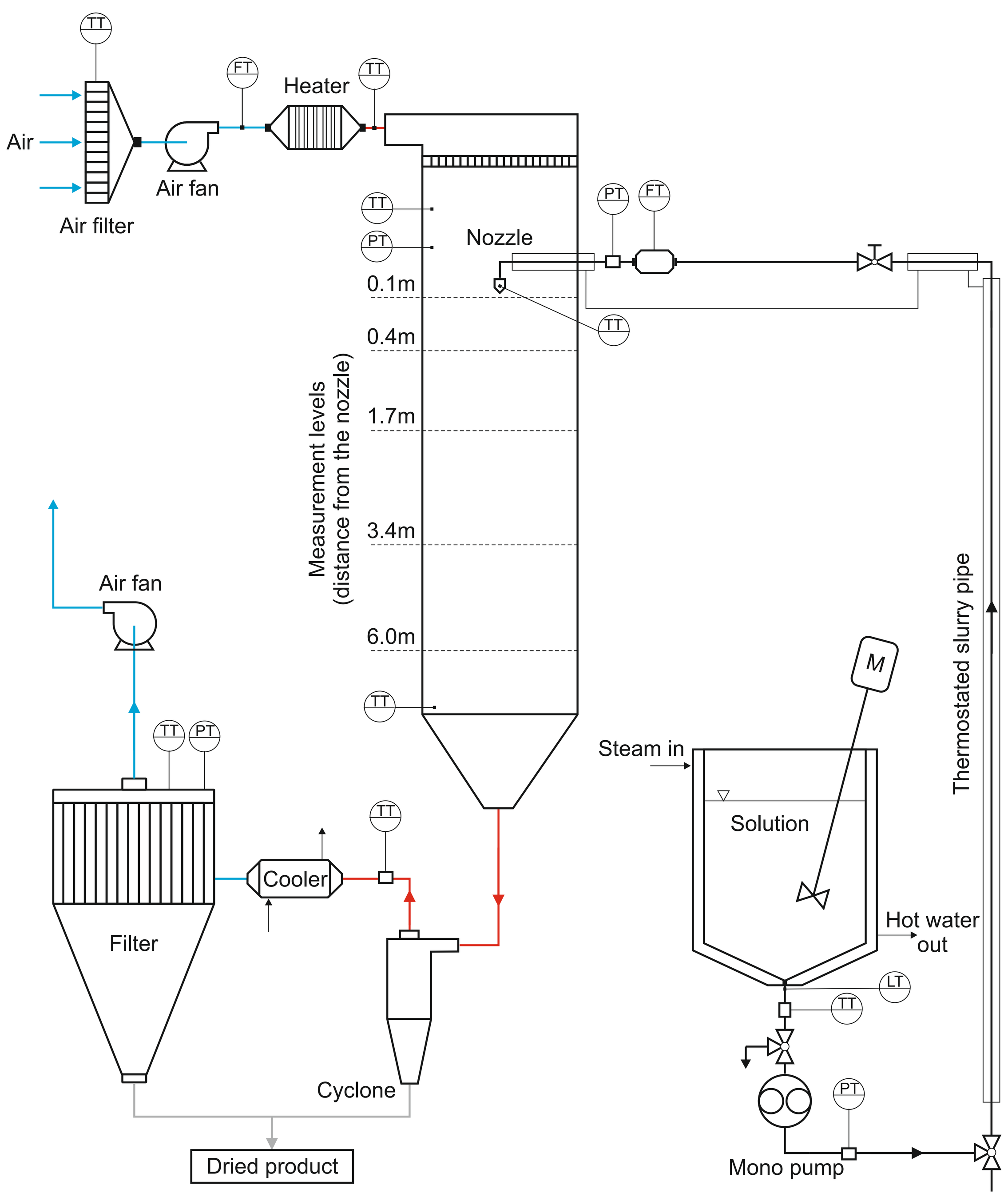
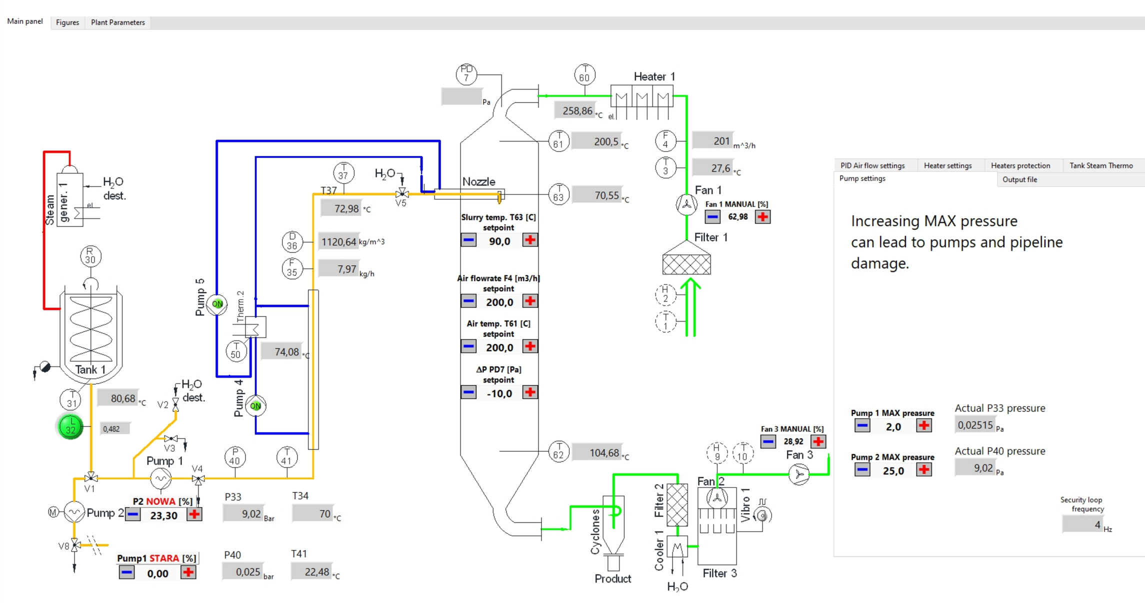


Diagram of experimental set-up for spray drying processes.

The powder for further analysis was obtained from a stainless steel drying tower with a diameter of 0.5 m and a height of 9 m, which was operated using the co-current phase flow method.

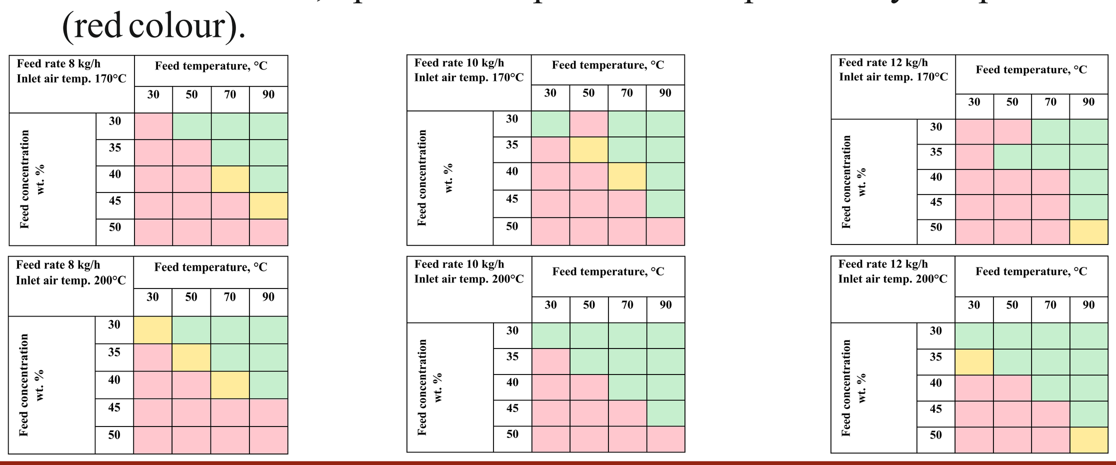


Control system for the co-current spray drying setup

Process parameters used during the experimental tests.

Feed concentration, wt. %	30, 35, 40, 45, 50
Feed temperature, °C	30, 50, 70, 90
Inlet air temperature, °C	170, 200
Feed flow rate, kg/h	8, 10, 12

- atomisation takes place properly, the powder does not deposited on the walls of the column (green colour);
- part of the powder is deposited on the walls of the column, but product separation is still possible (yellow colour);
- atomisation is not correct, most of the powder is deposited on the walls of the column, product separation is practically impossible (red colour).

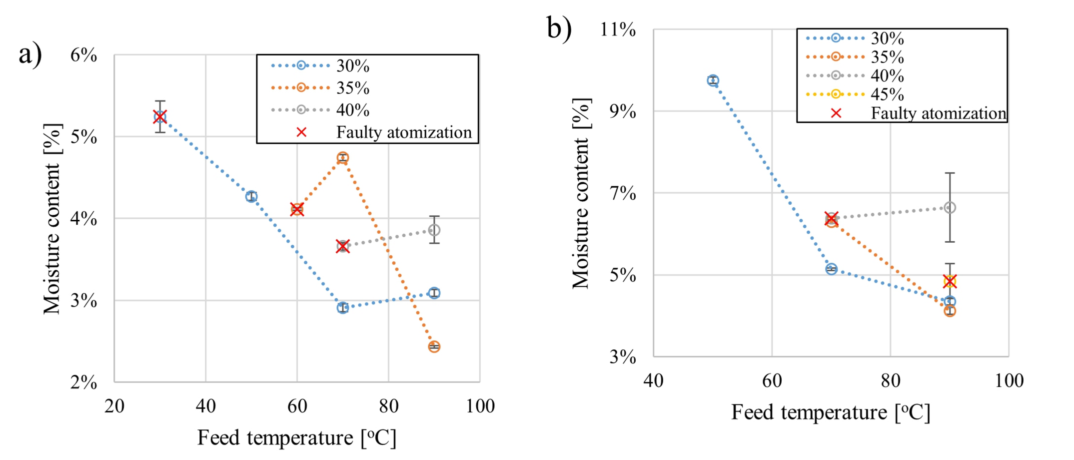


Powder properties

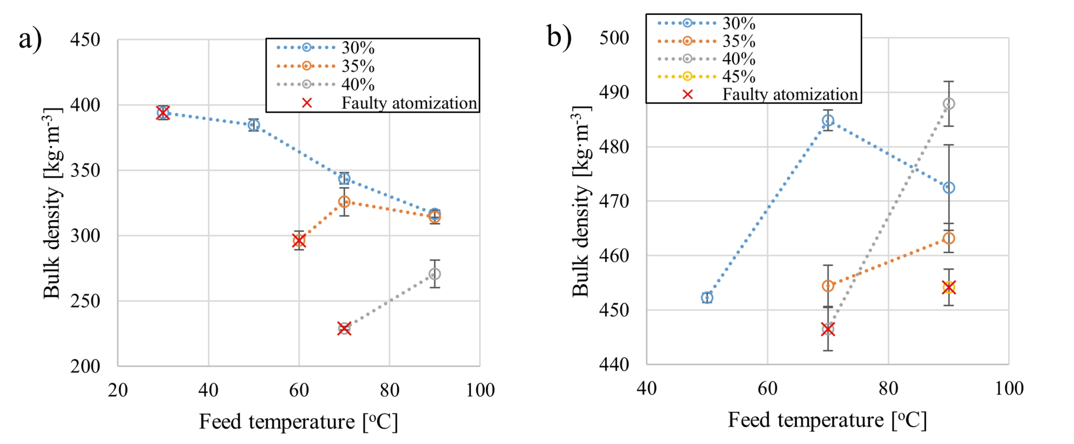
The moisture content of the samples was determined by the dryer weight method. The samples were dried at 105°C until their weight stabilised (about 3 h). Each measurement was repeated three times and then averaged.

The bulk density was determined by placing the powder in a 250 cm^3 measuring cylinder and then weighing the contents of the cylinder. Each measurement was repeated three times and then averaged.

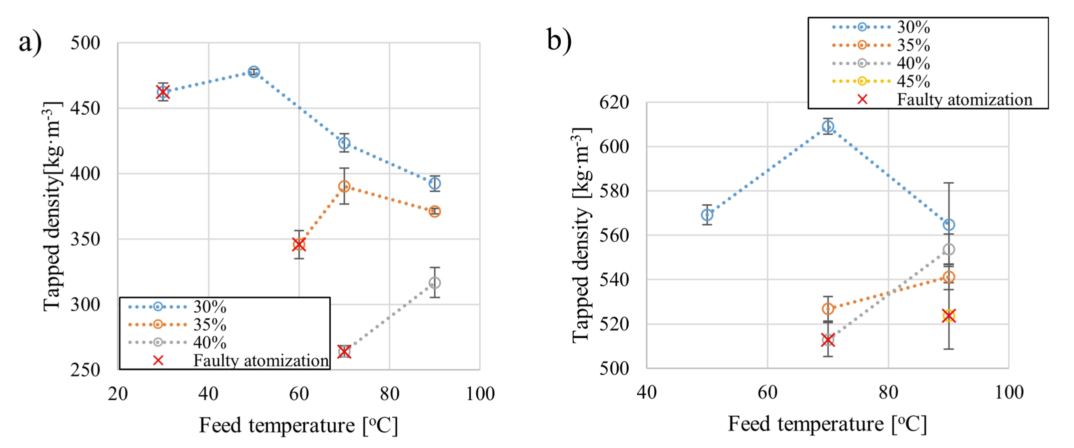
Tamped density was determined by placing the powder in a 250 cm^3 measuring cylinder and then weighing the contents of the cylinder. The contents of the cylinder were tamped by striking the cylinder 100 times on the ground from a height of about 15 mm and then measuring the volume occupied. Each measurement was repeated three times and then averaged.



Effect of feed temperature on product moisture content at inlet air temperature a) 200 °C, b) 170 °C



Effect of feed temperature on product bulk density at inlet air temperature a) 200 °C, b) 170 °C



Effect of feed temperature on product tapped density at inlet air temperature a) 200 °C, b) 170 °C

The samples collected during the experiments are continuously analysed. Other parameters related to the morphology of the particles that will be determined during the research are:

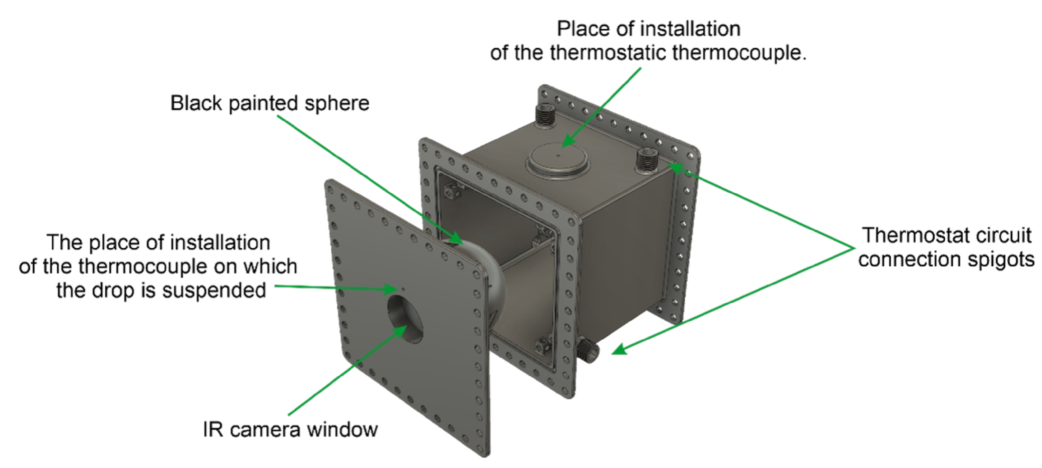
- Porosity of the bed and of a single particle,
- Diameter distributions and corresponding Rosin-Rammler distribution curves,
- Sorption isotherms,
- Images from an optical microscope,
- Images from an electron microscope (SEM),

Project status

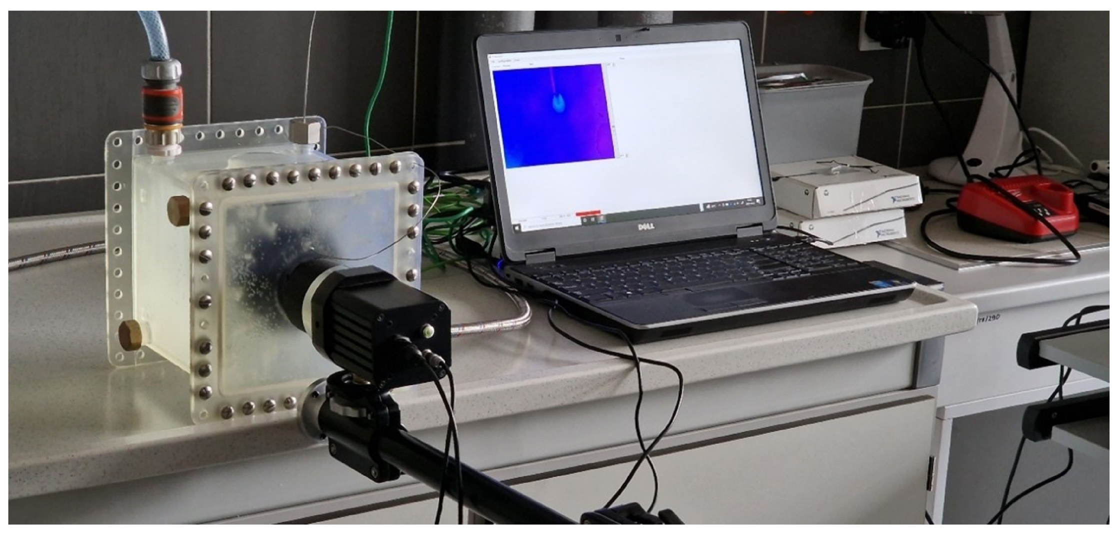
Topic	Status
	1st year
1. Adaptation of the existing equipment to the project requirements.	Done
2. Selection of suitable experimental media and determination of quality criteria.	Done
3. Measurements of rheological properties of aqueous solutions of selected materials.	Done
4. Design of particle free fall SDD measurement system;	In progress- We check the technical possibilities and the availability of equipment
	2nd year
1. Carrying out experimental drying processes and analysis of powder morphology obtained from different slurries and process parameters:	Done
- Identification of the effect of feed properties, feed rate, air flow rate, drying temperature on powder morphology;	In progress- The analysis of the collected powders will take about 4-5 months
- Specification of mathematical relationships describing the drying and powder properties;	In progress- we need morphology data- moved to 3td year
2. Experimental determination of critical moisture content of dried materials. 3. Construction and test of free fall drying kinetic determination system.	In progress- SDD tower is under construction

Free-fall SDD column

In our proposed method, the influences of emissivity, reflection and transmission coefficients of the object can be eliminated. The non-contact temperature measurements can be performed with any standard infrared detector operating in the spectral range of 3-16 µm, such as a pyrometer or a thermographic camera, without disturbing the object.



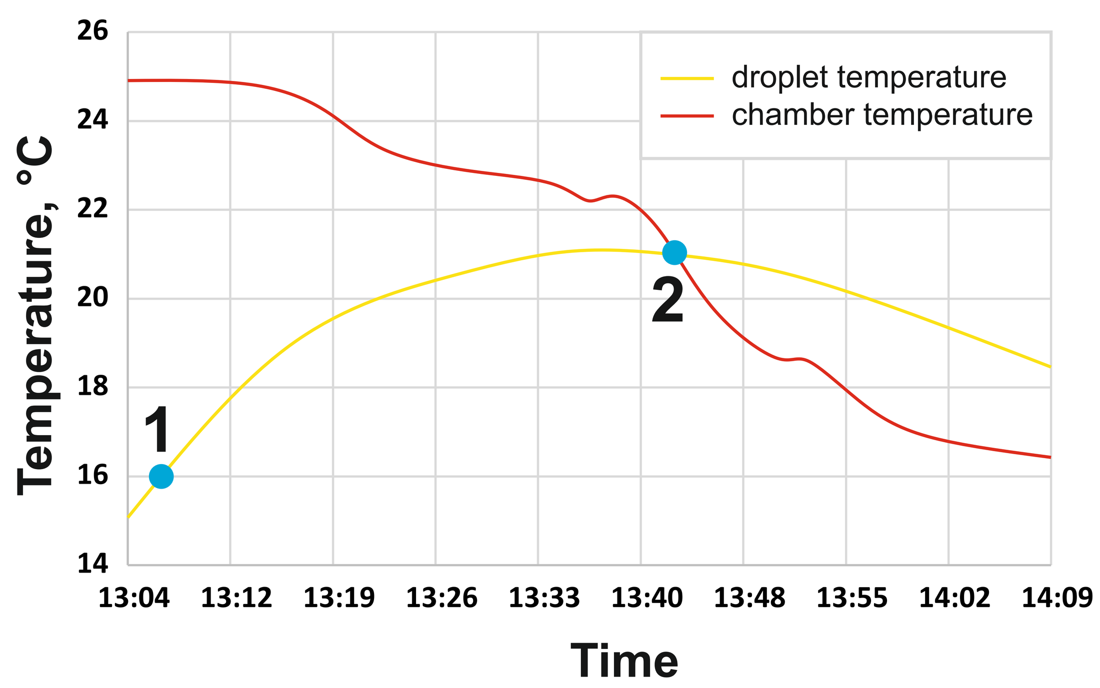
Thermostated chamber for experiments with a thermal imaging camera.



Test stand for measuring the drop temperature with the IR method.

Test methodology:

- a drop of silicone oil is placed at the end of the thermocouple in the measuring chamber
- the walls of the chamber are thermostatted and their temperature is read from a surface thermocouple
- the temperature of the wall is equated with the temperature of the drop.
- if both temperature values are equal, the temperature of the drop is measured with a IR camera

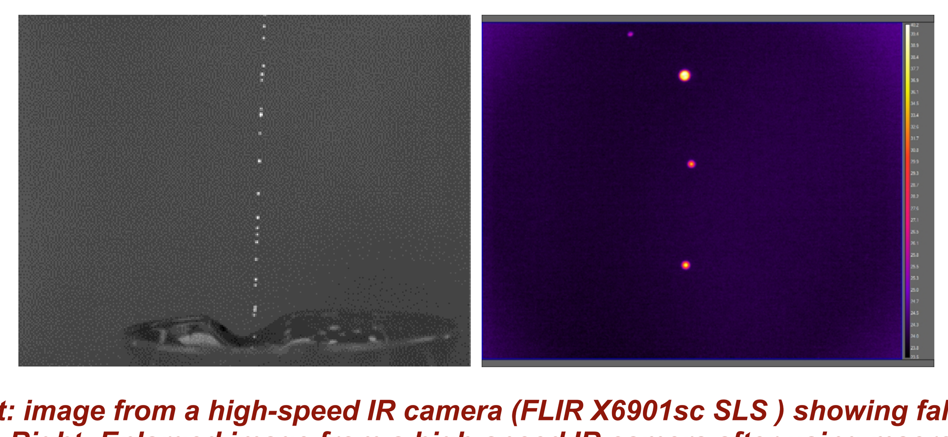


Changes in the temperature of the drop and surrounding walls during tests of temperature measurements from IR cameras.

Measuring point No. 1:
- actual drop temperature = 16.00°C,
- drop temperature according to IR camera = 16.89°C
Error = 5.5%

Measuring point No. 2:
- actual drop temperature = 21.32°C,
- drop temperature according to IR camera = 21.36°C
Error = 0.18%

We tested two cameras: a FLIR A6753 SLS camera with a reading speed of 125 Hz at a resolution of 640x512 pixels, and a FLIR X6901sc SLS camera that was able to capture the object at 1004 Hz at the same resolution.



Left: image from a high-speed IR camera (FLIR X6901sc SLS) showing falling drops. Right: Enlarged image from a high-speed IR camera after using macro rings.

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