



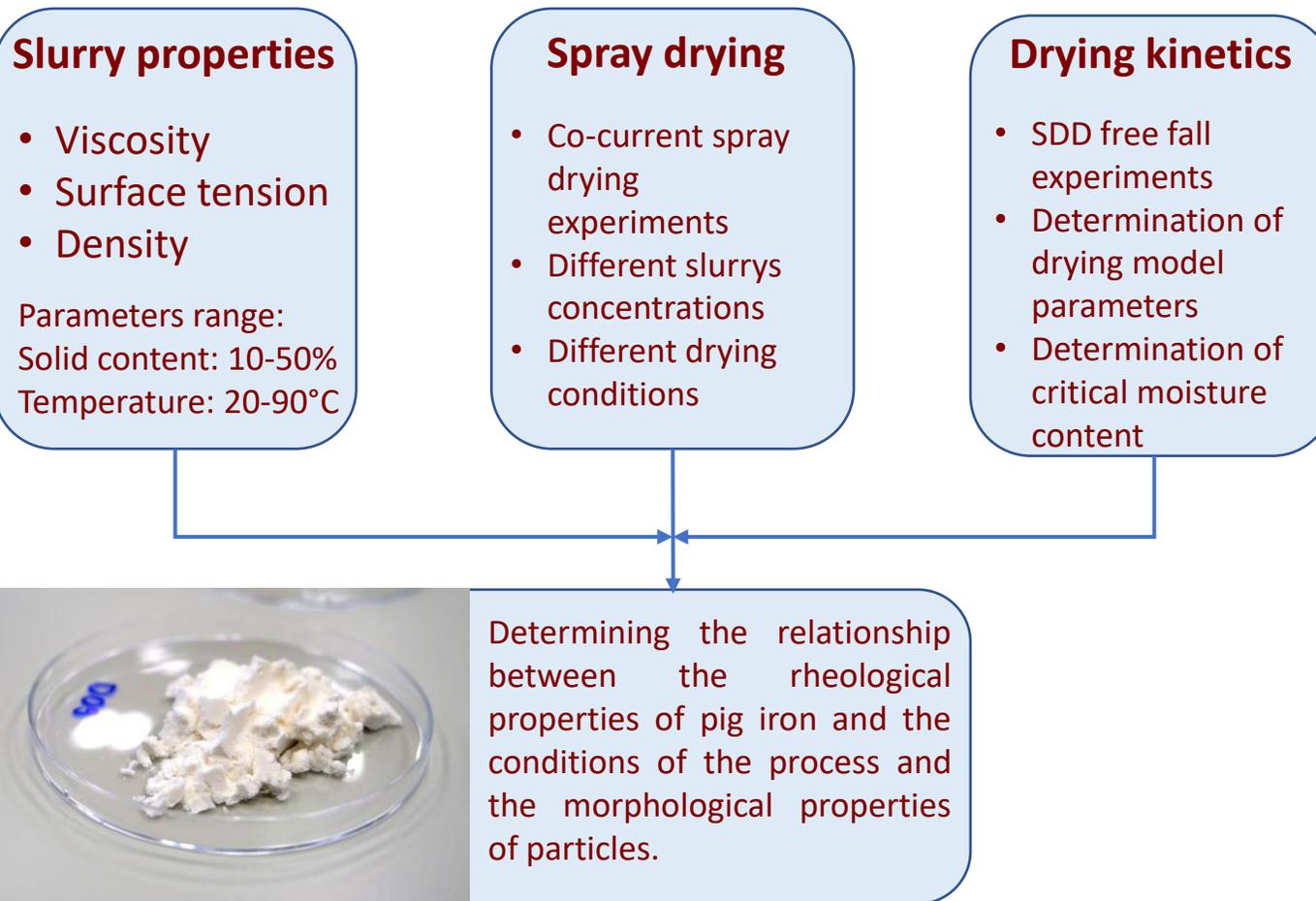
Lodz University of Technology
Faculty of Process and Environmental Engineering



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

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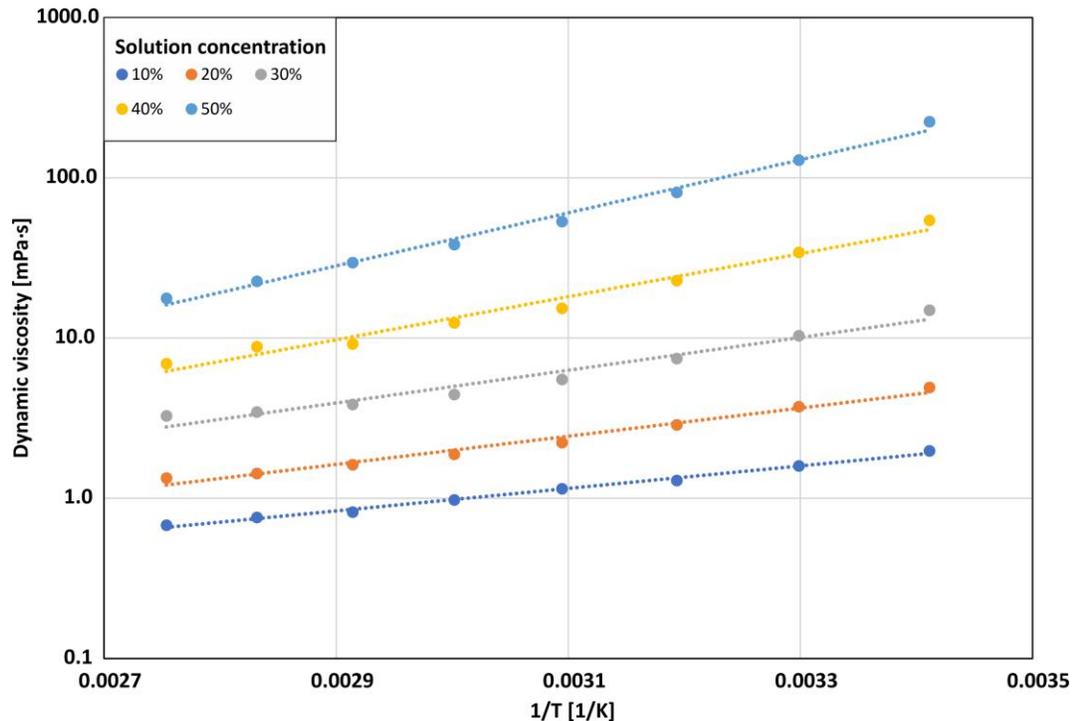
Aim of the project



Presentation plan

- **Aim of the project**
- Solutions rheology
- Spray drying
- SDD experiments
- Neural network
- Conclusions

Rheological properties of solutions- viscosity



Dependence of viscosity on reciprocal of temperature for aqueous maltodextrin solutions.

Rheological measurements were made with the Physica MR 301 rotational rheometer (Anton Paar). The measurements were carried out in the temperature range of 20-90°C with the use of a dedicated system of CC27-SN32556 coaxial cylinders used for rheological tests of low-viscosity media.

$$\eta = A \cdot \exp\left(\frac{B}{T}\right)$$

$$A = -2 \cdot 10^{-4} \cdot c_{s,0} + 0.009$$

$$B = 54.702 \cdot c_{s,0} + 939.46$$

Where:

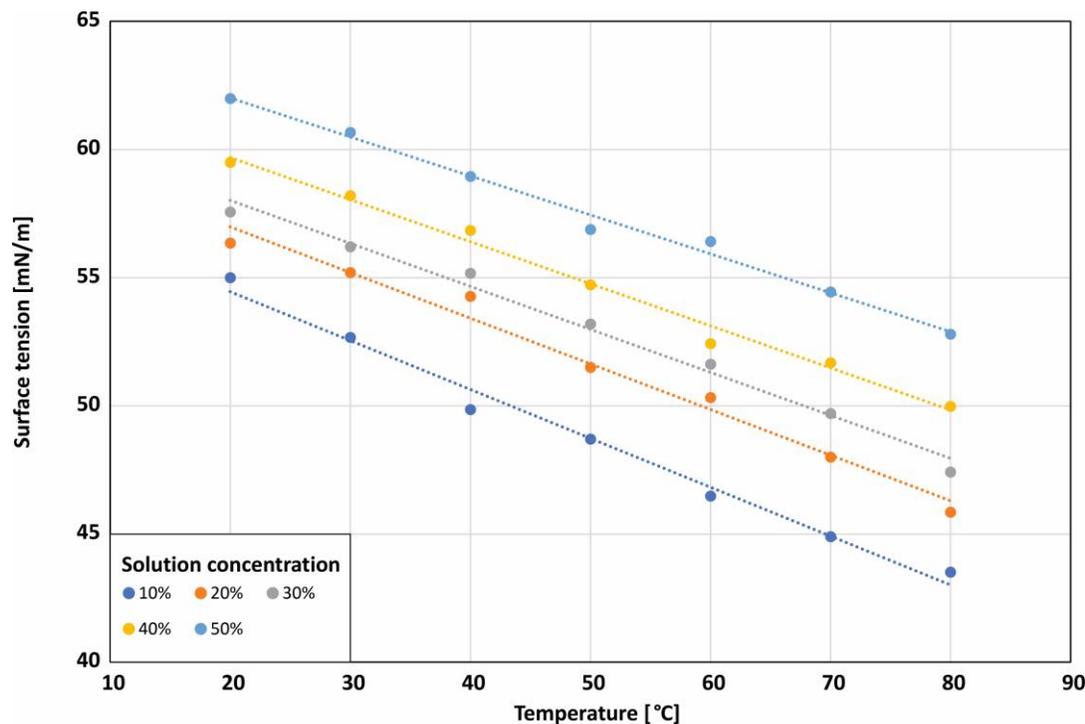
T – solution temperature

$c_{s,0}$ - initial solid concentration

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Rheological properties of solutions – Surface tension



Dependence of surface tension on temperature for aqueous maltodextrin solutions.

Surface tension measurements were made with the K100 tensiometer, manufacturer KRÜSS, using the ring method (Du Noüy) in the temperature range of 20-80°C. For all tested concentrations, a typical negative temperature dependence of the surface tension change was observed, which was described by a linear relationship:

$$\sigma = C \cdot T + D$$

$$C = 9 \cdot 10^{-4} \cdot c_{s,0} - 0.1978$$

$$D = 0.1601 \cdot c_{s,0} + 56.838$$

Where:

T – solution temperature

$c_{s,0}$ - initial solid concentration

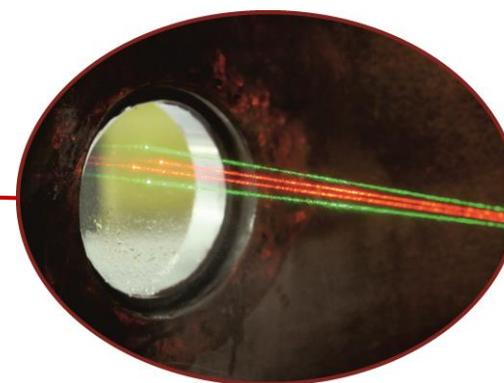
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Spray drying experiments



**PID MEASURING
LASER SYSTEM**



**DATA ACQUISITION
AND CONTROL**



POWDER SAMPLING

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Spray drying experiments

- Spray drying experiments:
 - Co-current configuration- minimization of the probability of agglomeration
 - Air flow rate: up to 400 Nm³/h
 - Air temperature: up to 250°C
 - Feed flow rate: maximum moisture evaporation rate 20 kg/h
- Feed properties:
 - Concentrations: 30, 40 and 50%
 - Initial temperature: up to 90°C

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Determination of single droplet drying kinetics

- Problems in determination of drying kinetics in spray drying:
 - Rapid evaporation
 - Particle recirculation
 - Problem in measurement system- separation of phases
 - Particle agglomeration
 - Limited access to spray drying installations
 - High costs
- Solution:
 - Simplification of spray drying system into the single droplet drying (SDD) measurements

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Determination of single droplet drying kinetics

GLASS FILAMENT

- Measurement of drying kinetics and visualization of the droplet during drying are relatively easy
- Can be used in for high drying temperatures
- Intrusion of filament into the droplet
- Relatively large droplets

ACOUSTIC AND MAGNETIC LEVITATION

- Measurement of drying kinetics and visualization of the droplet during drying are relatively easy
- Possible effect of the acoustic waves on mass transfer
- Low temperatures of drying

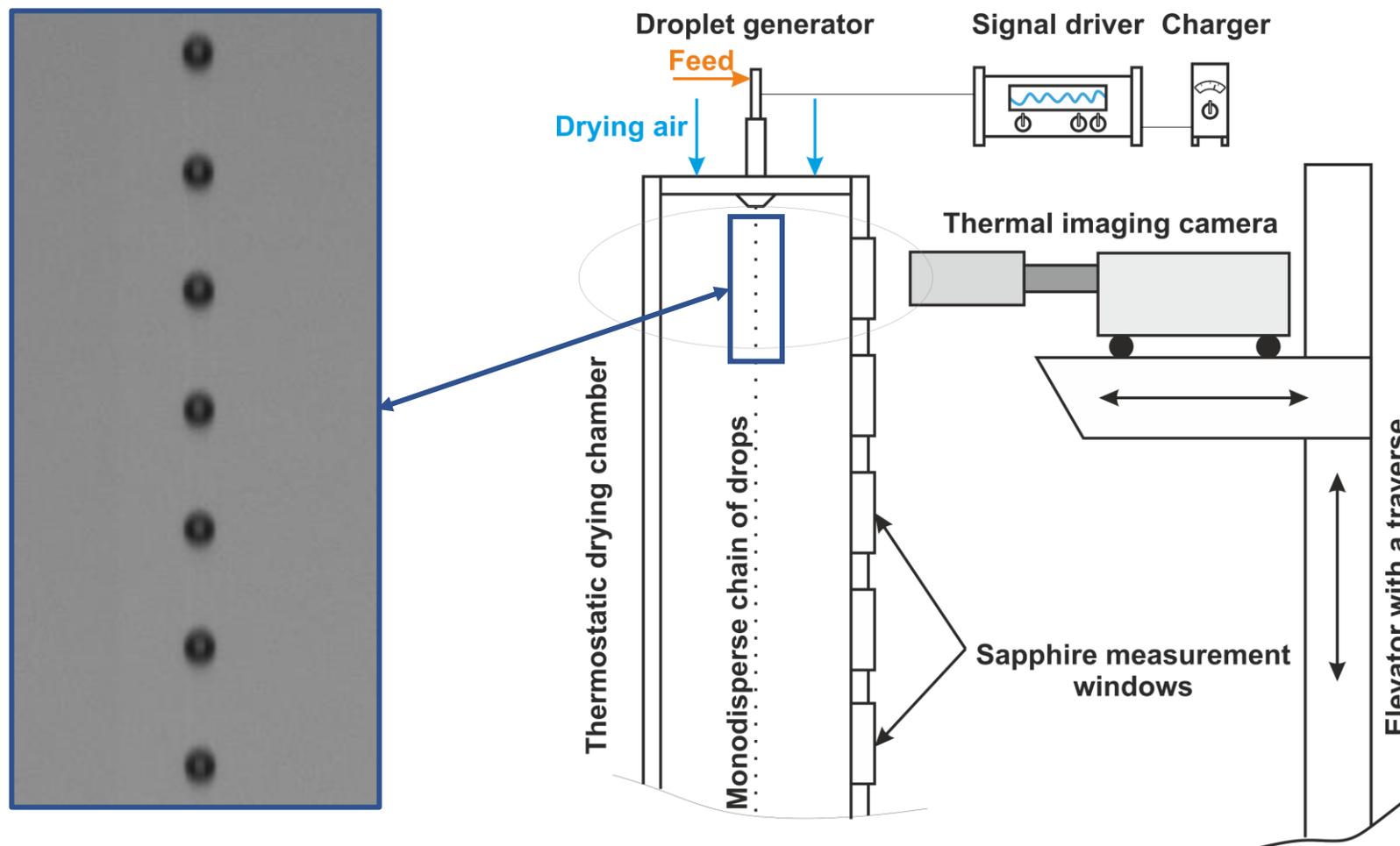
FREE FALL

- Drying conditions close to those of a spray dryer
- Measurement of drying kinetics and visualization of the droplet during drying are complex and difficult

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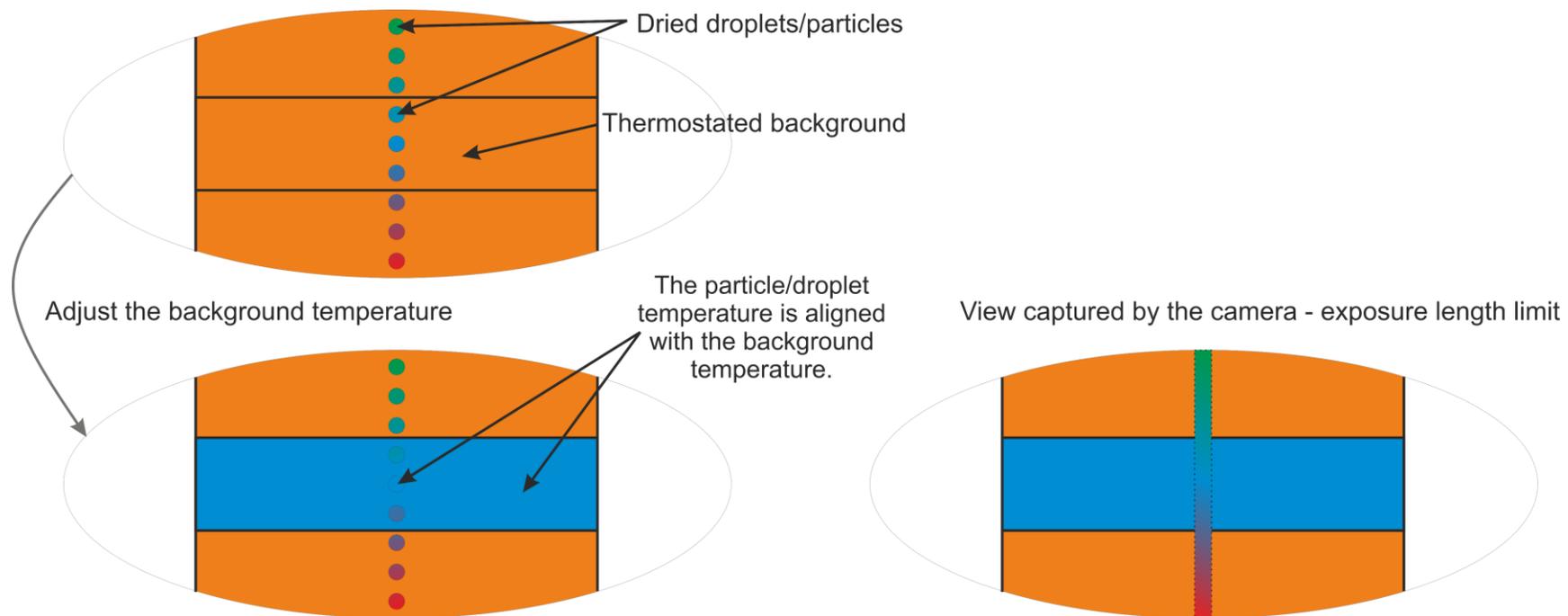
Free fall measurement equipment



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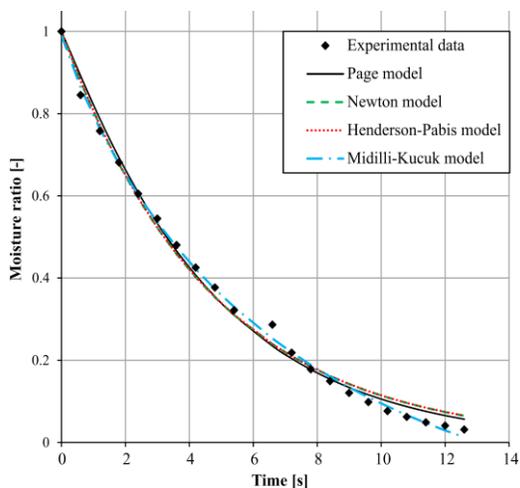
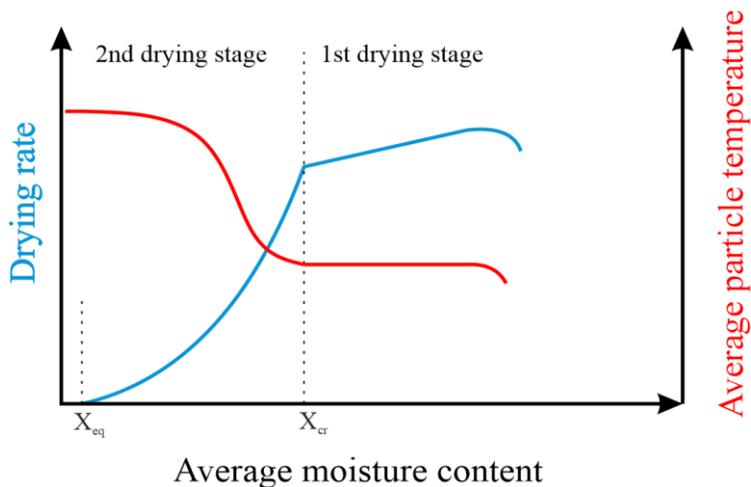
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Drying kinetic calculations



$$\frac{dm_p}{dt} = \frac{\frac{dT_p}{dt} m_p c_p - \alpha_p A_p (T_A - T_p)}{\Delta H_v}$$

$\frac{dT_p}{dt}$ - determined from thermal measurements

$m_p c_p$ - computed additively

α_p - determined for spherical objects

A_p - determined from observation with a high-speed camera

T_A - air temperature (constant throughout the column)

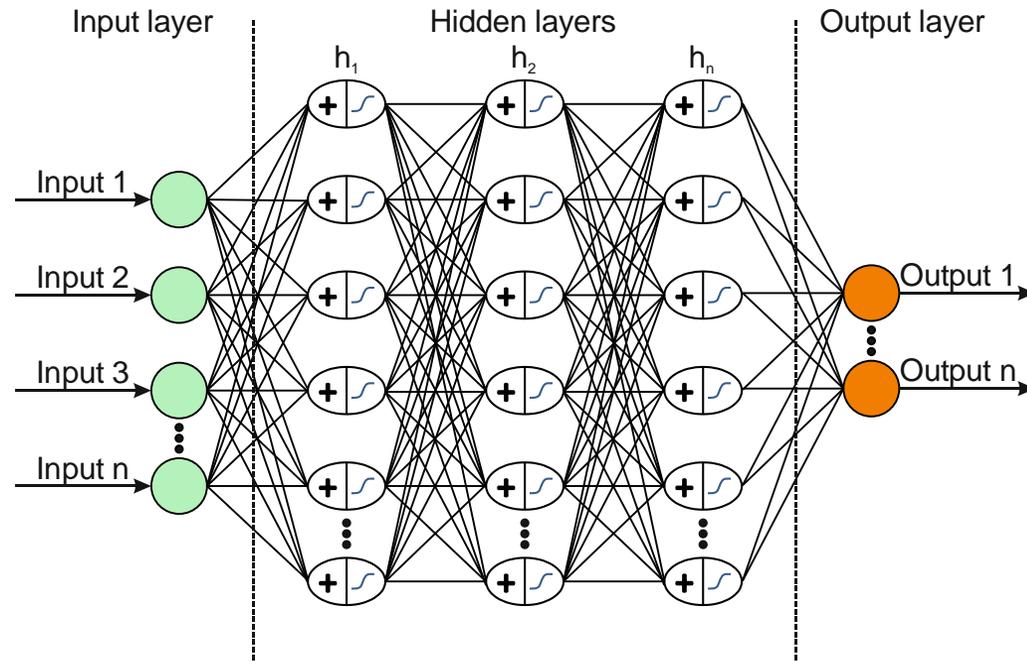
T_p - particle temperature from the background comparison experiment

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Maschine lerning

- Slurry properties**
Drying kinetic
- Viscosity
 - Surface tension
 - Density
 - Drying model parameters



- Powder properties**
- Mean diameter
 - Porosity
 - Bulk density

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Conclusions

Year	Topic	Status
1	<ol style="list-style-type: none"> Adaptation of the existing equipment to the project requirements. Selection of suitable experimental media and determination of quality criteria. Measurements of rheological properties of aqueous solutions of selected materials. Design of particle free fall SDD measurement system; 	<p>1st year</p> <p>In progress- Missing parts ordered</p> <p>Done – selected maltodextrin DE12</p> <p>Done – viscosity and Surface tension</p> <p>In progres- We check the technical possibilities and the availability of equipment</p>
2	<ol style="list-style-type: none"> Carrying out experimental drying processes and analysis of powder morphology obtained from different slurries and process parameters: <ul style="list-style-type: none"> Identification of the effect of feed properties, feed rate, air flow rate, drying temperature on powder morphology; Specification of mathematical relationships describing the drying and powder properties; <ol style="list-style-type: none"> Experimental determination of critical moisture content of dried materials. Construction and test of free fall drying kinetic determination system. 	<p>2nd year</p>
3	<ol style="list-style-type: none"> Mathematical modeling of changes in powder morphology depending on process parameters and feed rheological properties. Carrying out experiments with the use of free fall drying kinetic system 	<p>3th year</p>

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Thank you for your attention