

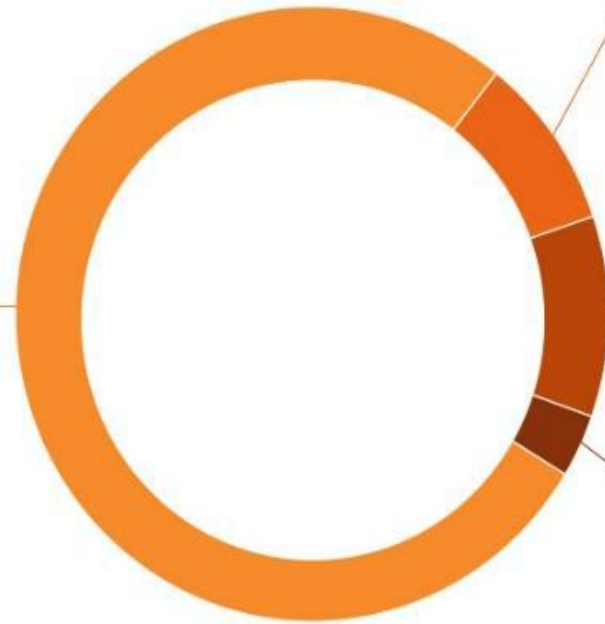
# Optimization of the high shear granulation process with respect to energy consumption

Matúš Čierny, Oliver Macho, Peter Peciar, Roman Fekete, Marián Peciar



# The influence of high shear granulation on process yield

77.01%  
Energy



9.10%  
Industrial processes  
and product use

Measuring torque  
and energy  
consumption

10.55%  
Agriculture

Use of waste liquids  
in limestone  
granulation

3.32%  
Waste management

Granulation of Waste  
from Nickel Ore



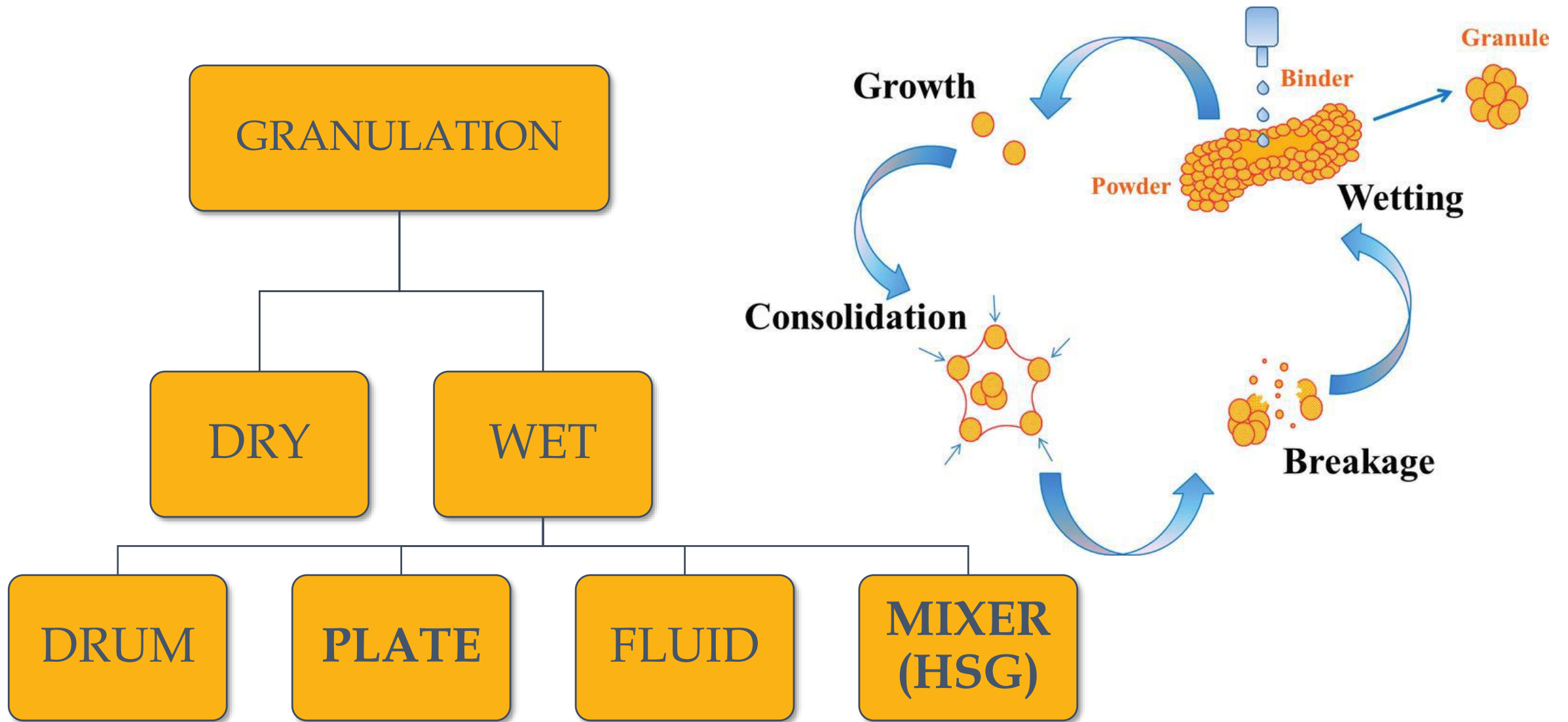
Future perspectives

Source: European Environment Agency (EEA)  
<https://www.europarl.europa.eu/news/en/headlines/society/20180703STO007129/eu-responses-to-climate-change>

The CCUV4 Workshop No.1 - 12.9.2022, Prague

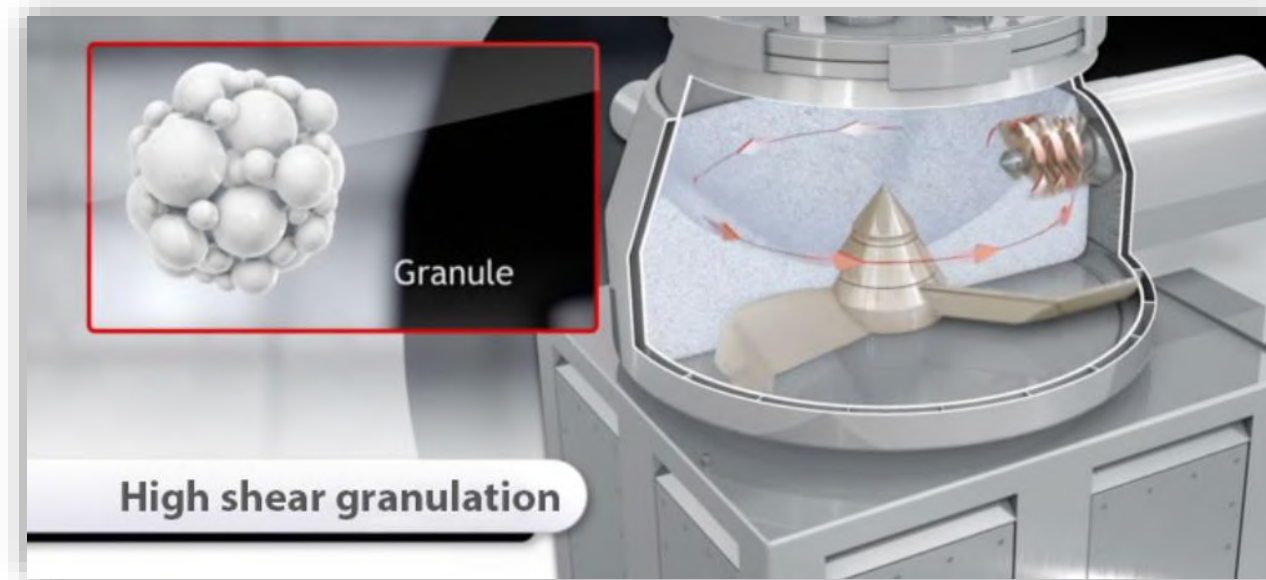
The project is supported by The International Visegrad Fund, project ID22120032.





# Advantages of granulation

- Improved flow properties
- Filling
- Reduced segregation
- Uniformity of drug content
- Uniformity of mass
- Compressibility - elasticity
- Reduced dustiness
- Reduced wear of punches



Source: GLATT  
<https://www.glatt.com/en/processes/granulation/high-shear-granulation/>

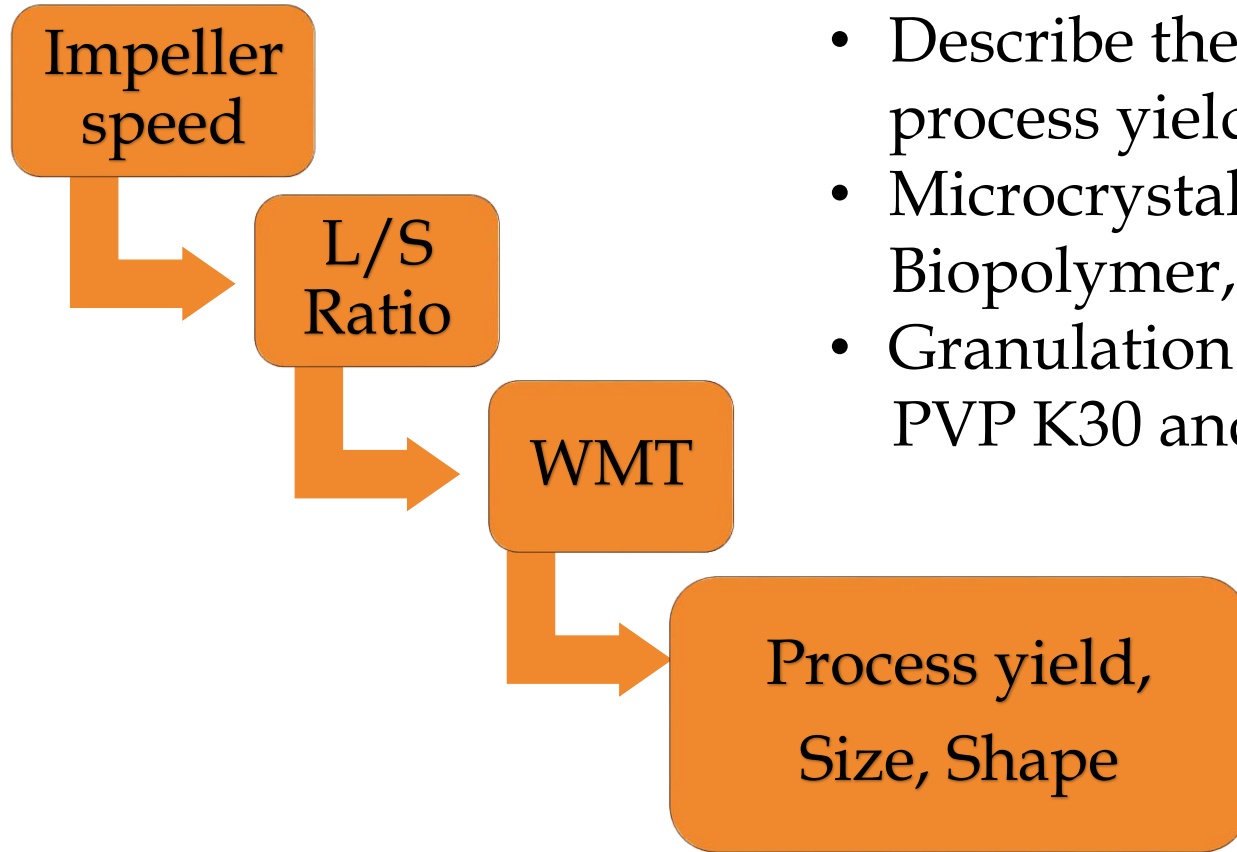
The CCUV4 Workshop No.1 - 12.9.2022, Prague

The project is supported by The International Visegrad Fund, project ID22120032.





# The influence of high shear granulation on process yield



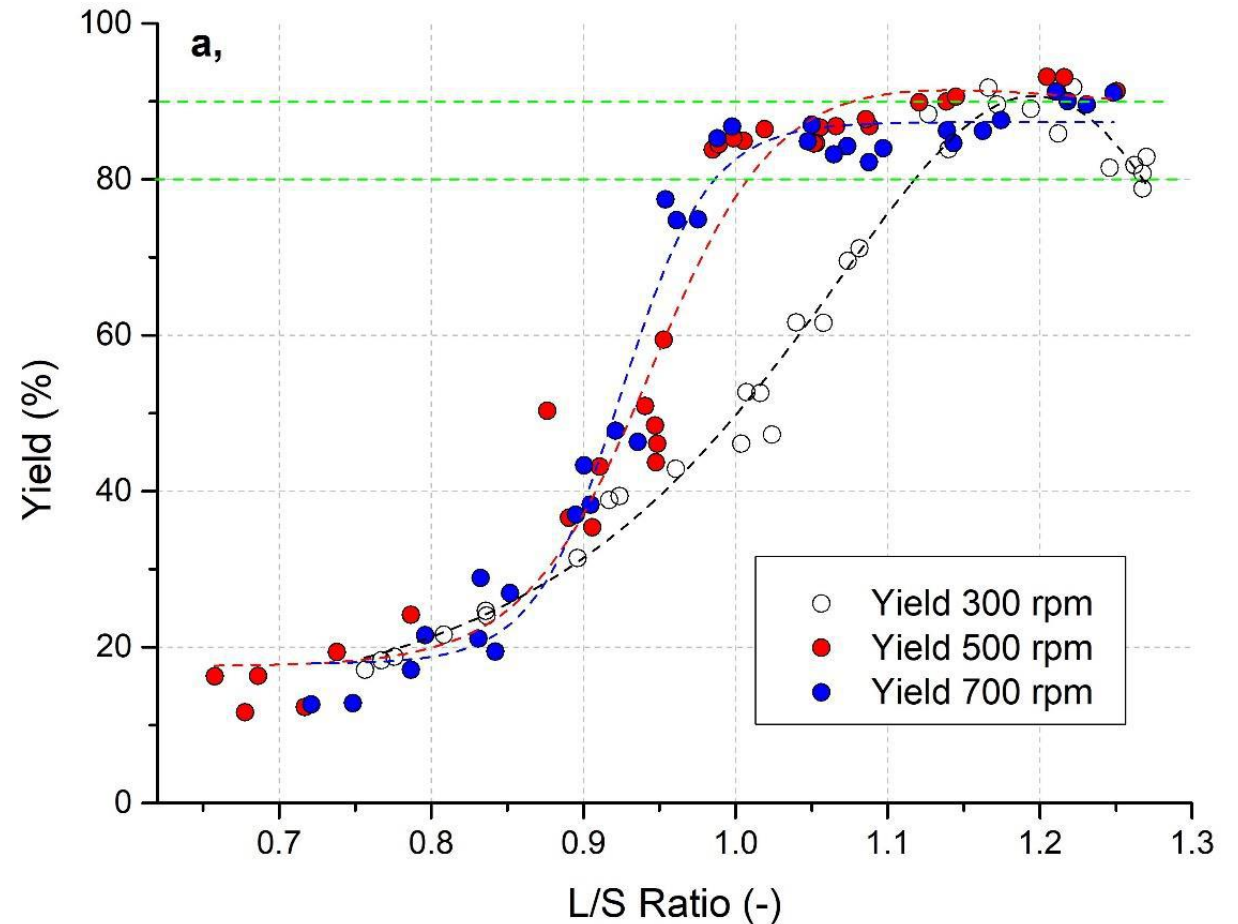
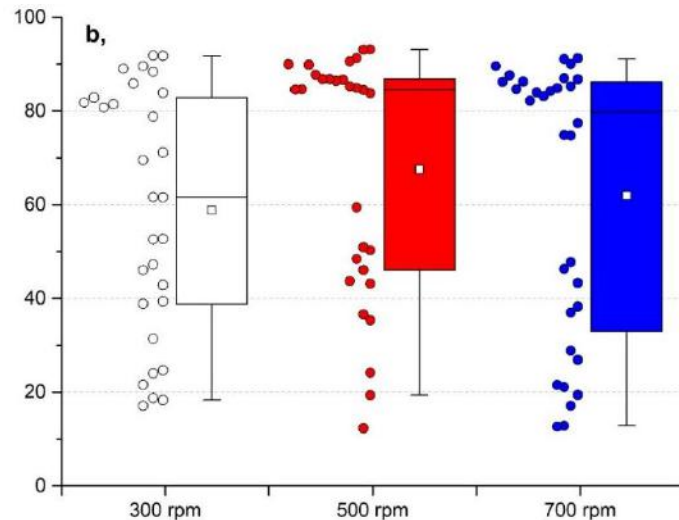
- Describe the influence of parameters HSG on process yield, granule size and shape
- Microcrystalline cellulose (Avicel® PH101, FMC Biopolymer, Ireland)
- Granulation liquid: 3% aqueous solutions of PVP K30 and PEG 8000 (AppliChem, Germany)





# The influence of high shear granulation on process yield

- Yield (product) size (0.4 – 3 mm)
- Higher L/S ratio – higher yield
- Higher impeller speed – higher yield



*Systematic Study of the Effects of High Shear Granulation Parameters on Process Yield, Granule Size, and Shape by Dynamic Image Analysis, Pharmaceutics 13(11):1894, DOI:10.3390/pharmaceutics13111894*

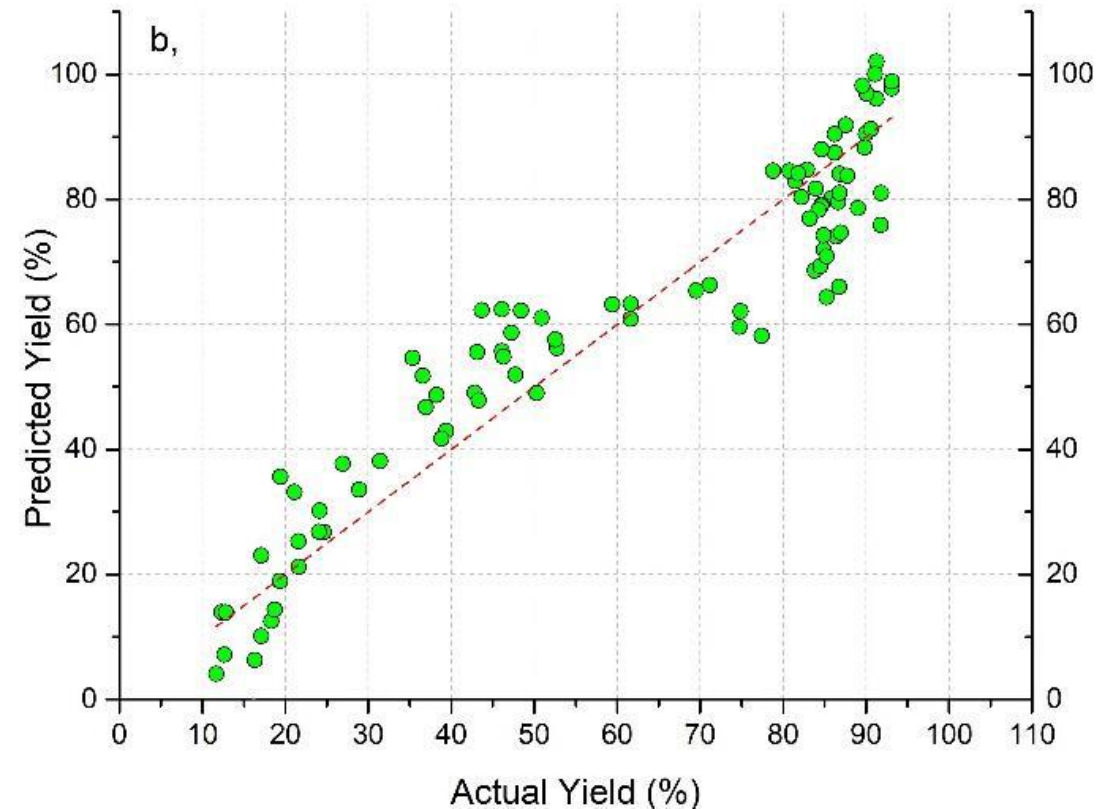
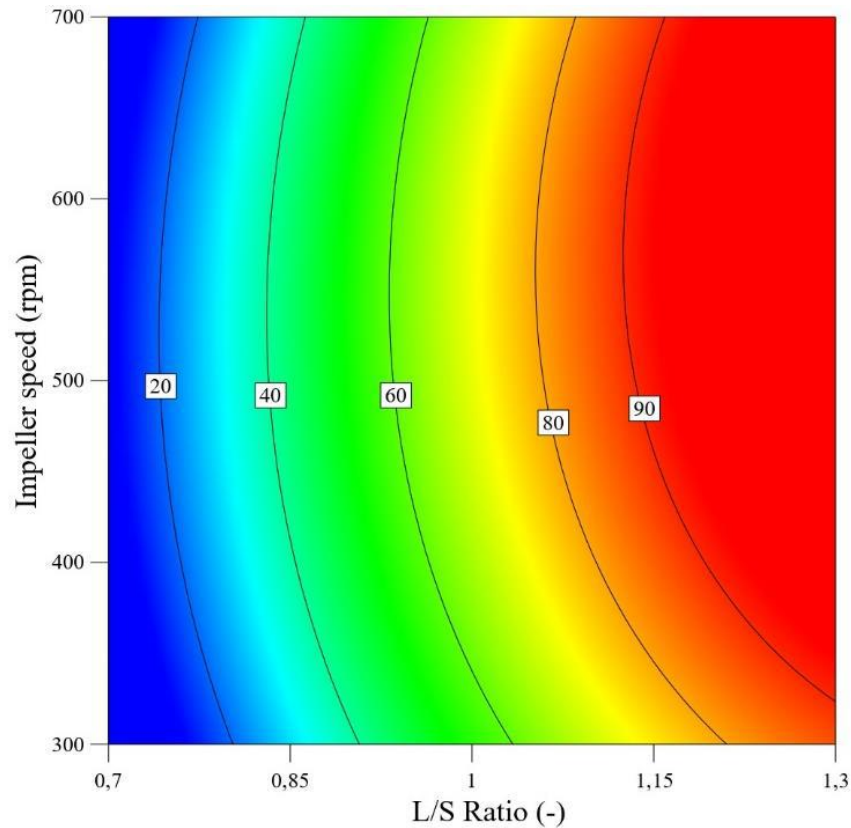
**The CCUV4 Workshop No.1 – 12.9.2022, Prague**

**The project is supported by The International Visegrad Fund, project ID22120032.**





# The influence of high shear granulation on process yield



*Systematic Study of the Effects of High Shear Granulation Parameters on Process Yield, Granule Size, and Shape by Dynamic Image Analysis, Pharmaceutics 13(11):1894, DOI:10.3390/pharmaceutics13111894*

**The CCUV4 Workshop No.1 - 12.9.2022, Prague**

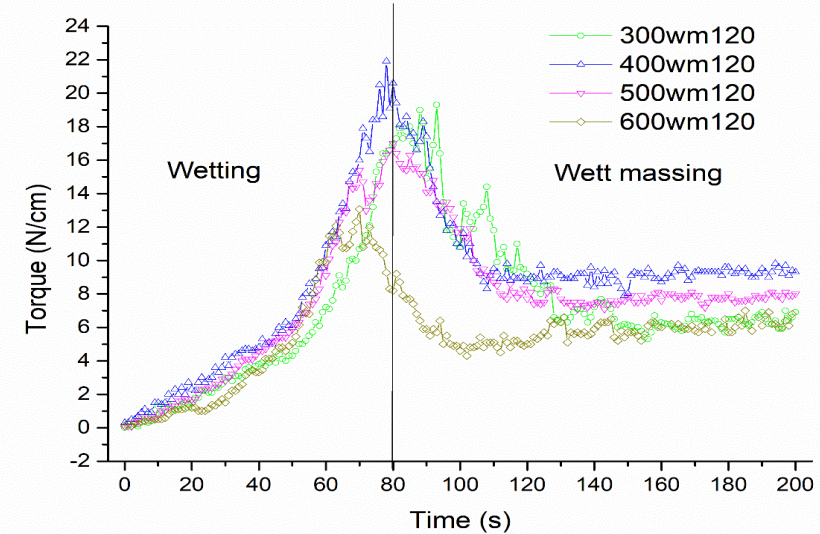
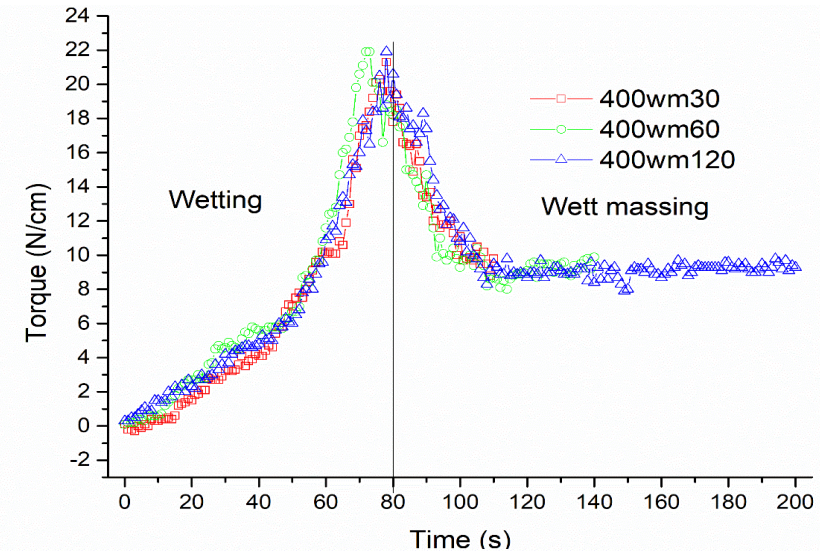
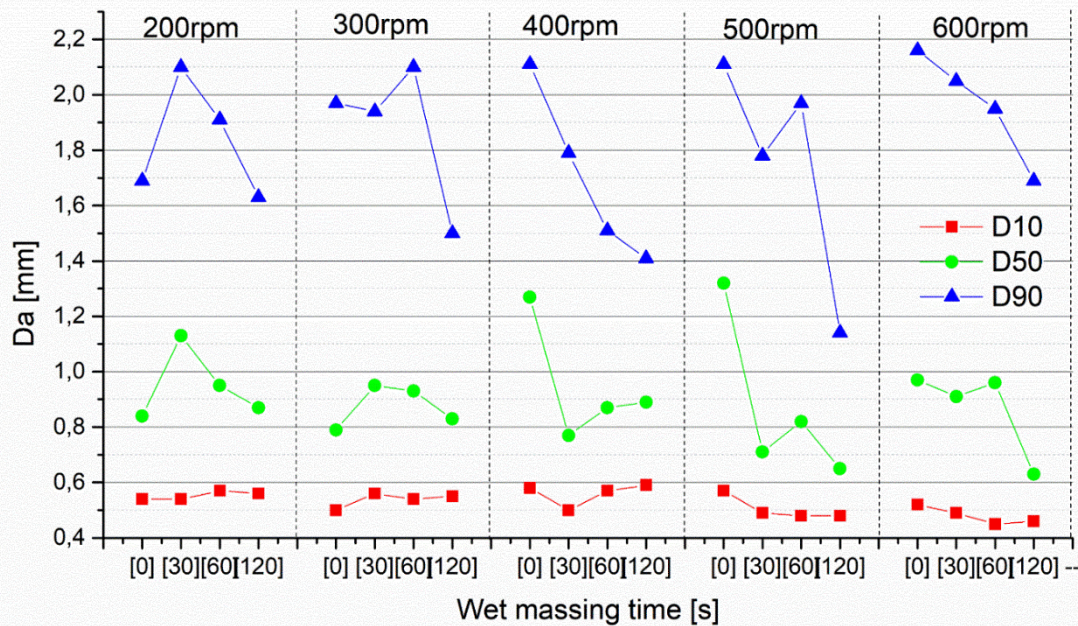
**The project is supported by The International Visegrad Fund, project ID22120032.**





# Measuring torque and energy consumption

- Increase of torque in wetting phase
- Torque change after wetting
- Torque → plateau → Growth & breakage eq.







# Granulation of Waste from Nickel Ore

- Find a suitable agglomeration technology to transform dusty waste from nickel ore processing into stable granules,

## ? Problem ?

electrolytic nickel, powdered nickel and nickel granules from chemical leaching and electrolysis of ore



## ↑ Goal ↑

- Good abrasion resistance
- High porosity - sorbent
- Required particle size - storage



*Granulation of Waste from Mineral Processing, Conference: 2019 International Council on Technologies of Environmental Protection (ICTEP), DOI:10.1109/ICTEP48662.2019.8968954*

**The CCUV4 Workshop No.1 - 12.9.2022, Prague**

**The project is supported by The International Visegrad Fund, project ID22120032.**





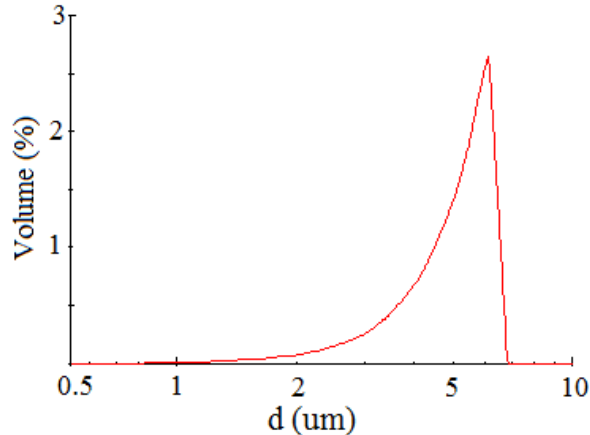
# Granulation of Waste from Nickel Ore

## Experimental Material

- Fine dust, black in color,
- $d_{90} = 6.2 \mu\text{m}$ ,
- Angle of Repose =  $37^\circ$
- Density  $1800 \text{ kg/m}^3$



Component	Symbol	Fraction (%)
Iron	Fe	50 – 80
Chromium oxide	$\text{Cr}_2\text{O}_3$	2.5 – 3.5
Silicon Dioxide	$\text{SiO}_2$	6 – 8
Aluminum oxide	$\text{Al}_2\text{O}_3$	6 – 8
Calcium Carbonate	CaO	2.5 – 3.5
Nickel	Ni	0.17
Phosphorous trioxide	$\text{P}_2\text{O}_3$	0.6 – 0.18



## High-shear Granulation Experiments

- Impeller 800 rpm,
- Chopper 1000 rpm,
- Batch 400 g,
- Duration of the process 5 min,
- Liquid - utility water



*Granulation of Waste from Mineral Processing, Conference: 2019 International Council on Technologies of Environmental Protection (ICTEP), DOI:10.1109/ICTEP48662.2019.8968954*

**The CCUV4 Workshop No.1 – 12.9.2022, Prague**

**The project is supported by The International Visegrad Fund, project ID22120032.**

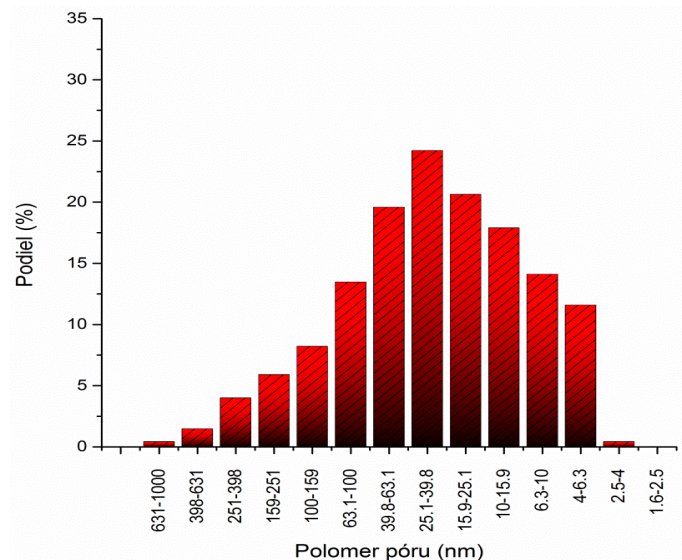




# Granulation of Waste from Nickel Ore

## Granule porosity

- A high proportion of micropores
- 30% of pores below 10 nm
- Large specific surface area
- Good sorbent.



## Conclusion

- Granules with high tensile strength
- Good abrasion resistance and porosity
- A smaller amount of granulation liquid
- Shorter process time



*Granulation of Waste from Mineral Processing, Conference: 2019 International Council on Technologies of Environmental Protection (ICTEP), DOI:10.1109/ICTEP48662.2019.8968954*

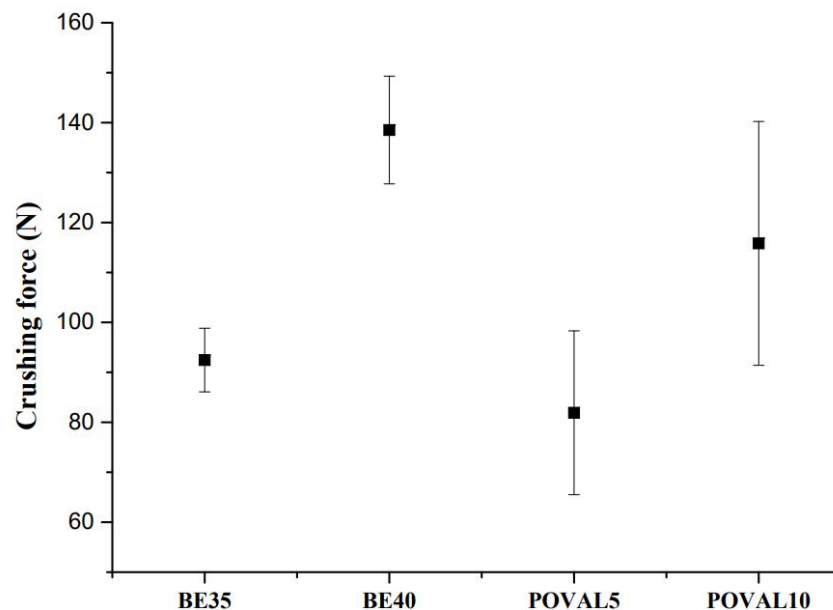
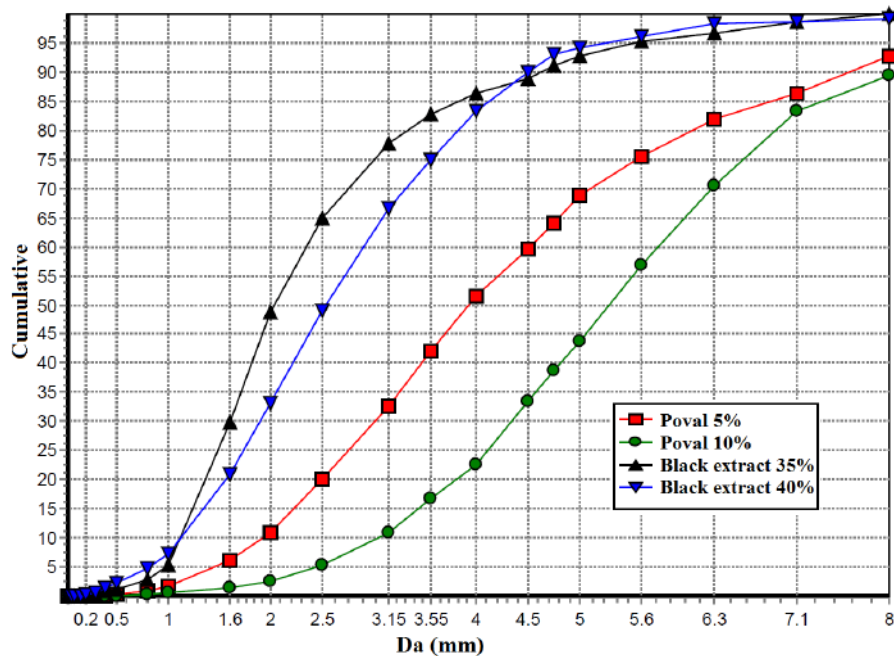
**The CCUV4 Workshop No.1 – 12.9.2022, Prague**

**The project is supported by The International Visegrad Fund, project ID22120032.**





# Use of waste liquids in limestone granulation



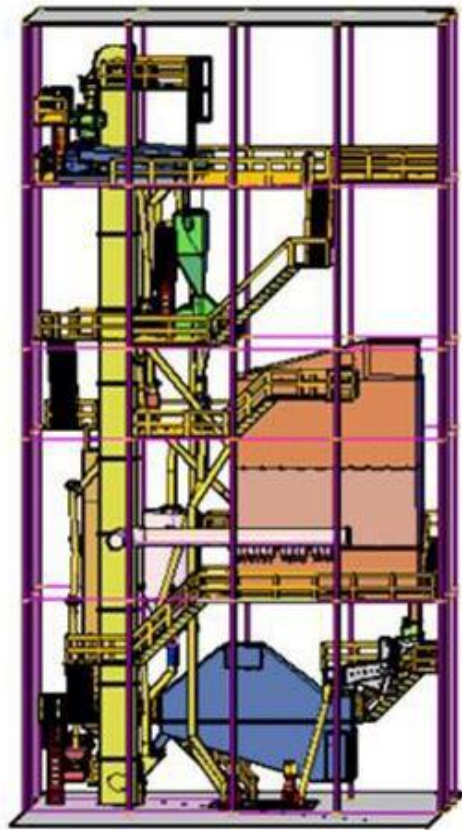
## Materials

- Limestone, Black extract (lye from paper mills),
- Poval (polyvinyl alcohol)

## Methods

- Plate granulation (480 rpm), 45°
- 600 g, 10 min

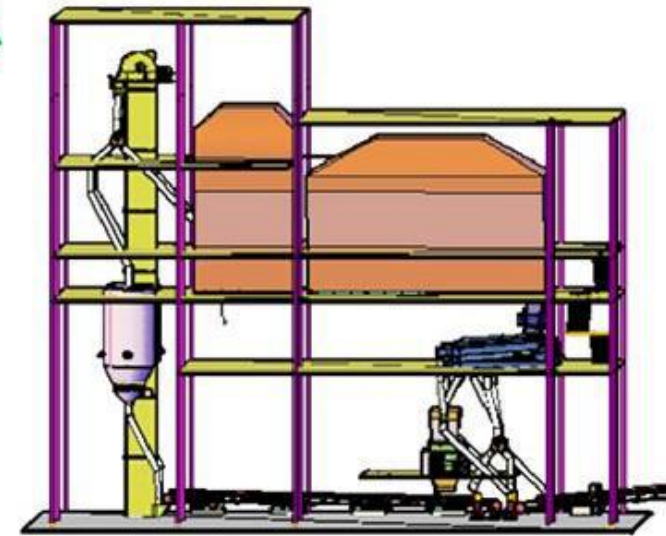




**Traditional Granulation Process**



- ▶ Lower building cost
- ▶ Lower total investment cost
- ▶ Facilitated operations
- ▶ Lower power consumption



**CRG Process**

[http://greengranulation.com/downloads/publication/GGT-CRG\\_2015\\_EN.pdf](http://greengranulation.com/downloads/publication/GGT-CRG_2015_EN.pdf)

**The CCUV4 Workshop No.1 - 12.9.2022, Prague**

**The project is supported by The International Visegrad Fund, project ID22120032.**



# Acknowledgment

- Visegrad Fund

CCUV4 - Green Deal strategies for V4 countries:  
The needs and challenges to reach low-carbon industry.

The CCUV4 Workshop No.1 - 12.9.2022, Prague

The project is supported by The International Visegrad Fund,  
project ID22120032.



 **MINISTRY**  
OF EDUCATION, SCIENCE,  
RESEARCH AND SPORT  
OF THE SLOVAK REPUBLIC

This research was created on the basis of the projects "**CEVIS Science**" (ITMS2014+ project code: 313021BXZ1) supported by Operational Programme Integrated Infrastructure and funded by the European Regional Development Fund. The authors wish to acknowledge the Ministry of Education, Science, Research and Sport of the Slovak Republic for the financial support of this research by grants KEGA 036STU-4/2020 and KEGA 021STU-4/2022.

- 
- Visegrad Fund
- 
- 

CCUV4 - Green Deal strategies for V4 countries:  
The needs and challenges to reach low-carbon industry.  
**The CUV4 Workshop No.1 - 12.9.2022, Prague**



**Thank you for your attention.**

•••• STU  
•••• SjF

SLOVAK UNIVERSITY OF  
TECHNOLOGY IN BRATISLAVA  
FACULTY OF MECHANICAL ENGINEERING  
INSTITUTE OF PROCESS ENGINEERING

**Ing. Matúš Čierny**  
**matus.cierny@stuba.sk**

