OTEC
PRECISION FINISHING SOLUTIONS

DEM PROCESS SIMULATION: THE KEY TO TOMORROW'S CENTRIFUGAL DISC FINISH TECHNOLOGY

Deburring EXPO expert forum 2023
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DEBURRING EXPO

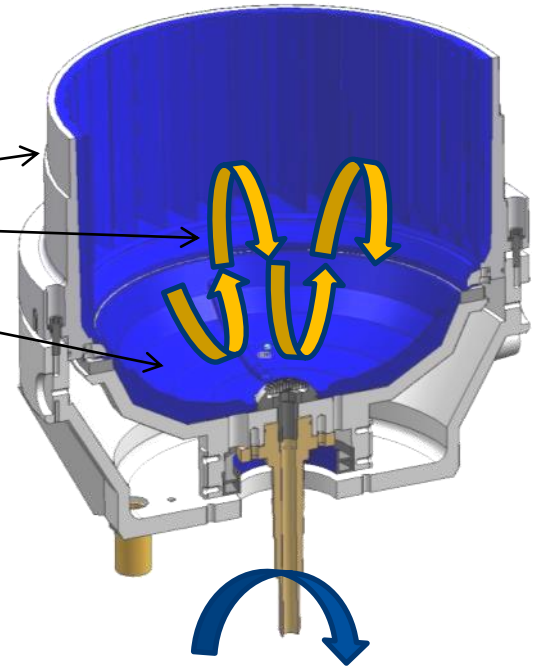
AGENDA

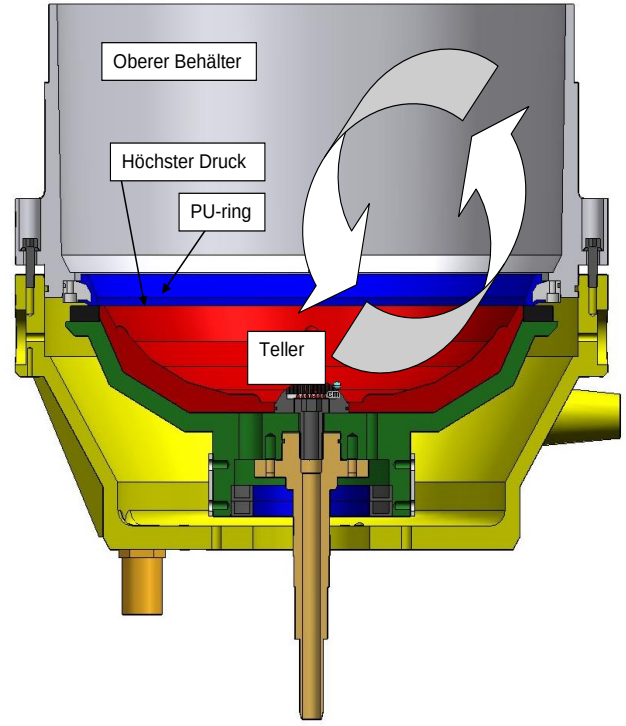
1. OTEC CF-technology, DEM process simulation
2. Problem Impact markings und extreme-test for analysis
3. Evaluation extreme-test and comparison DEM process simulation
4. Furhter developments e.g. OTEC pressure cover

CENTRIFUGAL DISC FINISHING-MACHINE

Principle

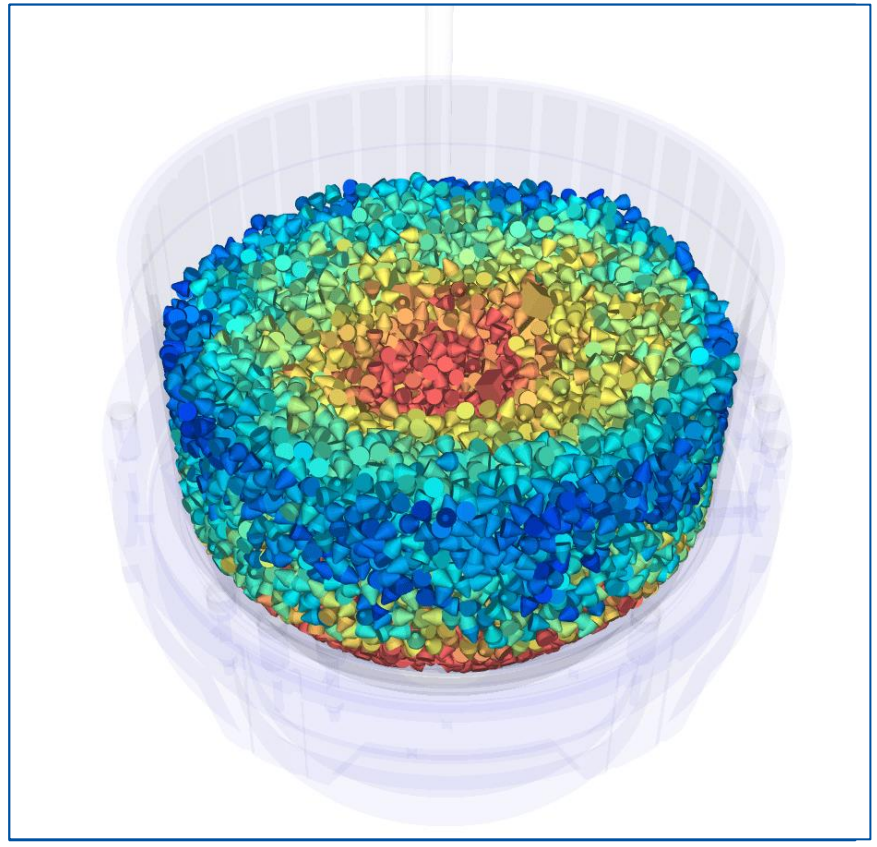
- Stationary cylinder
- Movement of the media
- Rotating disc





CENTRIFUGAL DISC FINISHING-PROCESS

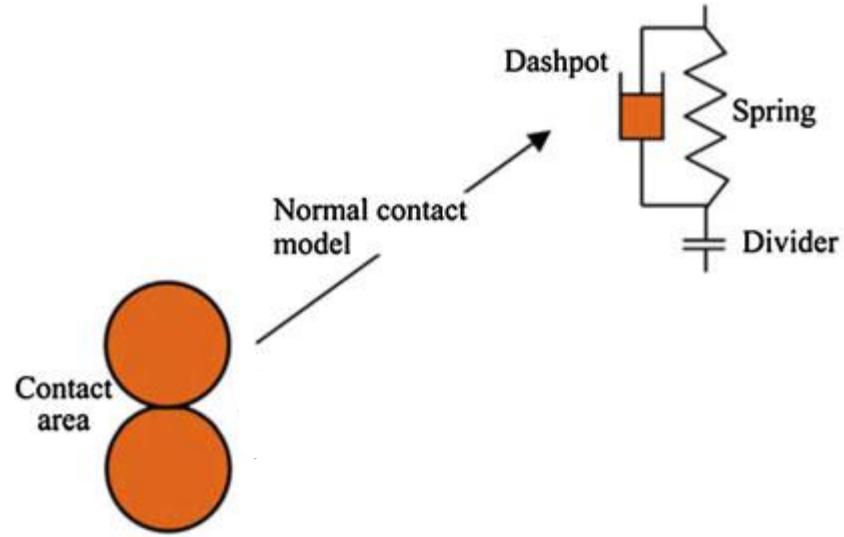
Discrete Element Method Simulation

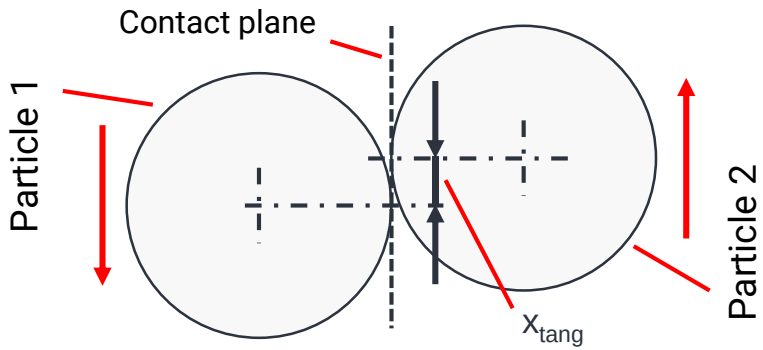


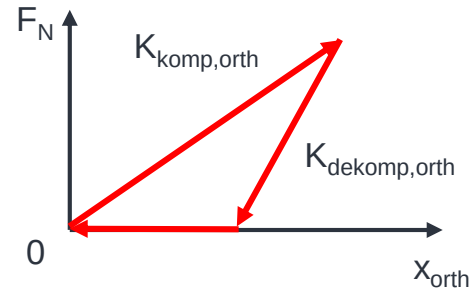
DEM SIMULATION

Mass finishing becomes digital…

- Motion and interaction of Mio. Individual particles
- No computation grid, easy complex motion
- Explicit, no “classic convergence” needed





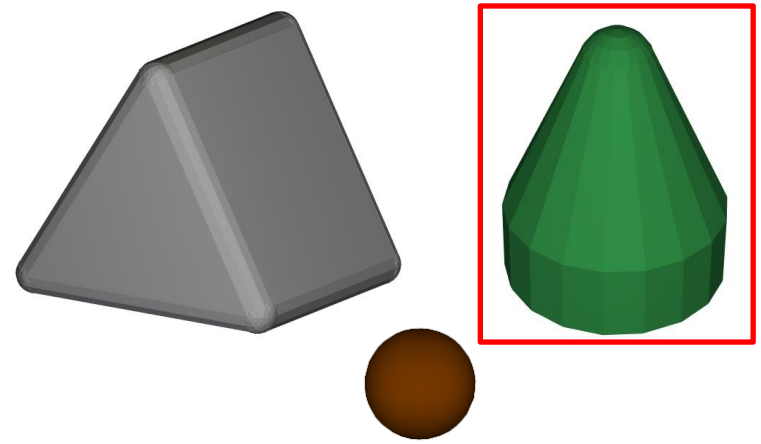


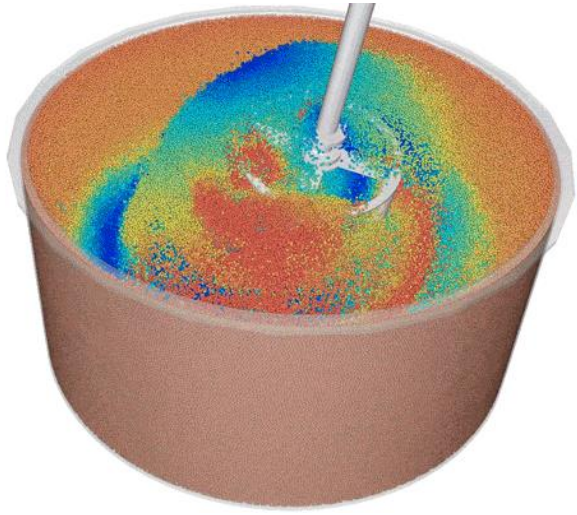
source: Zhao. T.

DEM SIMULATION

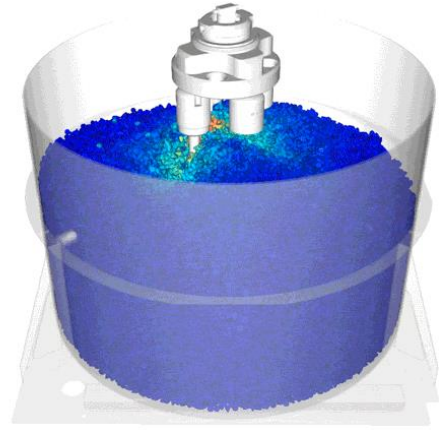
Mass finishing becomes digital…

- No shape limitations
- Any mass finishing process possible

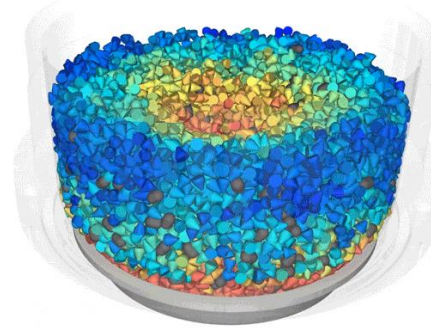




SF Streamfinish



DF Drag Finish



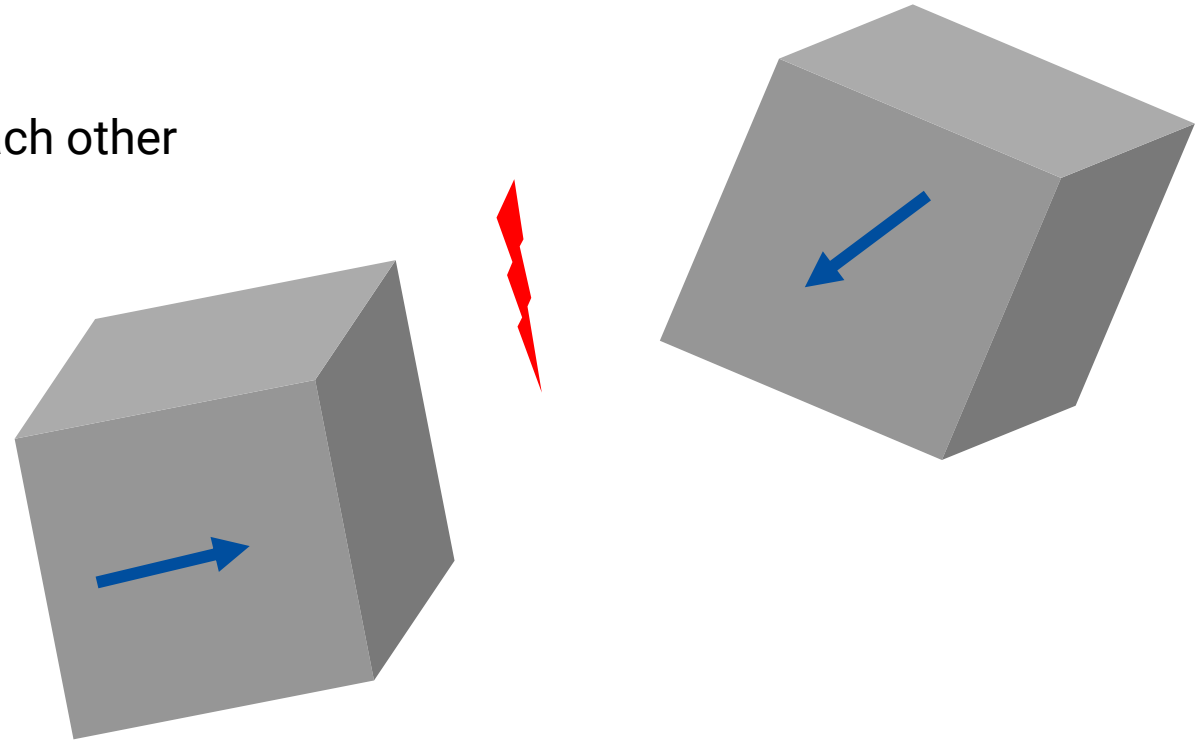
CF Centrifugal Disk Finish

BULK PROCESSES ISSUE IMPACT MARKINGS

Todays focus

- Bulk processes are not guided
- Workpieces can collide with each other

… and they do.



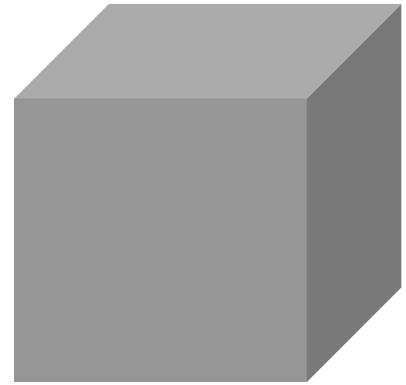
BULK PROCESSES ISSUE IMPACT MARKINGS

Test under extreme conditions

- Impact markings can occur
- Extent and penetration depth is crucial
- Result strongly depended on process parameter and number of workpieces

→ Test with an approach sensitive to impact markings

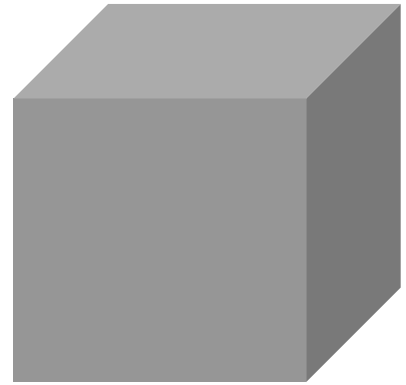
- Aluminum-cube 15 x 15 x 15 mm
- Sharp edges, soft, „big“



BULK PROCESSES ISSUE IMPACT MARKINGS

Test under extreme conditions

- **Question:** How many parts can you process at once in a „useful“ way?



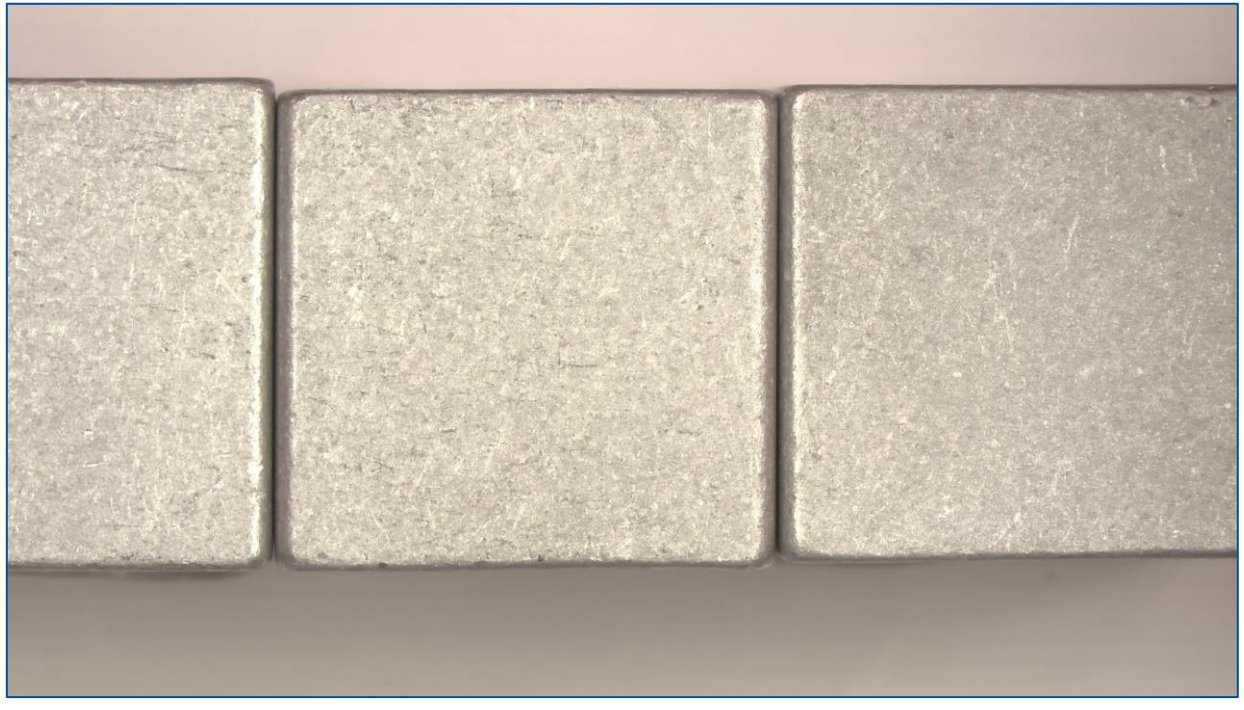
→Tests with **20**, **120**, **220** and **320** cubes

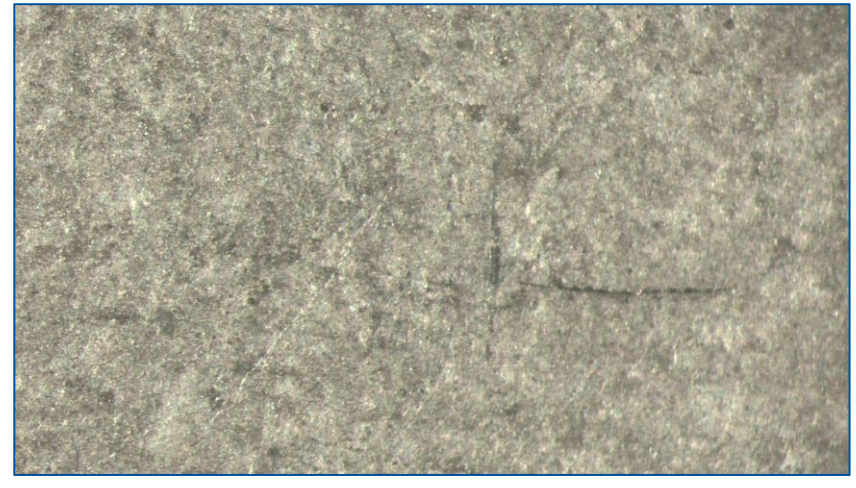
→Optical analysis, but how?

BULK PROCESSES ISSUE IMPACT MARKINGS

Evaluation approach 1 – optical top light

- Initial rough grinding trough mass finishing for similar input quality

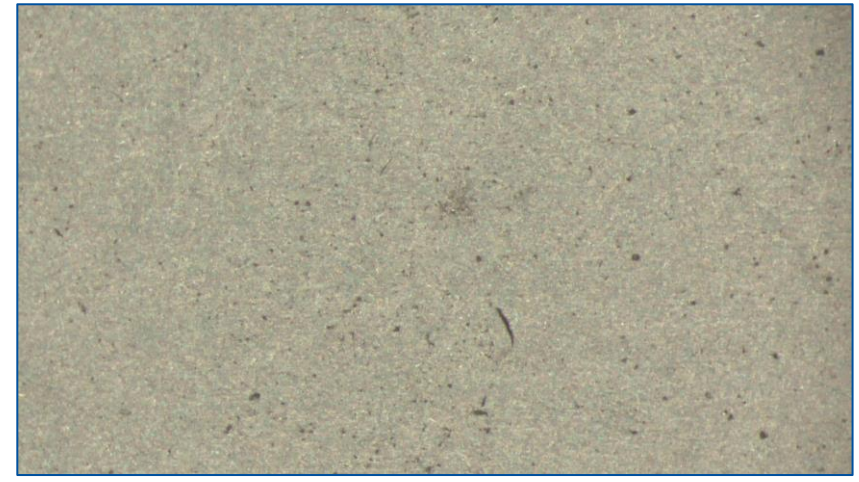


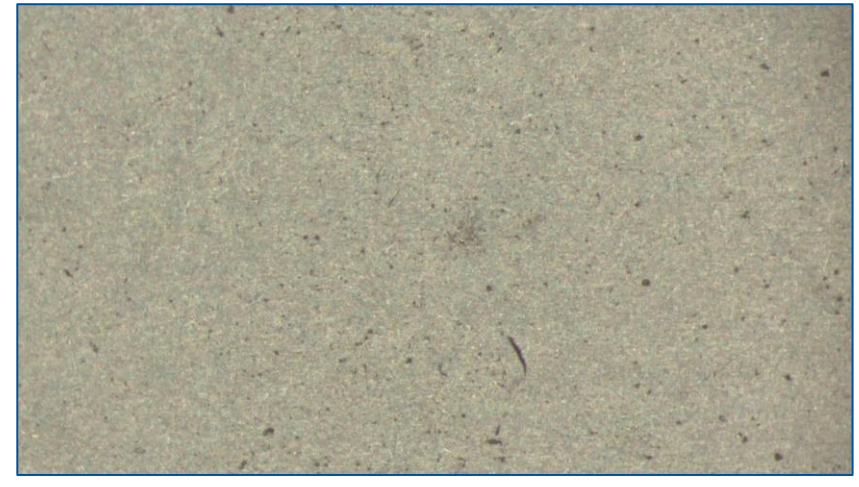


BULK PROCESSES ISSUE IMPACT MARKINGS

Evaluation approach 1 – 20 parts

- **20** parts, barely markings

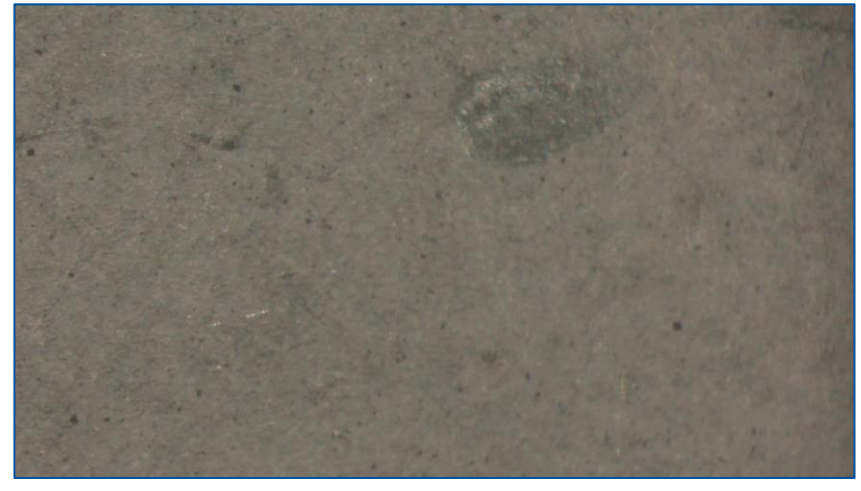




BULK PROCESSES ISSUE IMPACT MARKINGS

Evaluation approach 1 – 320 parts

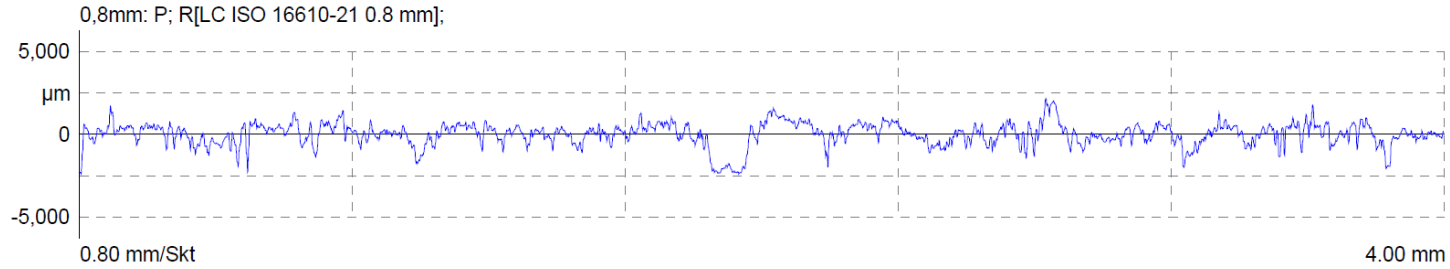
- **320** parts many markings noticeable



BULK PROCESSES ISSUE IMPACT MARKINGS

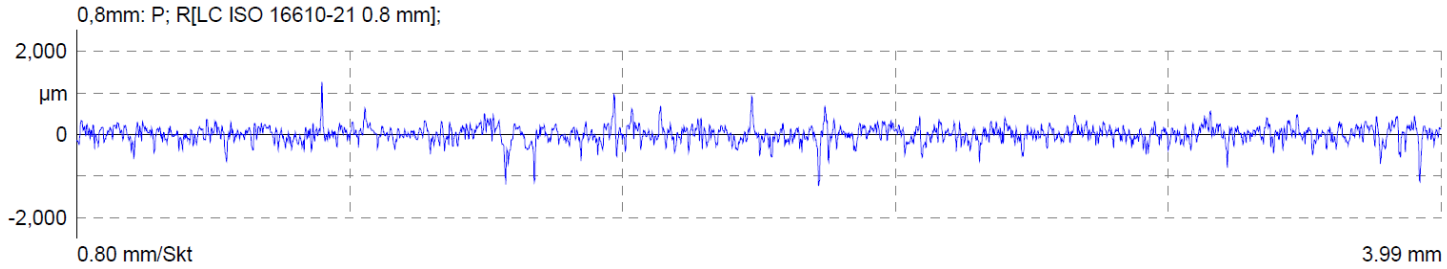
Evaluation approach 2 – roughness measurement tactile

Initial
Rough mass finish



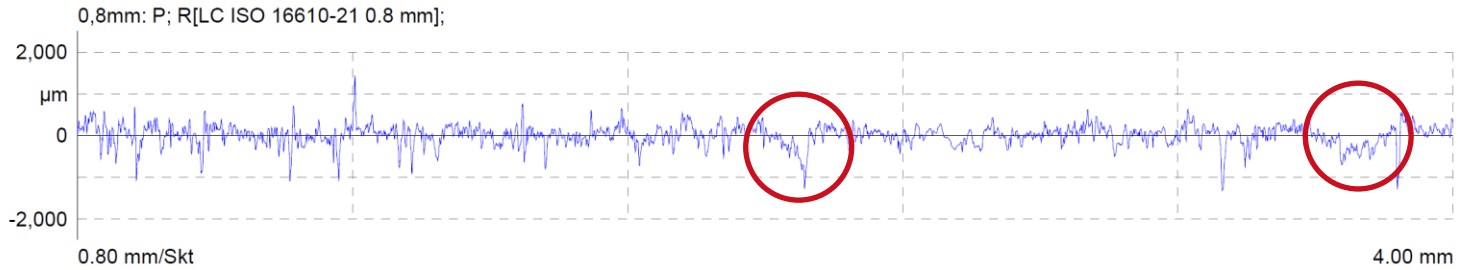
Ra: 0,51
Rz: 3,62

20 Teile
Finer mass finish



Ra: 0,15
Rz: 1,81

320 Teile
Finer mass finish



Ra: 0,18
Rz: 1,81

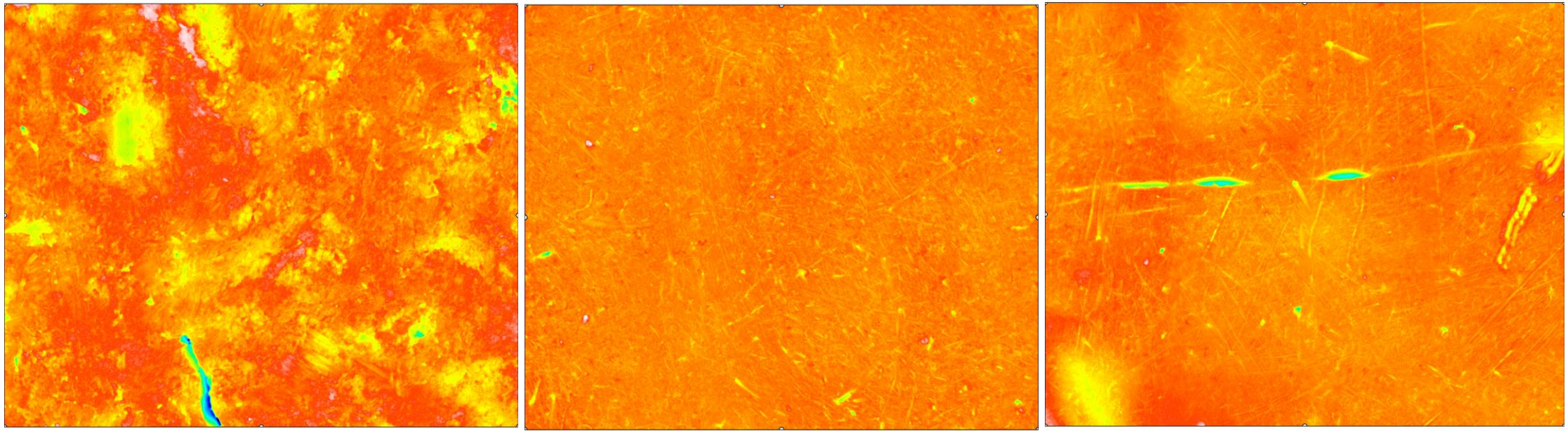
BULK PROCESSES ISSUE IMPACT MARKINGS

Evaluation approach 3 – 3D confocal – *1125 x 925 µm*

Initial
Rough mass finish

20 Parts
Finer mass finish

320 Parts
Finer mass finish



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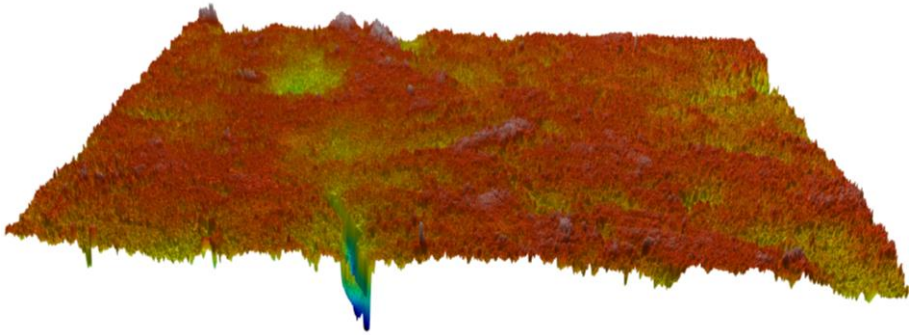
BULK PROCESSES ISSUE IMPACT MARKINGS

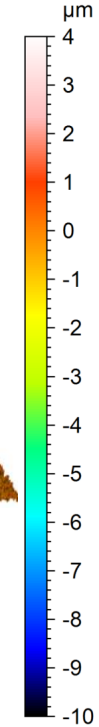
Evaluation approach 3 – 3D confocal – *1125 x 925 µm*

Initial
Rough mass finish



20 Parts
Finer mass finish

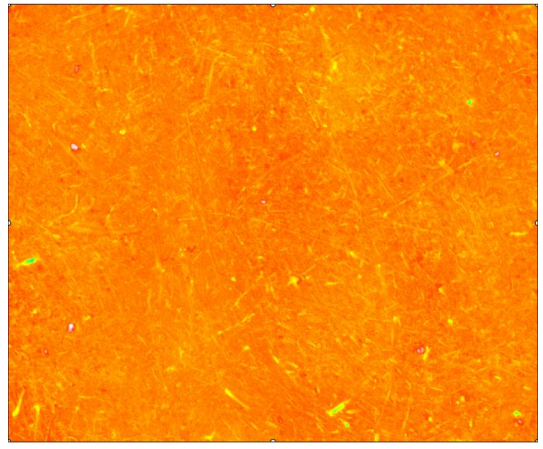
320 Parts
Finer mass finish



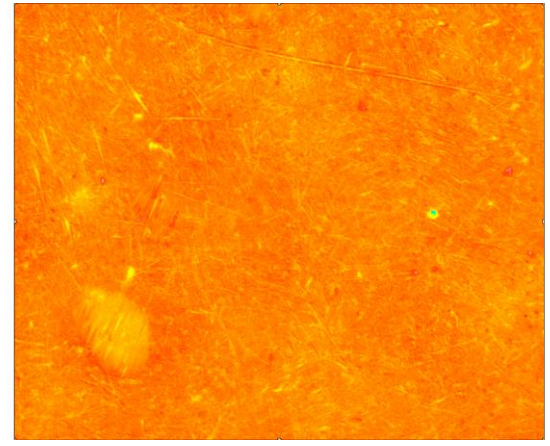
BULK PROCESSES ISSUE IMPACT MARKINGS

Evaluation approach 3 – 3D confocal – *1125 x 925 µm*

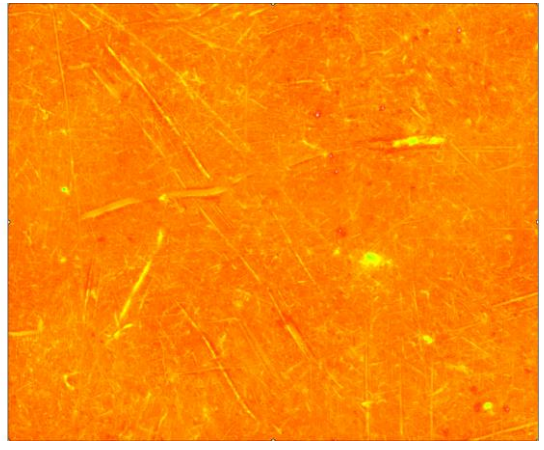
20 Parts



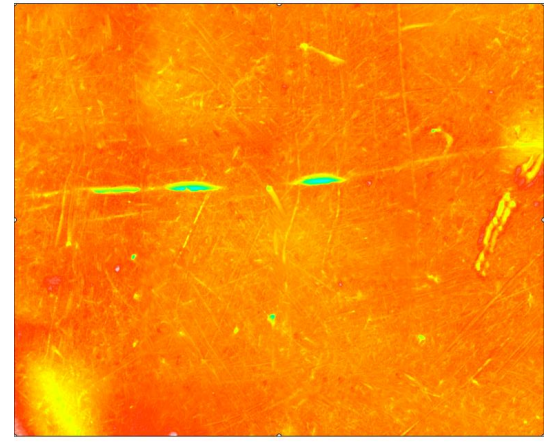
220 Parts

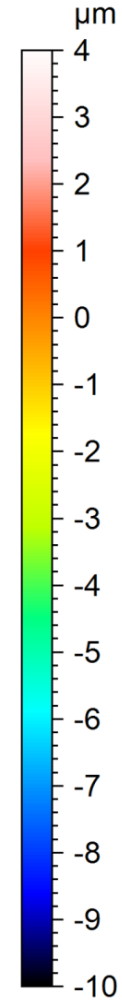


120 Parts



320 Parts



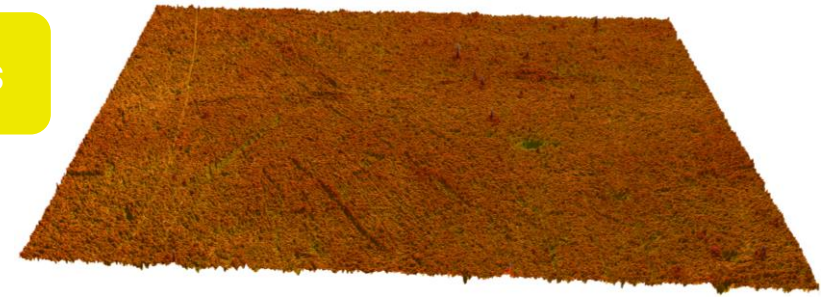


BULK PROCESSES ISSUE IMPACT MARKINGS

Evaluation approach 3 – 3D confocal – *1125 x 925 µm*

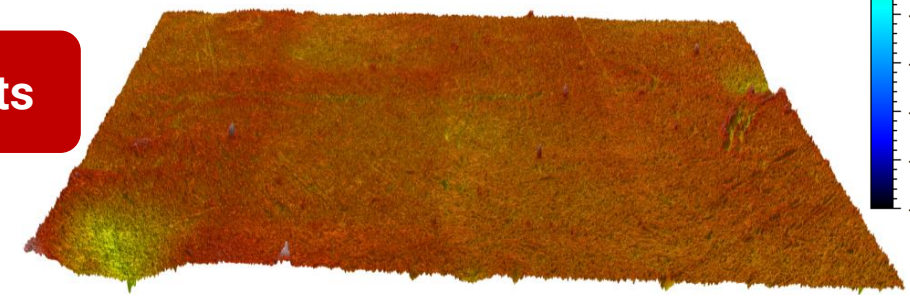
20 Parts

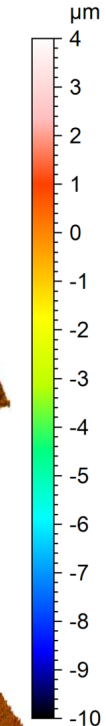
120 Parts



220 Parts

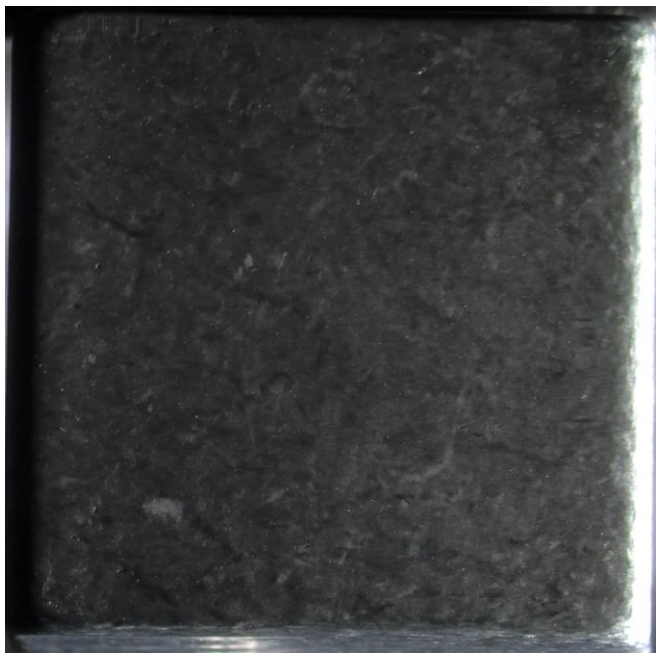
320 Parts

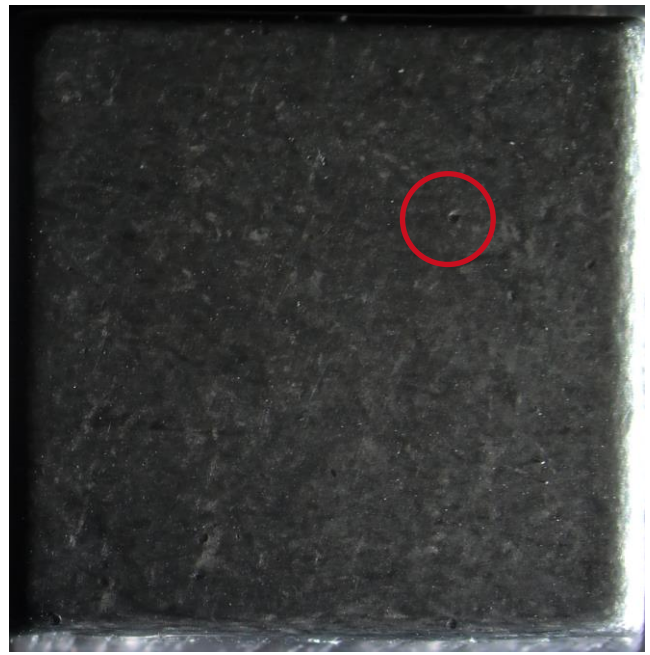


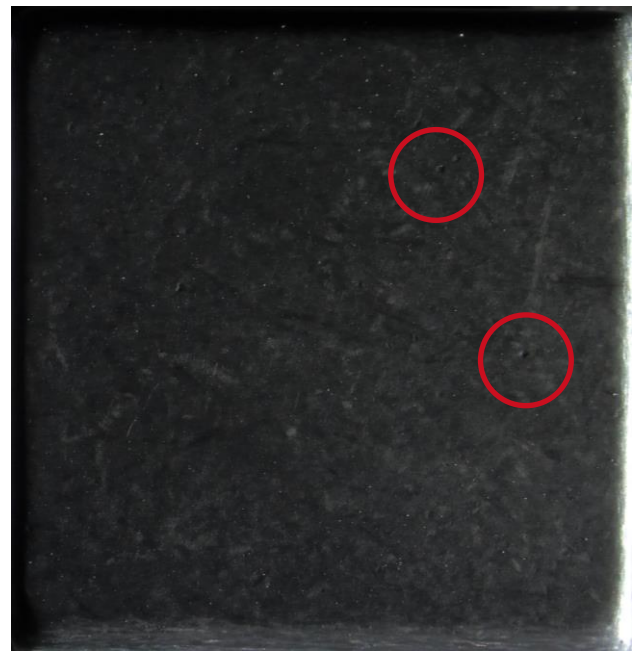


BULK PROCESSES ISSUE IMPACT MARKINGS

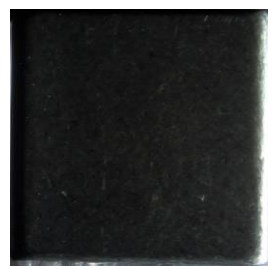
Evaluation approach 4 – shadow picture created by flat, one-sided lighting







20 Parts



BULK PROCESSES ISSUE IMPACT MARKINGS

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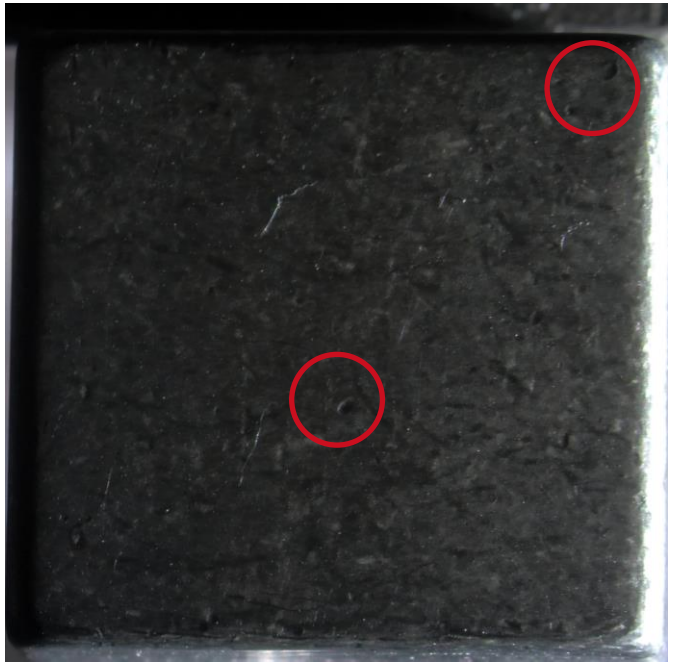
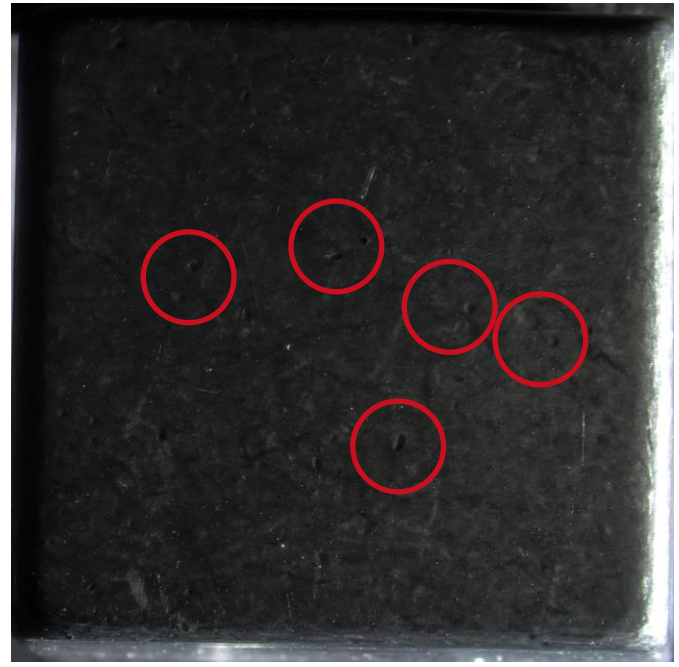
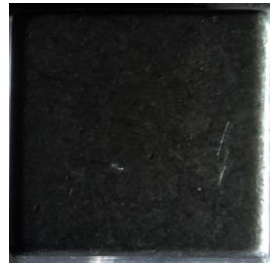


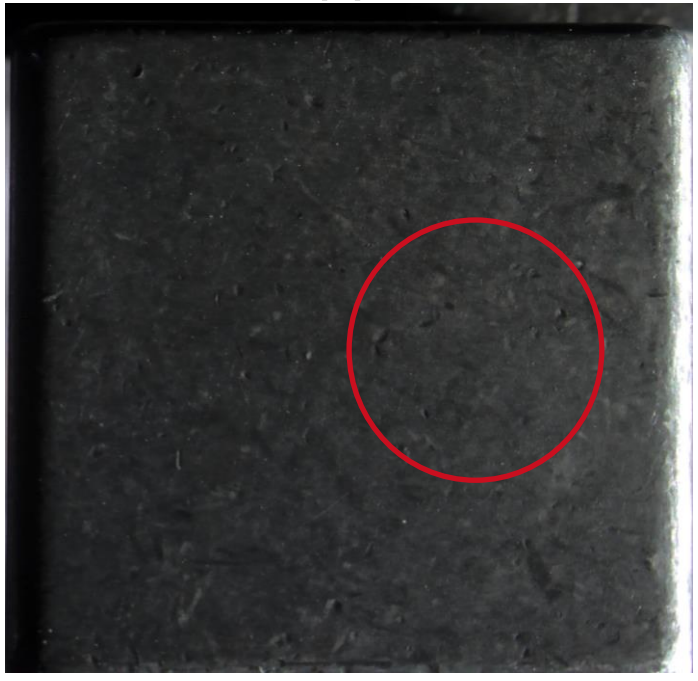


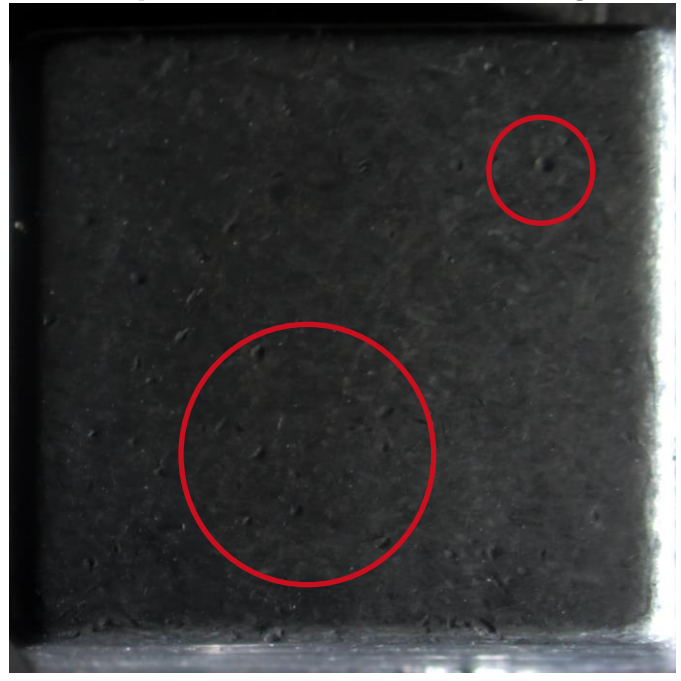
120 Parts

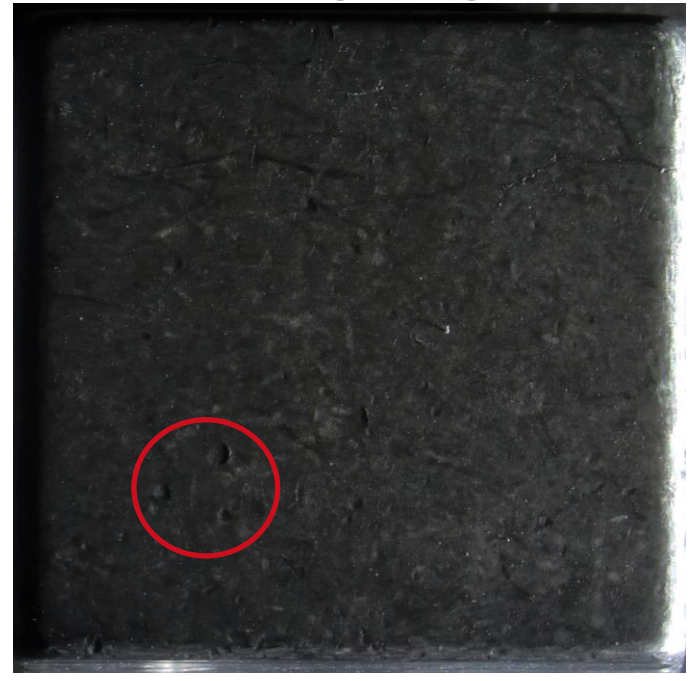


BULK PROCESSES ISSUE IMPACT MARKINGS

Evaluation approach 4 – shadow picture created by flat, one-sided lighting



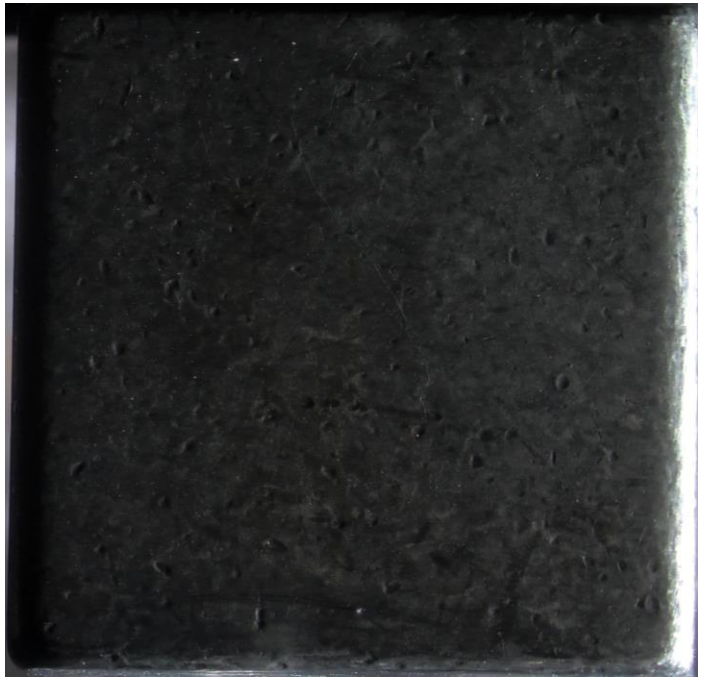


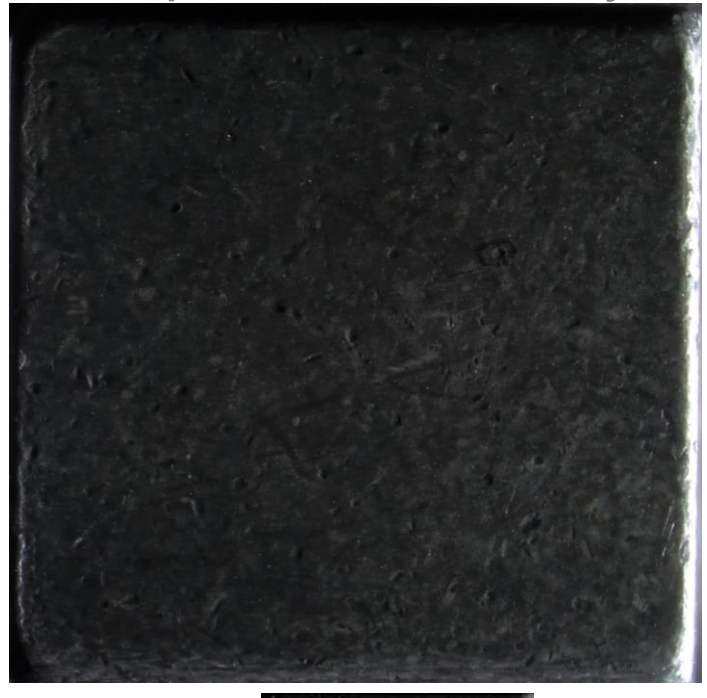


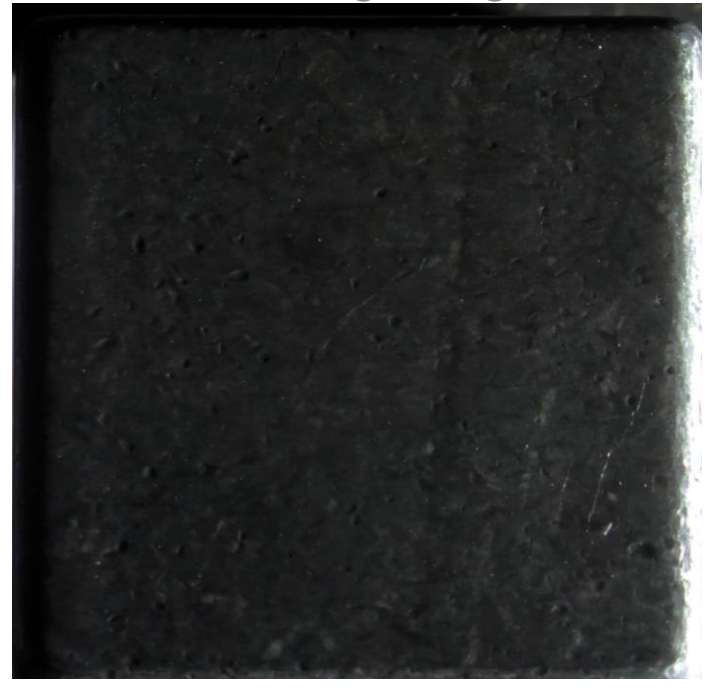
220 Parts

BULK PROCESSES ISSUE IMPACT MARKINGS

Evaluation approach 4 – shadow picture created by flat, one-sided lighting







320 Parts

BULK PROCESSES ISSUE IMPACT MARKINGS

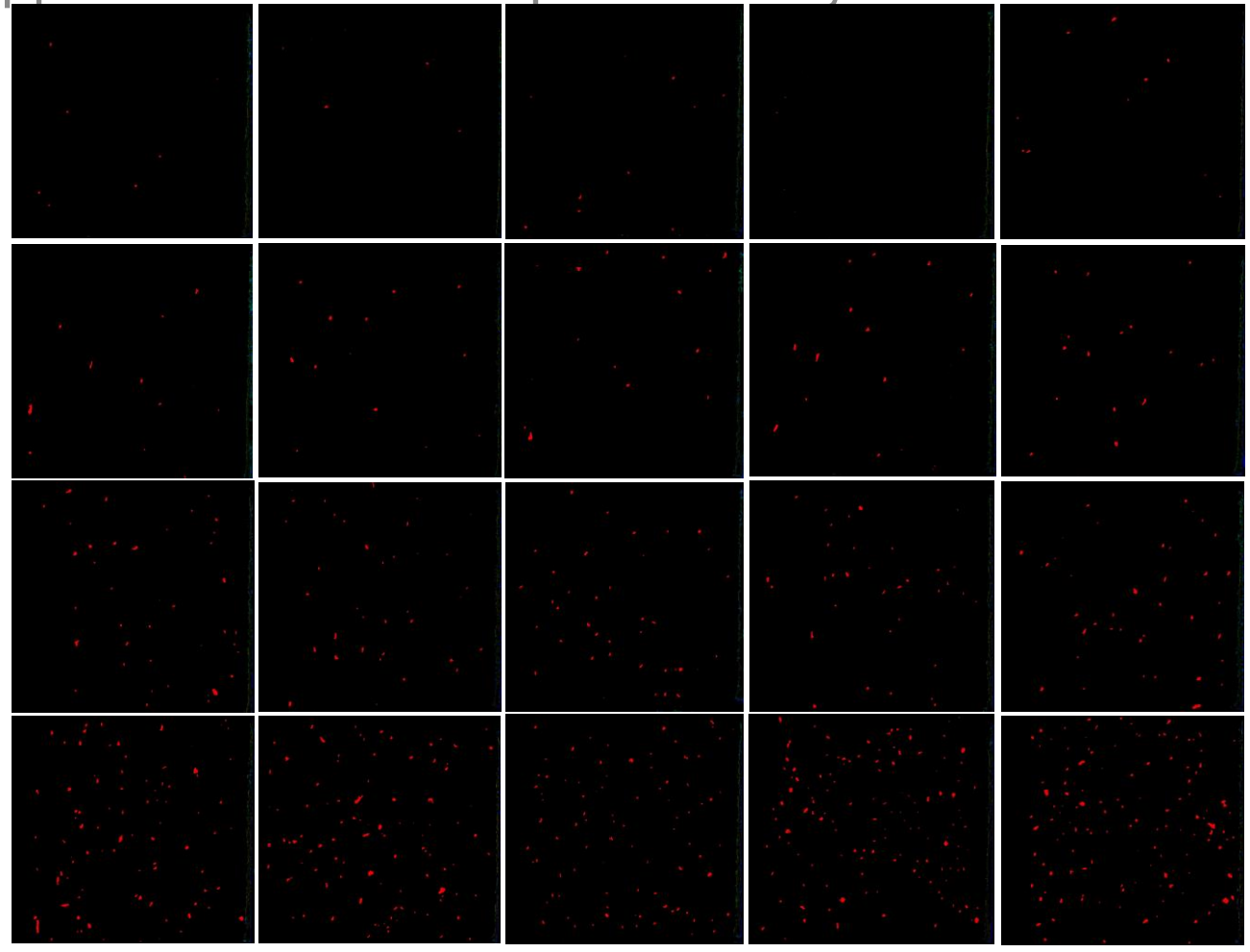
Evaluation approach 4 – shadow picture analysis

20 Parts

120 Parts

220 Parts

320 Parts



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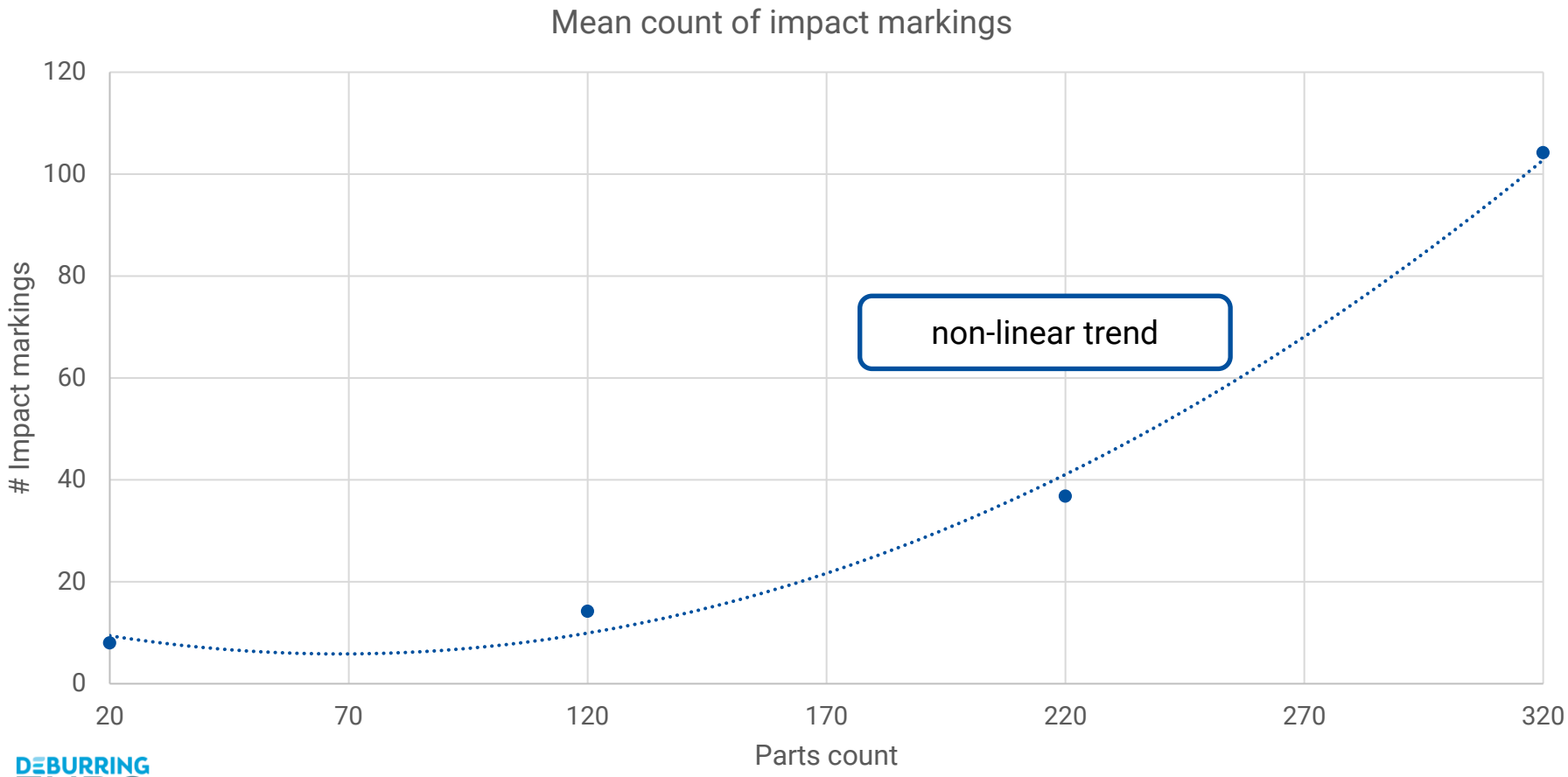
BULK PROCESSES ISSUE IMPACT MARKINGS

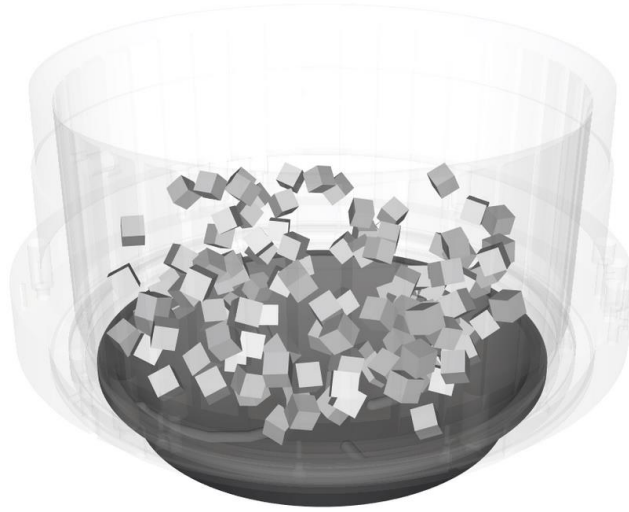
Evaluation approach 4 – shadow picture analysis



SIMULATION RESULTS

Overview – only cubes displayed

20 Parts



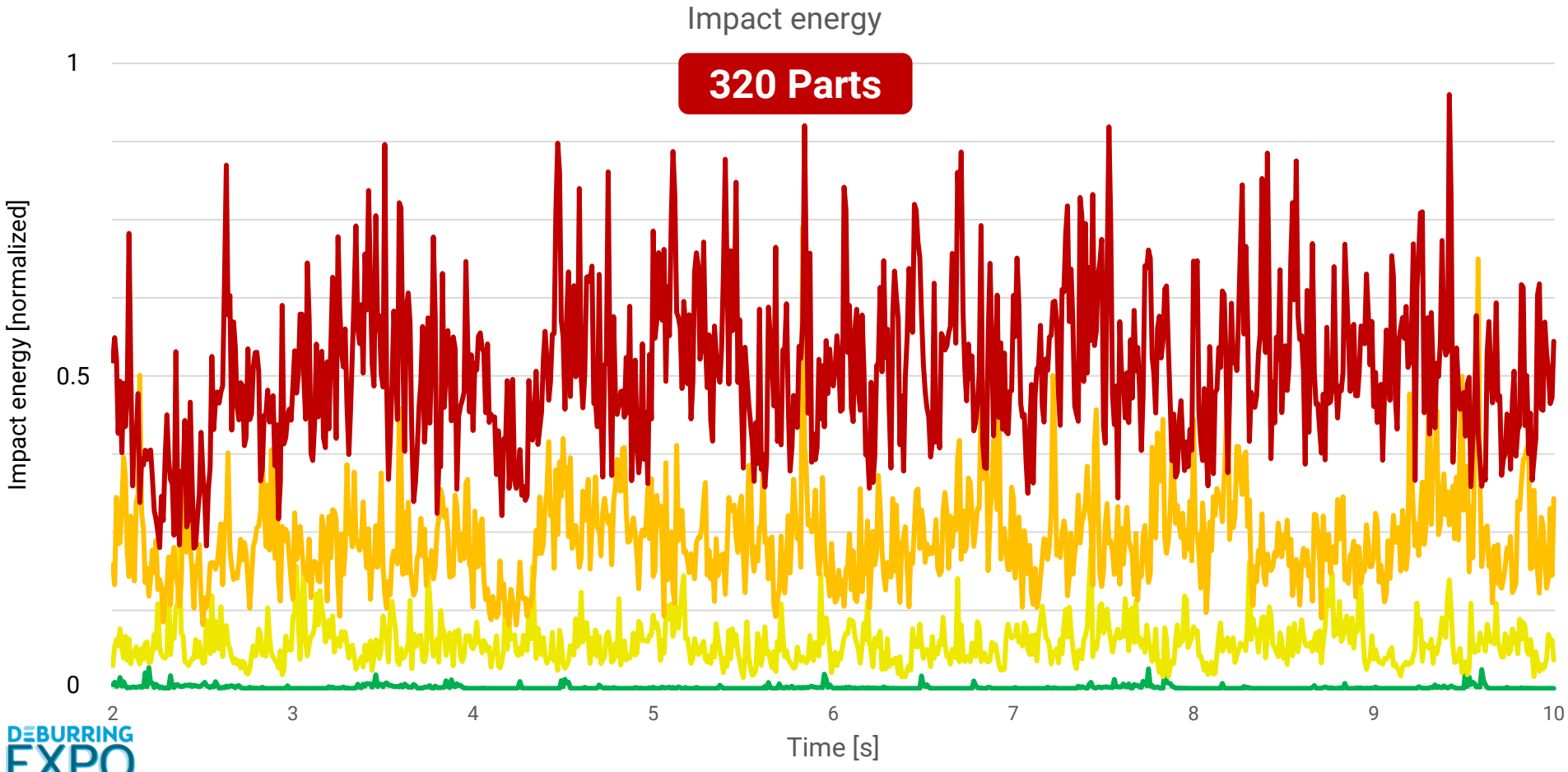
120 Parts

220 Parts

320 Parts

SIMULATION RESULTS

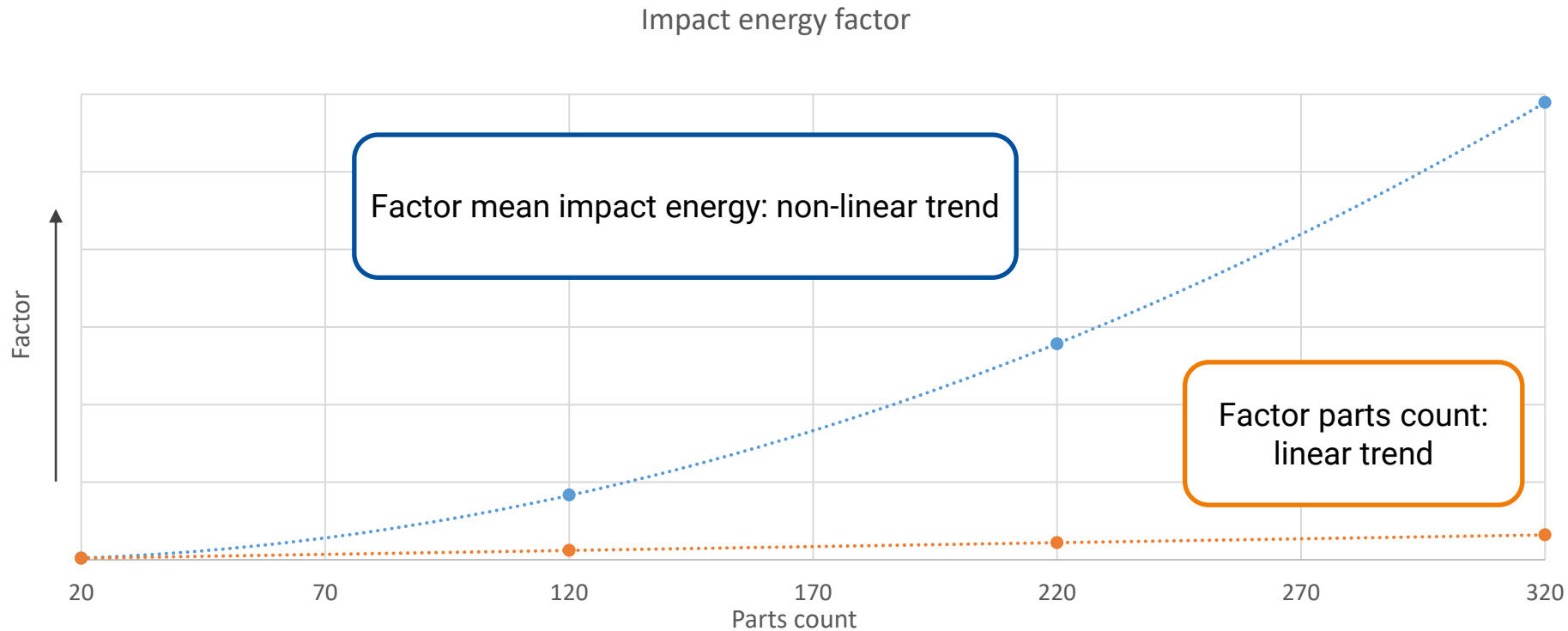
Impact energy / parts count



SIMULATION RESULTS

Impact energy / parts count -- mean

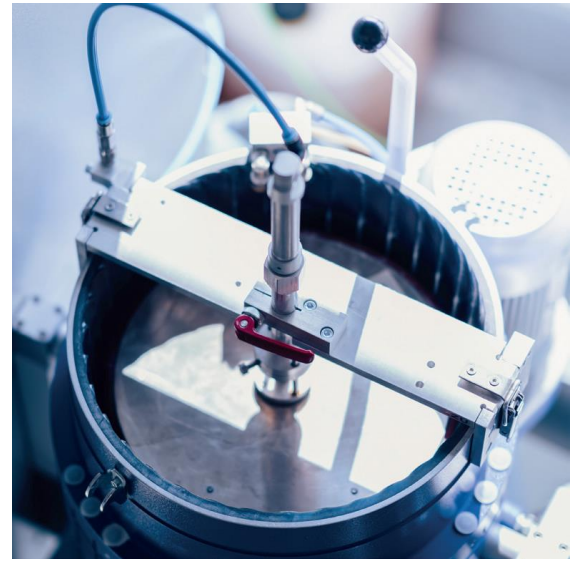
Comparable non-linear trend



SIMULATION FOR FURTHER DEVELOPMENT

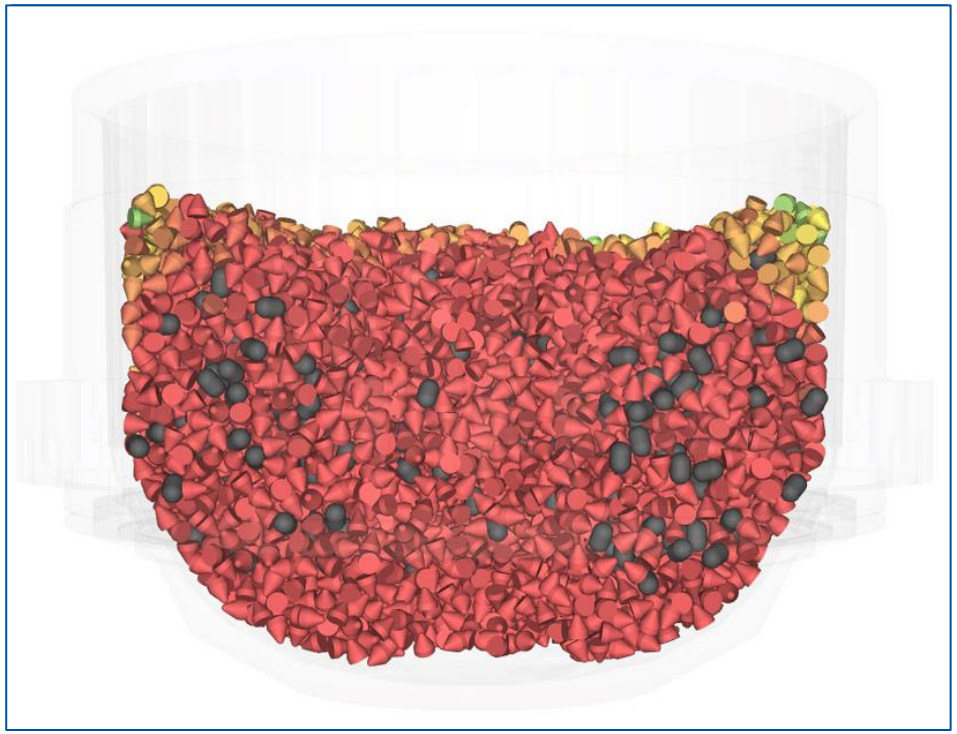
Example pressure cover

- Intensive processing
- Removes rough structures



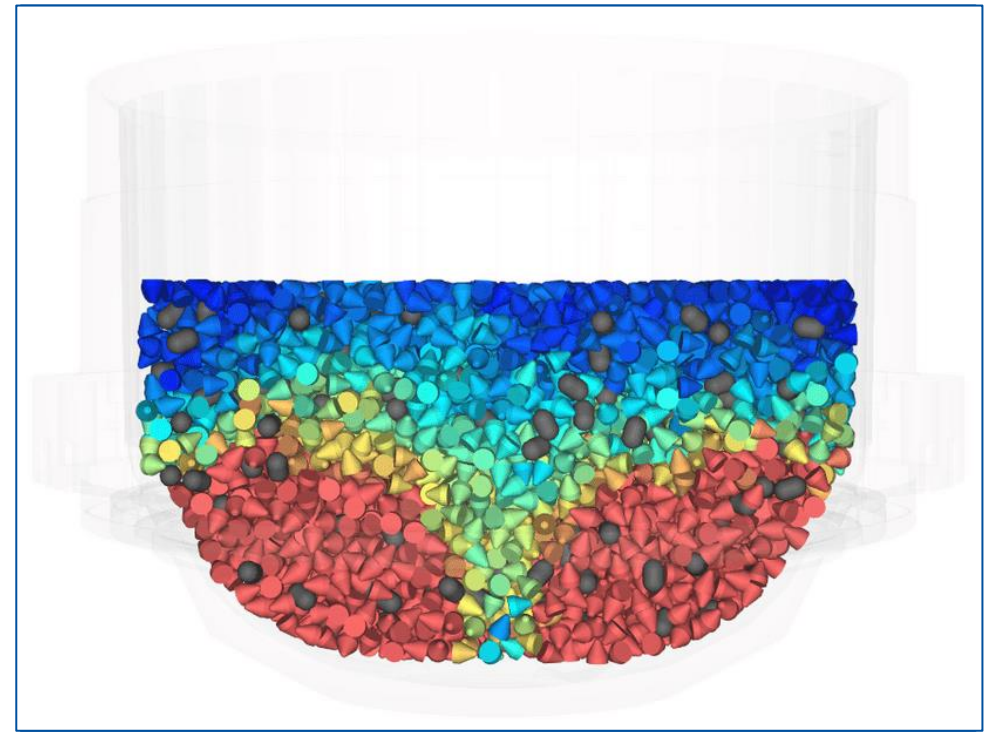
SIMULATION FOR FURTHER DEVELOPMENT

Example pressure cover



higher rpm

with pressure cover



higher rpm

SIMULATION FOR FURTHER DEVELOPMENT

Example pressure cover

- Movement somewhat slowed, but relative speed crucial
- The actual processing takes place in the lower part of the process

Therefore, under these conditions:

- **Relative speed** increased by a factor of **1.2** due to pressure cover
- **Normal force** increased by a factor of **2.2**!
- Workpiece-to-workpiece impact energy slightly higher

→ Ideal if a more powerful grinding process is needed

FAZIT

- Process simulation allows for very useful quantitative analyses
- Process optimizations are simplified and can be "measured" in a simulated manner
- High potential for further development of the established centrifugal disc technique
- Additional potential: Development of prediction regarding edge rounding and roughness

THANK YOU FOR YOUR INTEREST!

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