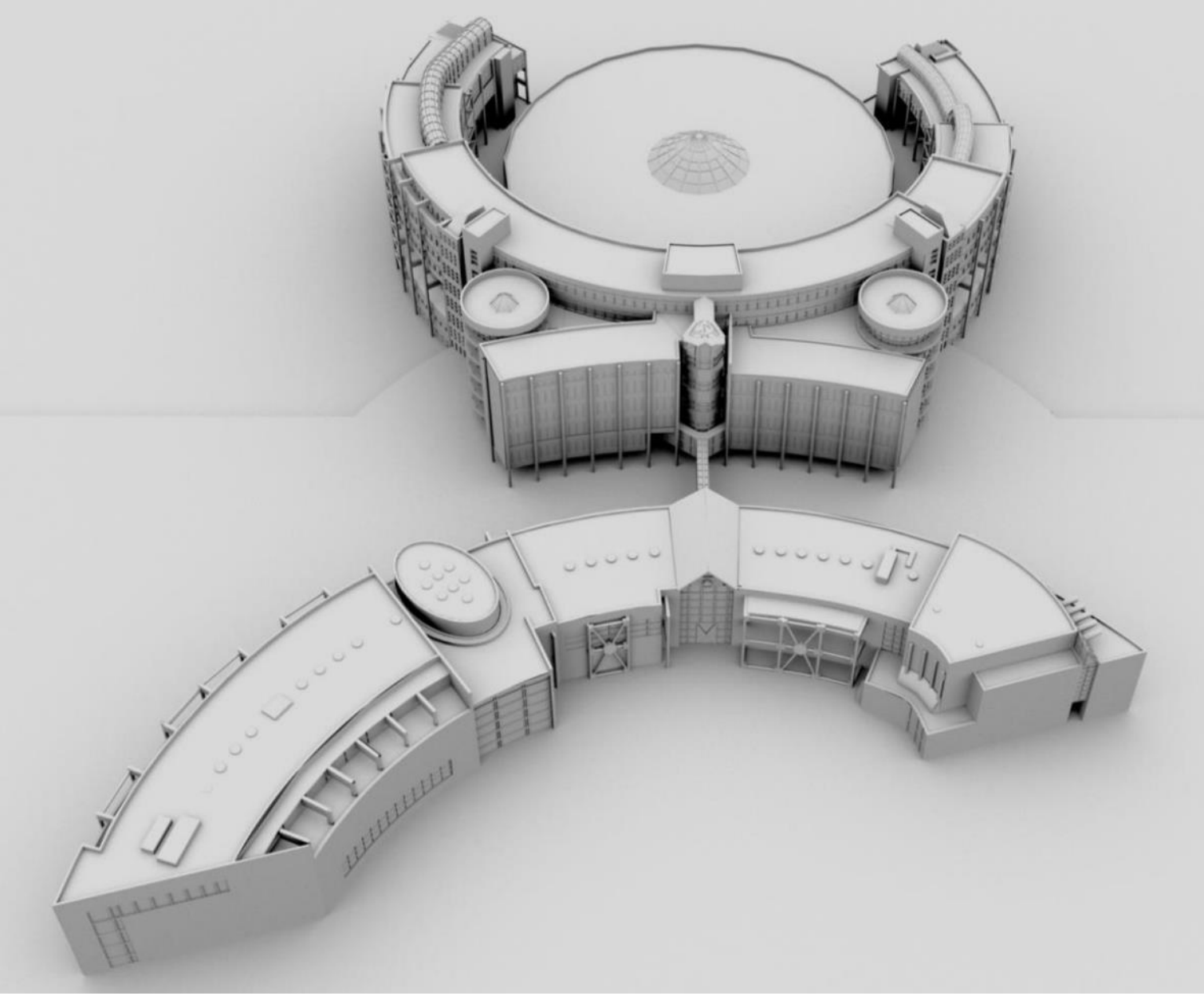

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# Anticipation of the edge rounding during the post-processing of additively manufactured parts through centrifugal disc finishing


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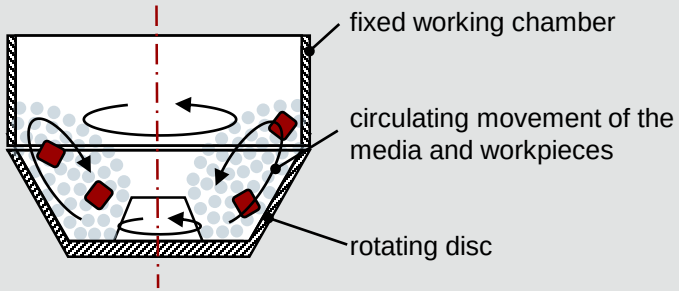
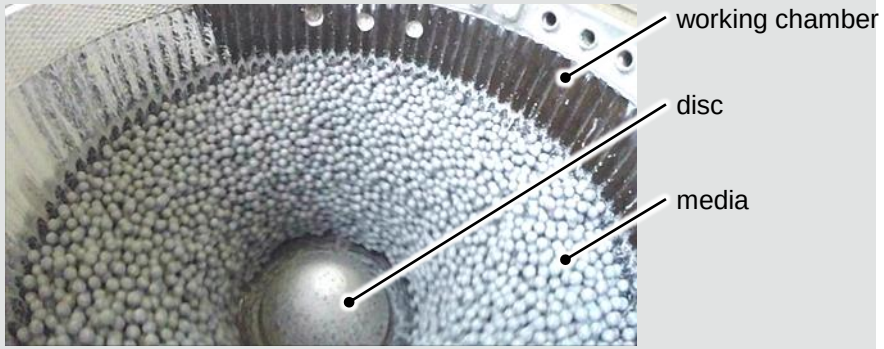
# Centrifugal disc finishing

## Basics

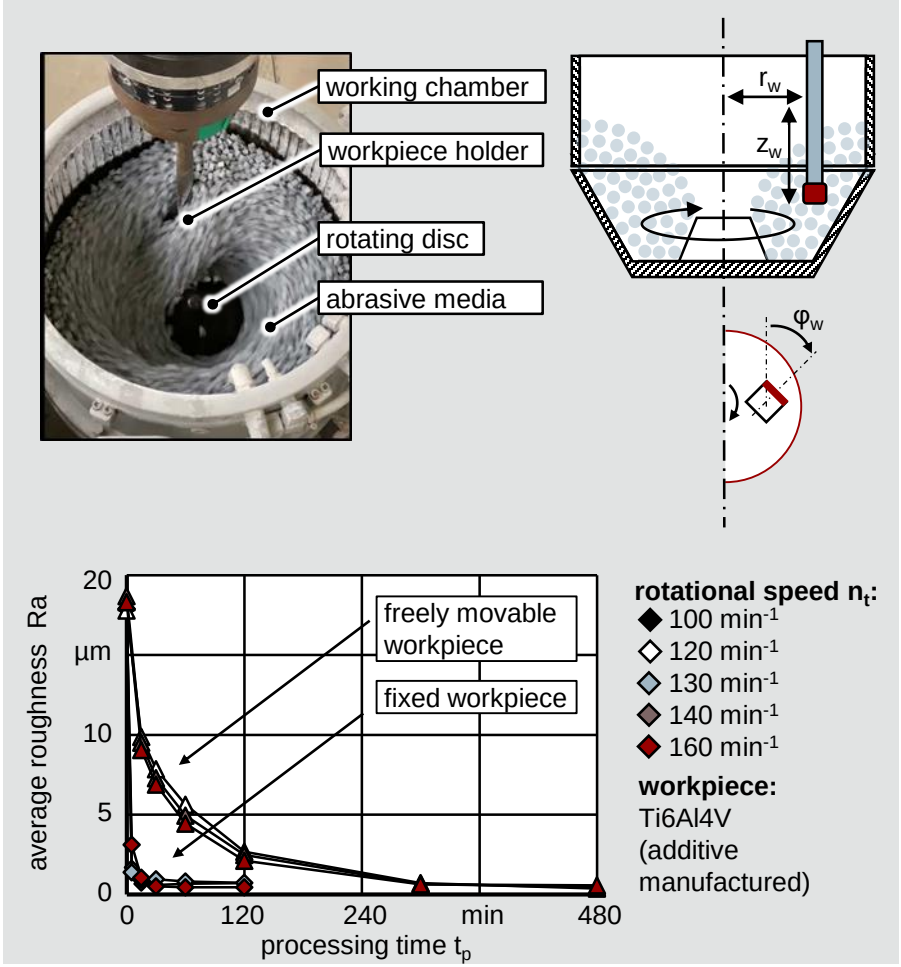




- Mass finishing
  - Manufacturing process for surface and edge processing
  - Processing through relative movement between workpieces and freely movable abrasive media
- Centrifugal disc finishing
  - Induction of the movement through rotating disc at the bottom of working chamber
  - Formation of a toroidal ring flow
  - High velocity of media
    → intensive processing
  - Suitable for finishing of additively manufactured workpieces
  - Processing of workpieces as bulk material

# Centrifugal disc finishing

## Basics

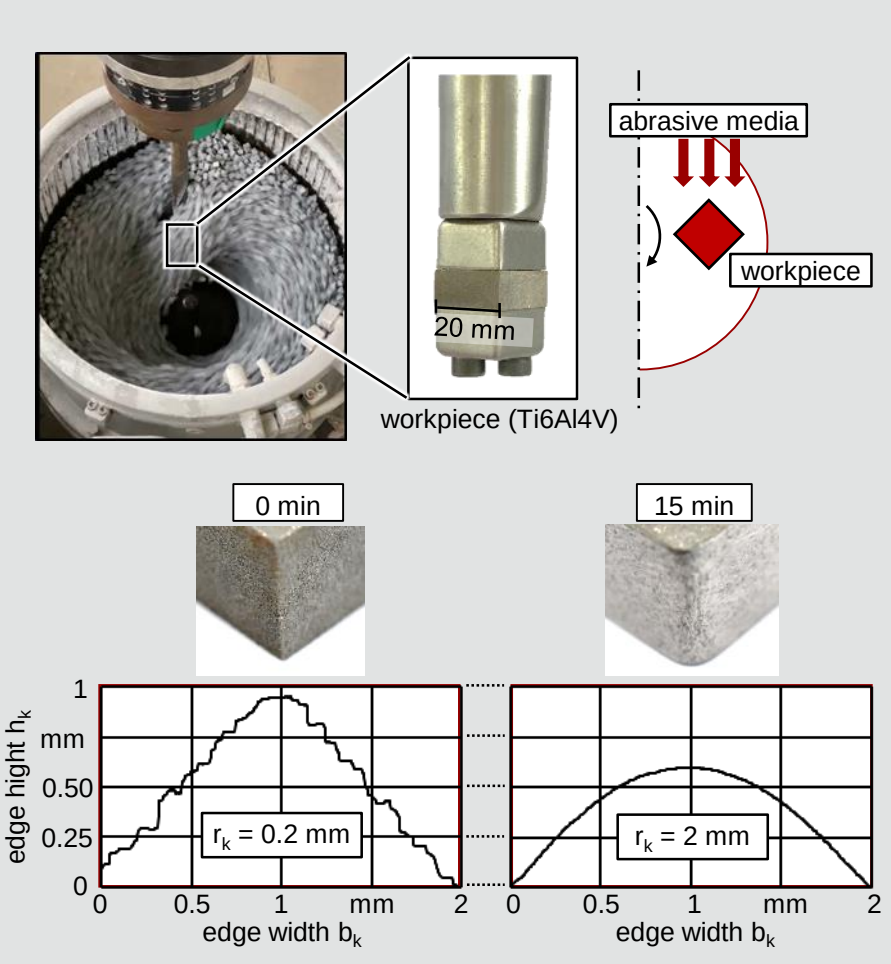



- Process variant
  - Processing with fixed workpiece
  - High process control via defined positioning of the workpiece ($r_w$, $z_w$, $\varphi_w$)
  - Increase relative speed→ Increase in machining intensity
    - e.g.: from Ra = 17 µm to Ra = 2 µm

      → 120 min of processing with freely movable workpiece

      → 5 min of processing with fixed workpiece

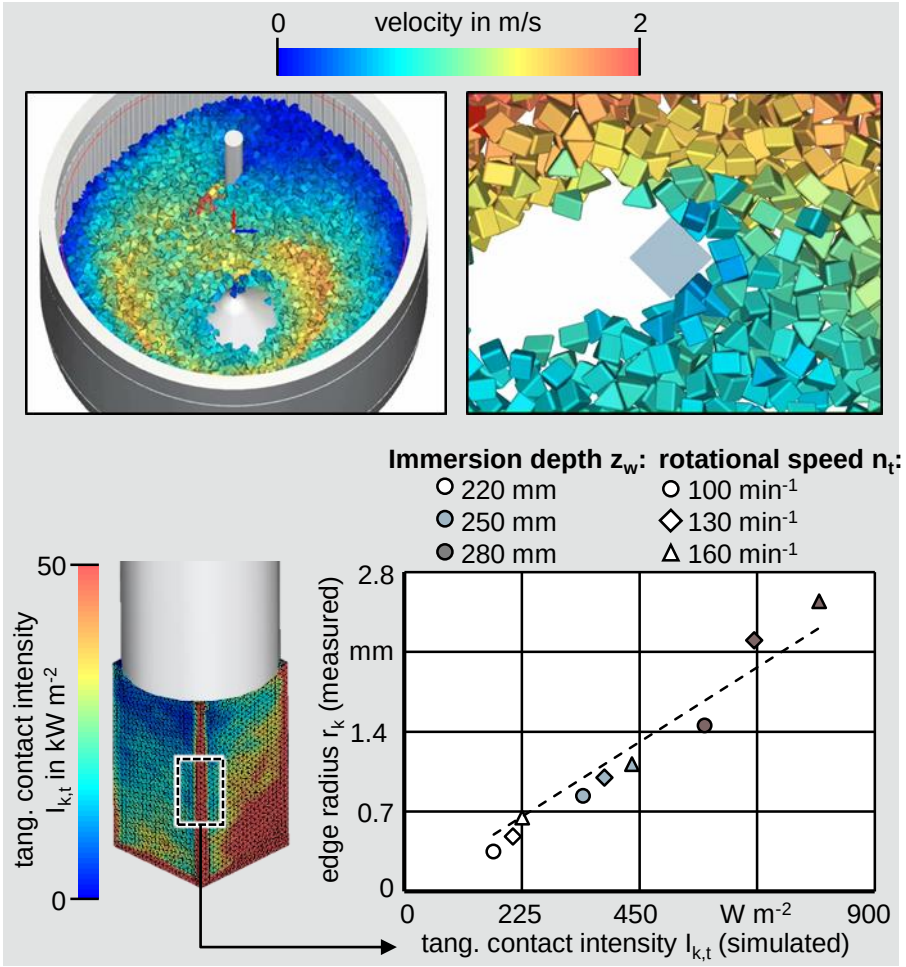
# Motivation and approach



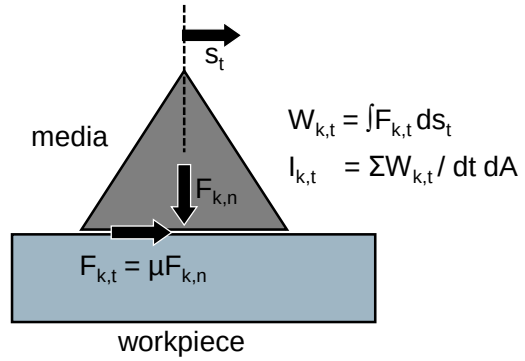

- High processing intensity
  - → High material removal rate
  - → Rounding of exposed edges and corners, e.g. edge radius from $r_k$ = 0.2 mm to $r_k$ = 2 mm in 15 min
  - → Risk of undersizing/shape deviations, especially for near-net-shape manufactured workpieces
- Previous solution approach to avoid undersizing
  - Global material allowance, e.g. + 0.3 mm
  - Challenge: Metal removal rate depends on geometry of workpiece
- New approach
  - Local and demand-driven material measurement

# Simulation of mass finishing processes

## Characterization of the media-workpiece-contact




- Application of the Discrete Element Method for the simulation of the motion of abrasive media
  - → Knowledge about media-workpiece-contact
  - → Characterization of the media-workpiece-contact with **tangential contact intensity $I_{k,t}$**




- High correlation ($R^2 = 0.94$) between measured edge radius $r_k$ and simulated tangential contact intensity $I_{k,t}$



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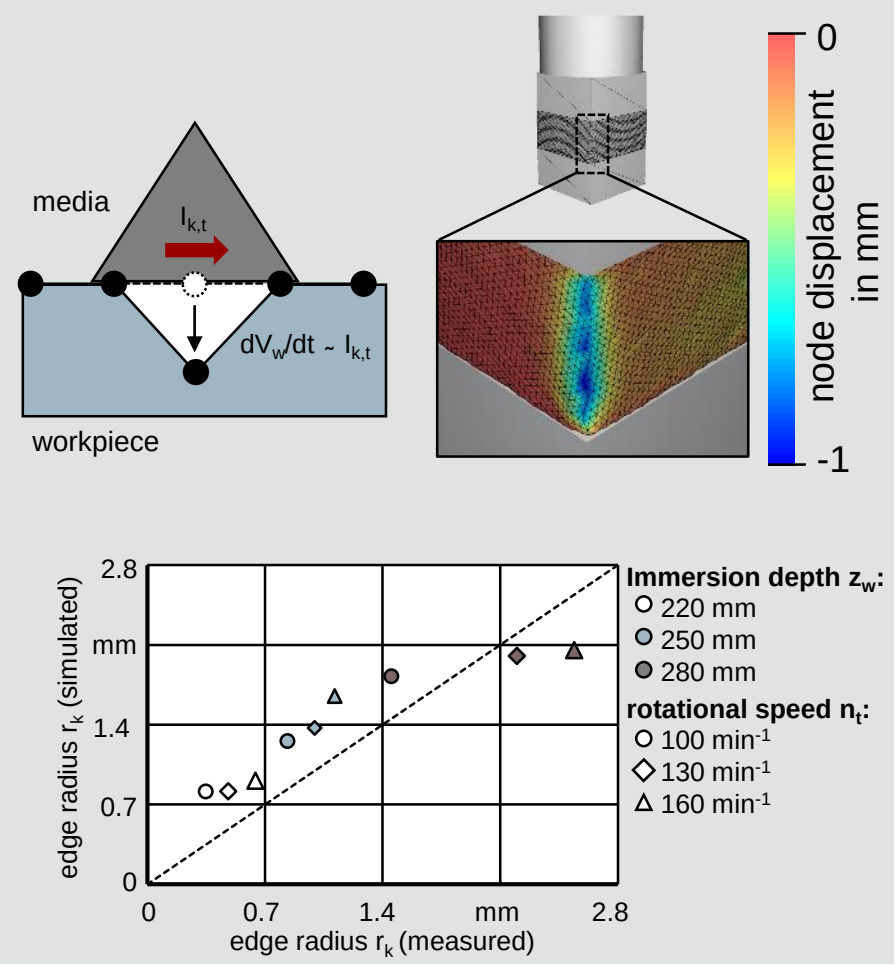
# Simulation of mass finishing processes

## Simulation of material removal




- Previously: Characterization of the media-workpiece-contact
- Now: Simulation of material removal
- Model of material removal
  - $dV_w/dt = k\ l_{k,t}$
  - Node displacement to achieve $dV_w/dt$
- Comparison of the measured and simulated edge radii $r_k$

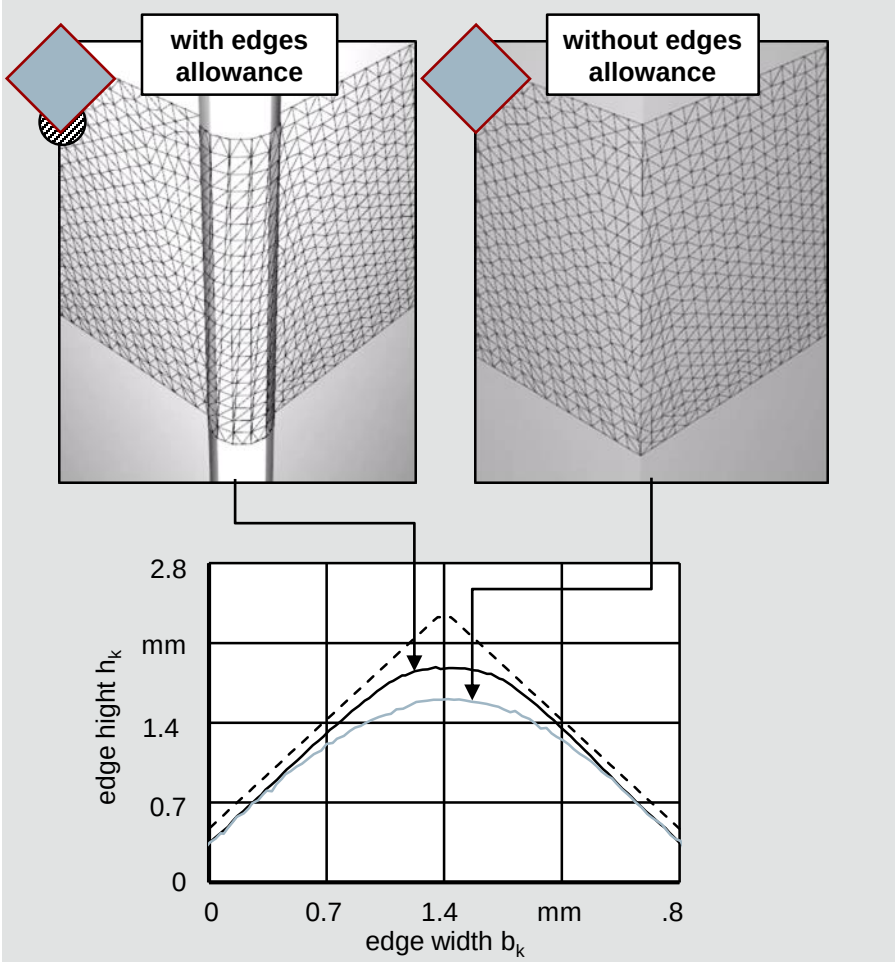
  → Qualitative agreement

  → 48 % deviation

  → Adjustment of the material removal model necessary

# Simulation of mass finishing processes

## Simulation-based design of edge allowance




- Simulation of material removal with varying edge geometries

  → Prediction of the resulting edge rounding

- Resulting edge rounding is influenced by edge allowance



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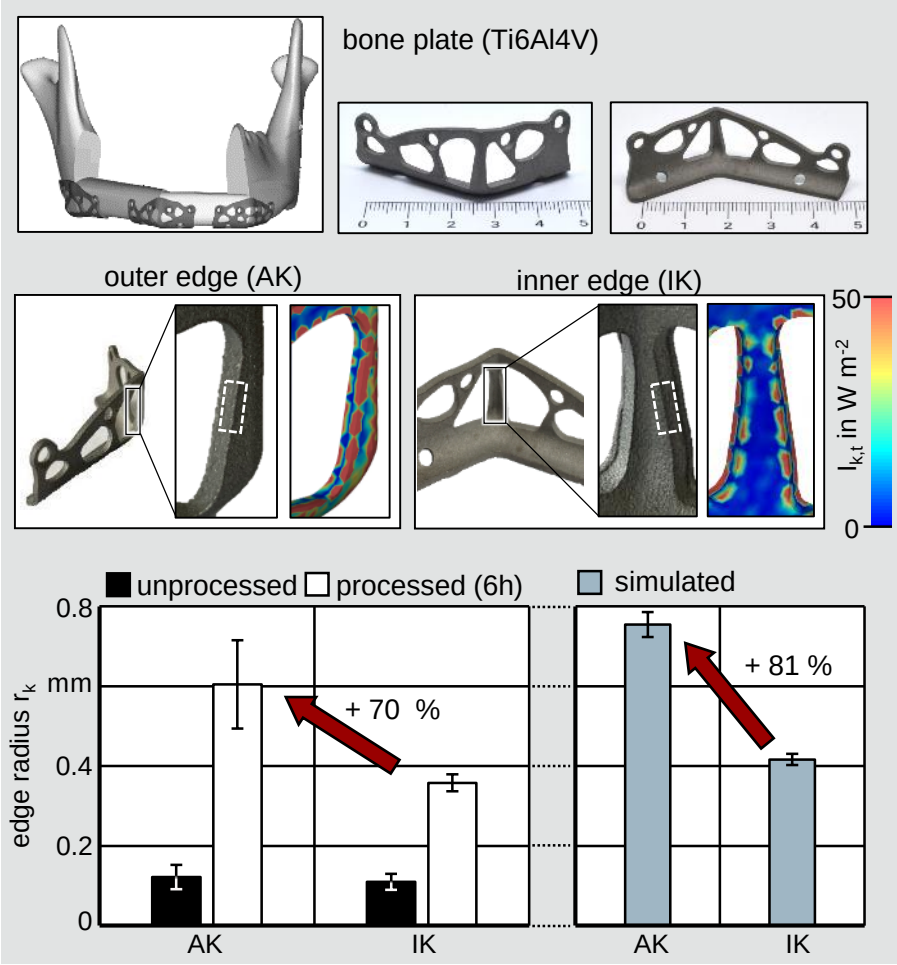
# Method verification

## Use case: individualized bone plate




- Additive manufacturing enables economical production of complex and individualized components
- Post-processing required due to high as-built roughness
  - Target roughness Ra < 1 µm to avoid bone ingrowth
- Complex component geometry poses a challenge for finishing

  → accessible outer edges

  → limited access to inner edges

  → 70 % higher rounding of the outer edge than the inner edge

  → Reduction of the component strength

→ By means of simulation, this information could already be available before the component is manufactured.



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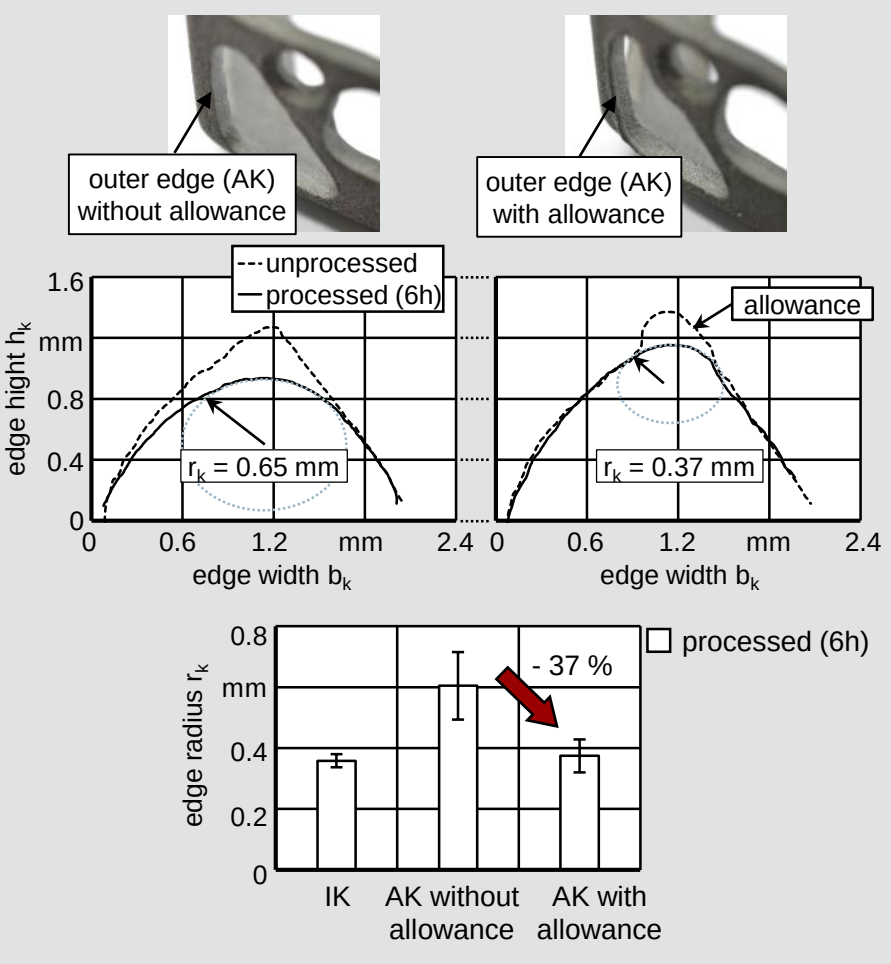


- Anticipation of edge rounding
  - → Adaptation of the component geometry with local and demand-driven edge allowance
  - → Reduced edge roundness after processing
  - → Uniform rounding of the inner and outer edge



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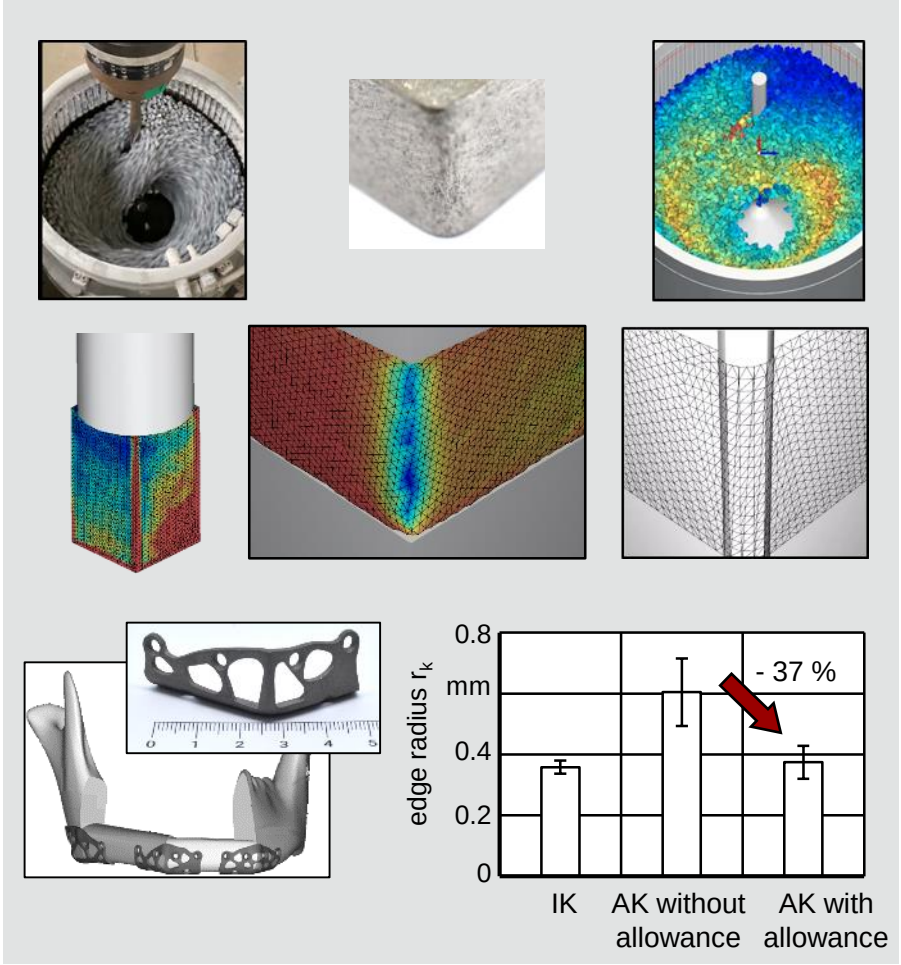
# Summary




- Centrifugal disc finishing is a suitable process for the surface finishing of additively manufactured components
  - high material removal rate
- Process can be simulated using Discrete Element Method
- Tangential contact intensity is a suitable parameter for describing the media-workpiece-contact
  - → Simulation of material removal: $dV_w/dt = k\, I_{k,t}$
  - → Simulation-based design of local and demand-driven edge allowance for influencing resulting edge rounding
- Testing on the real use case
  - → Uniform edge rounding through simulation-based design of edge allowance



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# Thank you for the attention


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