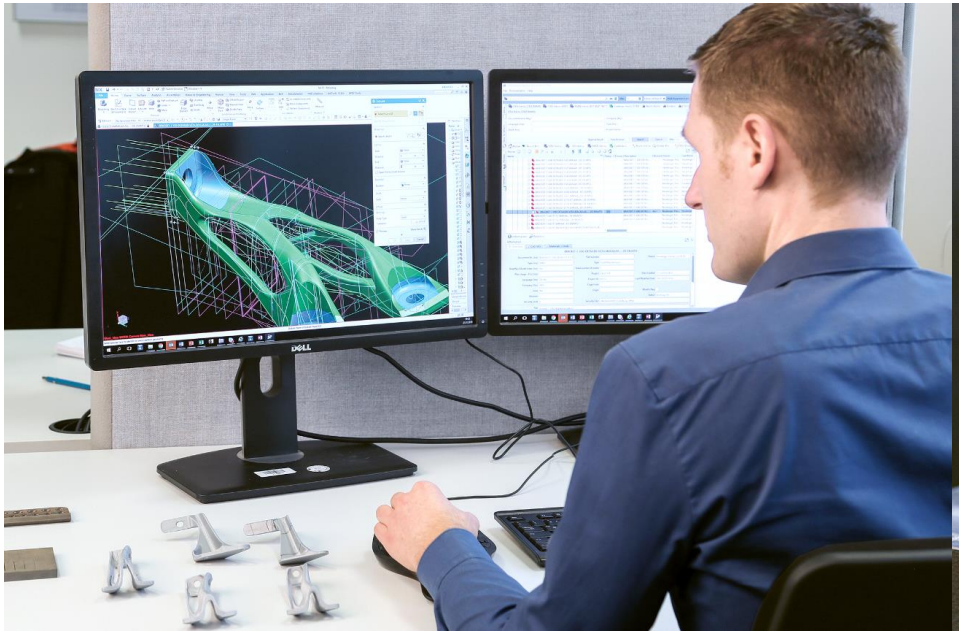
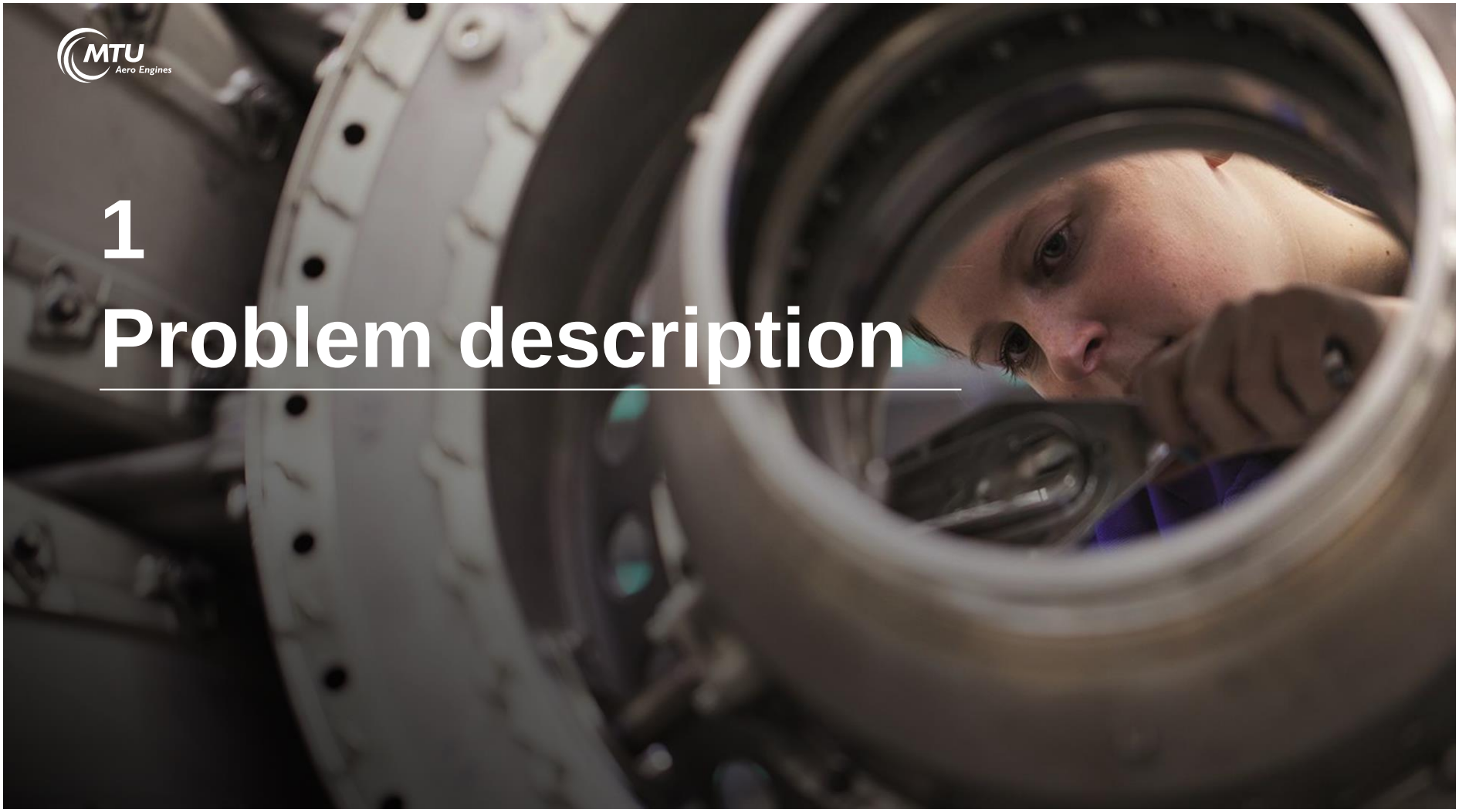


Defining acceptance limits for Ni-AM powder
using materials simulation

Caspar Schwalbe, Magdalena Futoma, Thomas Göhler, Andreas Fischersworring-Bunk

MTU Aero Engines AG

EASA-FAA AM Event (Day 3) 10.11.2021



1 Problem description

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Contamination of Ni-AM powders

Two types of contaminants regularly occur in the standard processing cycle

Residual AM-powder from a previous job

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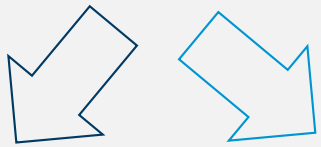

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Non AM-powder contaminants (e.g. metal chips)

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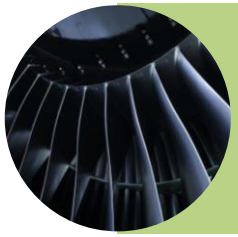


Approach:

1. Classify the contaminant and determine its abundance
2. Calculate the dilution factor
3. Determine if the contamination results in a lifing debit

2 Contamination classification

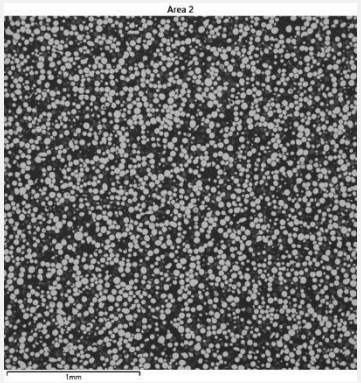
Classification of the contamination in the standard workflow

Detection of contaminants

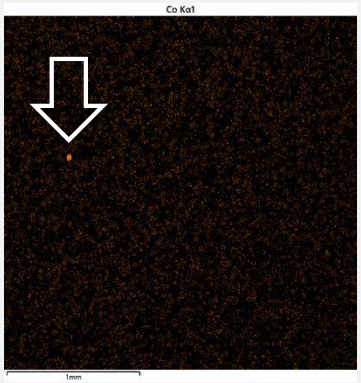
Routine powder inspection is carried out to determine presence and composition of contaminations.

⇨ e.g. Co particles

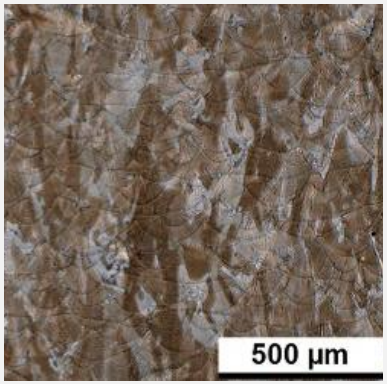
SEM µ-graph



Contaminant detection



LM post build



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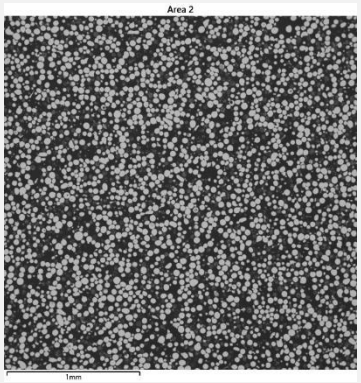

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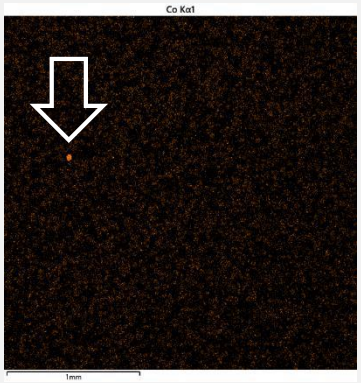

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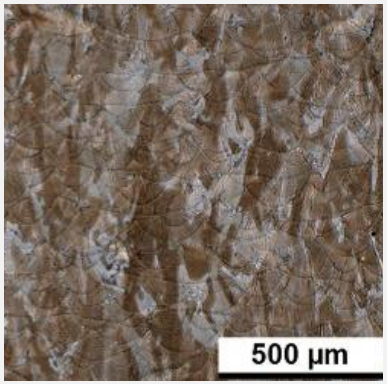


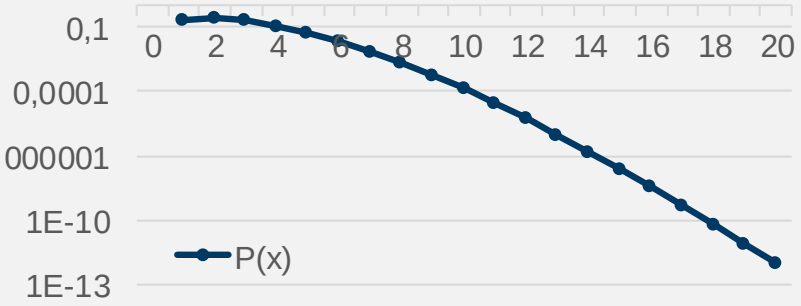
Estimating prevalence of contamination

Assuming a spherical powder shape and a Poisson law for the distribution of contaminants the likelihood of any number of contaminant particles per imaged area is calculated.

⇨ e.g. Likelihood of 2 Co particles per 10k ~27%

Likelihood of Co-Al particles per 10000 particles

$$P(x; \mu) = (e^{-\mu})(\mu^{x}) / x!$$

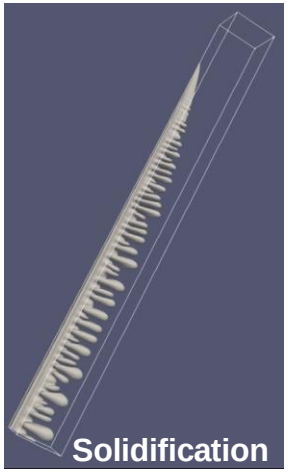


3 Deriving acceptance criteria

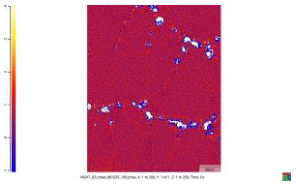
Deriving acceptance criteria using materials simulation

CC

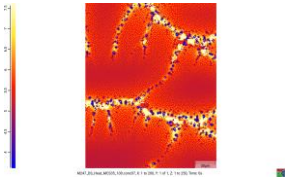
Conventional casting results in a *dilution* of any contaminant particle through the *entire crucible*.



Phase formation



Al concentration



Softw are used: MICRESS; Licensed by Access e.V.

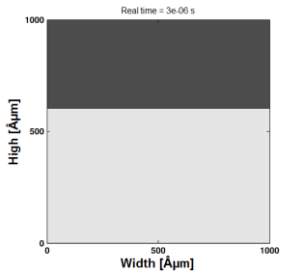
AM

We need to simulate the AM process on a *local scale* to gather key information :

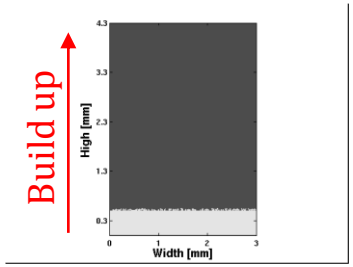
- How large is the meltpool ?
- How many layers are re-melted with each pass ?
- What are the melt flow dynamics ?

→ **How large is the dilution factor ?**

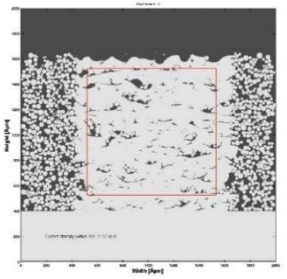
A single meltpool



AM build-up



Completed job



Softw are used: Sample2D; Licensed by FAU Erlangen

Deriving acceptance criteria using materials simulation

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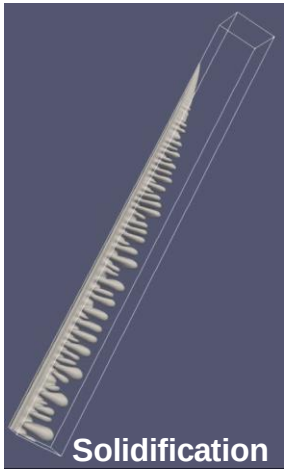

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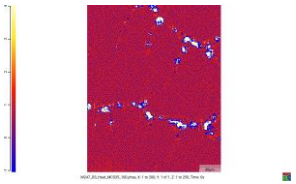

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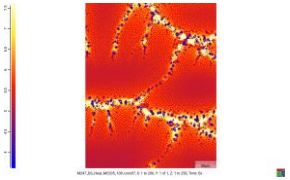

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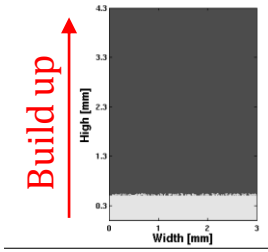


⇨ e.g. 500 particles in meltpool from up to 4 re-melt layers

⇨ dilution factor < 1:500

Softw are used: MELB; Licensed by FAU Erlangen

Deriving acceptance criteria using materials simulation

Goal

Is the diluted contaminant in the meltpool resulting in a component lifing debit ?

Methodology

Is the **chemistry** of the diluted meltpool included **in** the **specification range** ?
Using simple rule of mixture

yes → ACCEPT

no → Do **new phases form** in the meltpool ?
Using phase formation simulation

no → ACCEPT

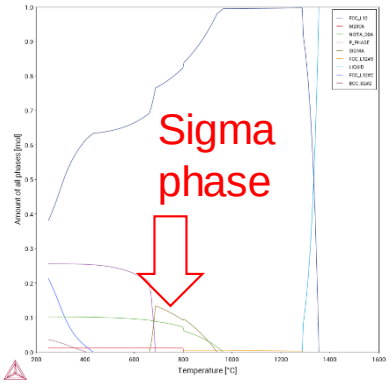
yes → Do the new phases result in a **lifing debit** ?
Using plastic deformation simulation

yes → REJECT

no → ACCEPT

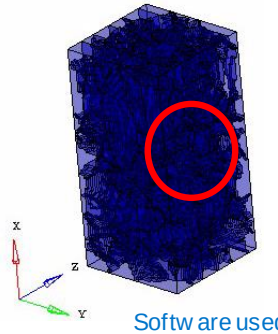
Simulation

Phase formation



Softw are used: ThermoCalc.

Plastic deformation



Softw are used: Abaqus.

Thank you for your attention!

References

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