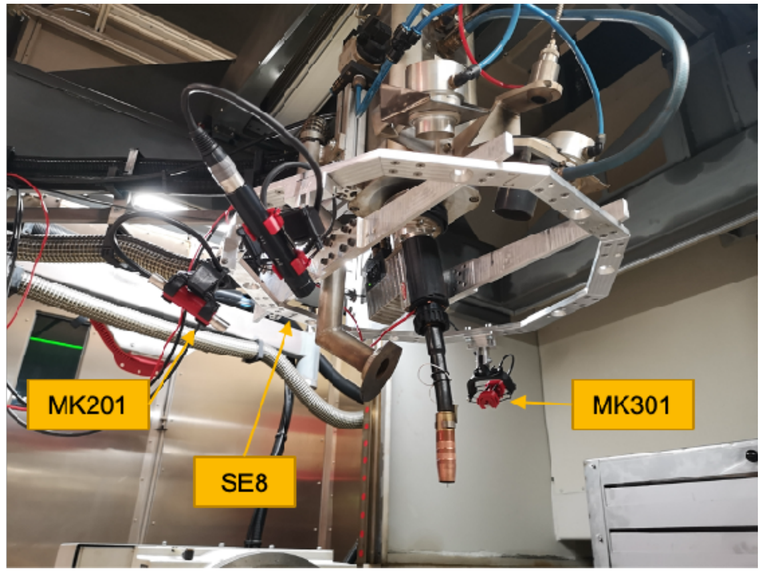
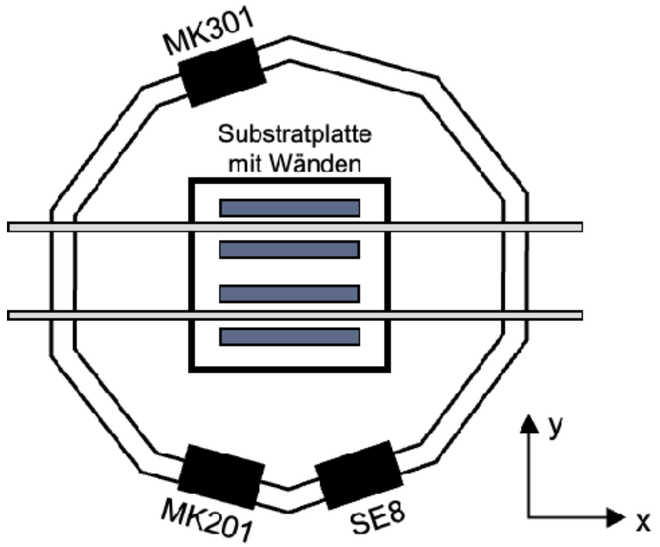
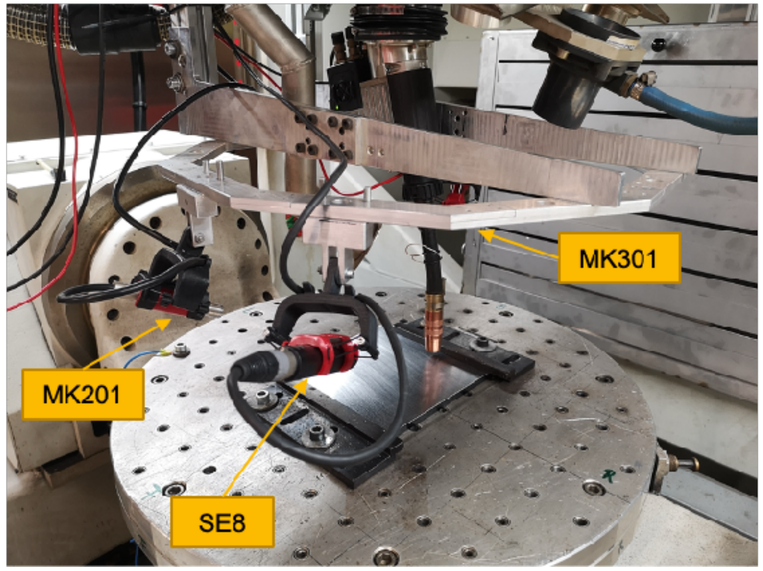
AKoS - Acoustic inspection of weld seams on safety-critical components as part of quality assurance

Experiment Set-Up







Data acquisition

Positionsdate (X, Y, Z)

Welding current strength

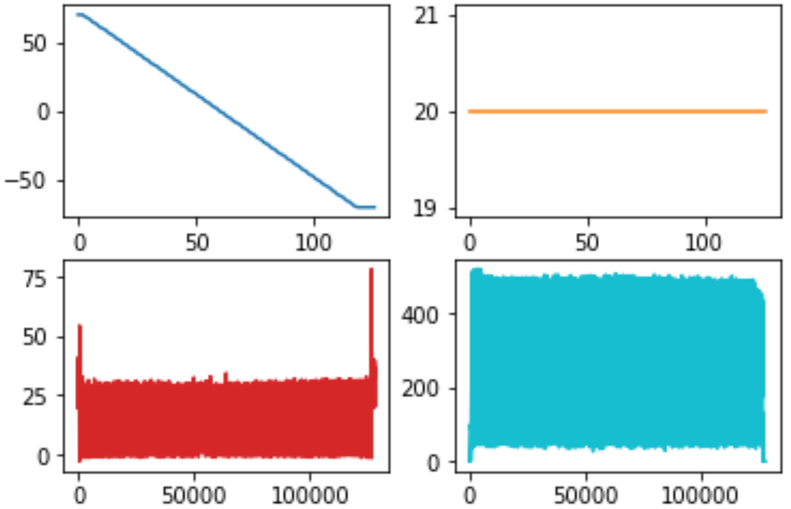
Welding voltage via voltage transformer

Microfonsignals

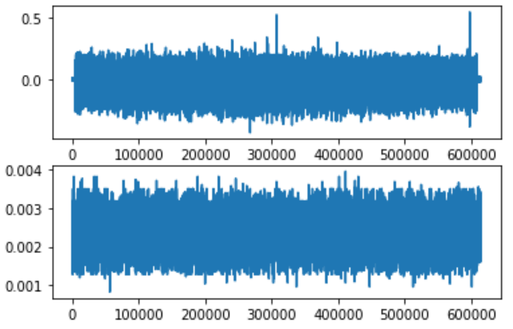
Measuring case

```python
from bitstring import ConstBitStream

def read_i32(filepath):
    file=open(filepath,'rb')
    raw=ConstBitStream(file)
    count=raw.len // 32
    floararray = [ ]
    for i in range(count):
        floararray.append(raw.readlist('floatle:32'))
    return floararray
```



Visualisation in Python



Carrying out the experiment

- Microphone signal
  - Setting the amplification of the respective microphone signals
    - Microphone Gefell 1 = MK301, Amplification "32"
    - Microphone Gefell 2 = MK201, Amplification "16"
- Data recording
  - Setting the start and end signal trigger via the welding current intensity
    - Start trigger: 5 A (≙ 0.05 V) with 1000 values
      (output unit: V -> 1 V ≙ 100 A)
    - End trigger: 1.5 A (≙ 0.015 V) with 1 value
      (output unit: V -> 1 V ≙ 100 A)

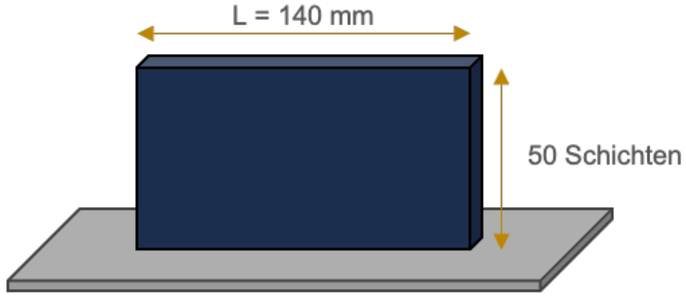
Welded wall made of 316L with 20 layers according to TU Ilmenau parameters

Welding Parameters

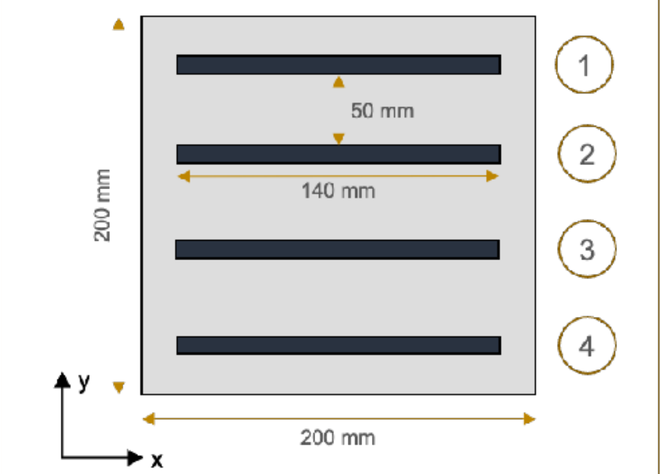
Parameter	Value
Current intensity	151 A
Voltage	17,7 V
Wire feed speed	5,3 m/min
Welding speed	300 mm/min
Layer height	1,88 mm
Stickout	10 mm
Intermediate layer temperature	120°C
Shielding gas	Cronigon 2
Shielding gas quantity	14,0 l/min

Test Plan

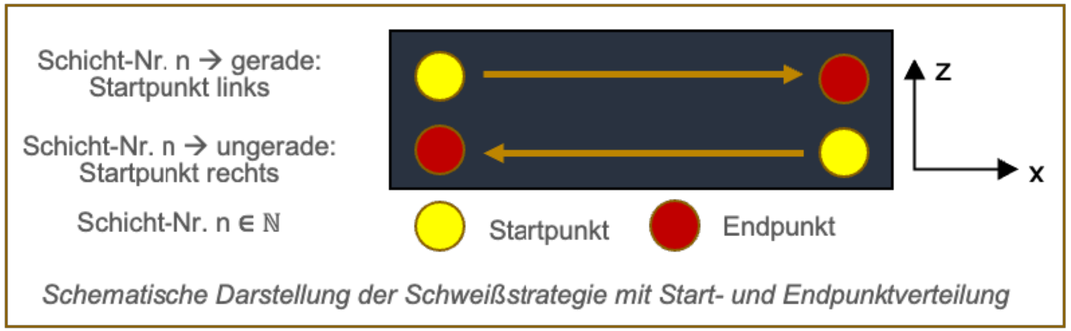
- Wall geometry:
  - L = 140 mm
  - 50 layers
- 11 walls per material:
  - One OK wall per material wall
  - Per n.i.O. wall one defect type
  - Defect insertion in every 3rd layer
- Maximum of four walls per substrate plate:
  - Distance between walls: 50 mm
  - Position of the individual walls on the substrate plate numbered (1 - 4) in the documentation
- Welding strategy:
  - Alternating start and end points
  - One individual welding bead per shift
- Machine maintenance:
  - One new current contact tube and cleaned gas nozzle per wall
  - No preheating of the substrate plate
  - No cooling of the welding tab



Schematische Darstellung der Wandgeometrie



Schematische Darstellung der Positionierung der Versuchswände auf Substratplatte



Schematische Darstellung der Schweißstrategie mit Start- und Endpunktverteilung

Defect Generation

Defect generation - shielding gas quantity

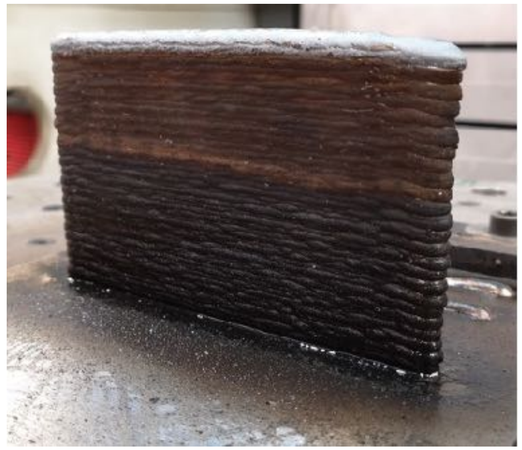
- Reduction of the supplied shielding gas quantity to 90%, 80%, 70% and 50% of the original gas flow to generate pores
- Only one percentage shielding gas volume reduction per wall
- Defect insertion in every 3rd layer

Proportion of shielding gas [%]	Gas flow volume [l/min]
100 %	14,0 l/min
90 %	12,6 l/min
80 %	11,2 l/min
70 %	9,8 l/min
50 %	7,0 l/min

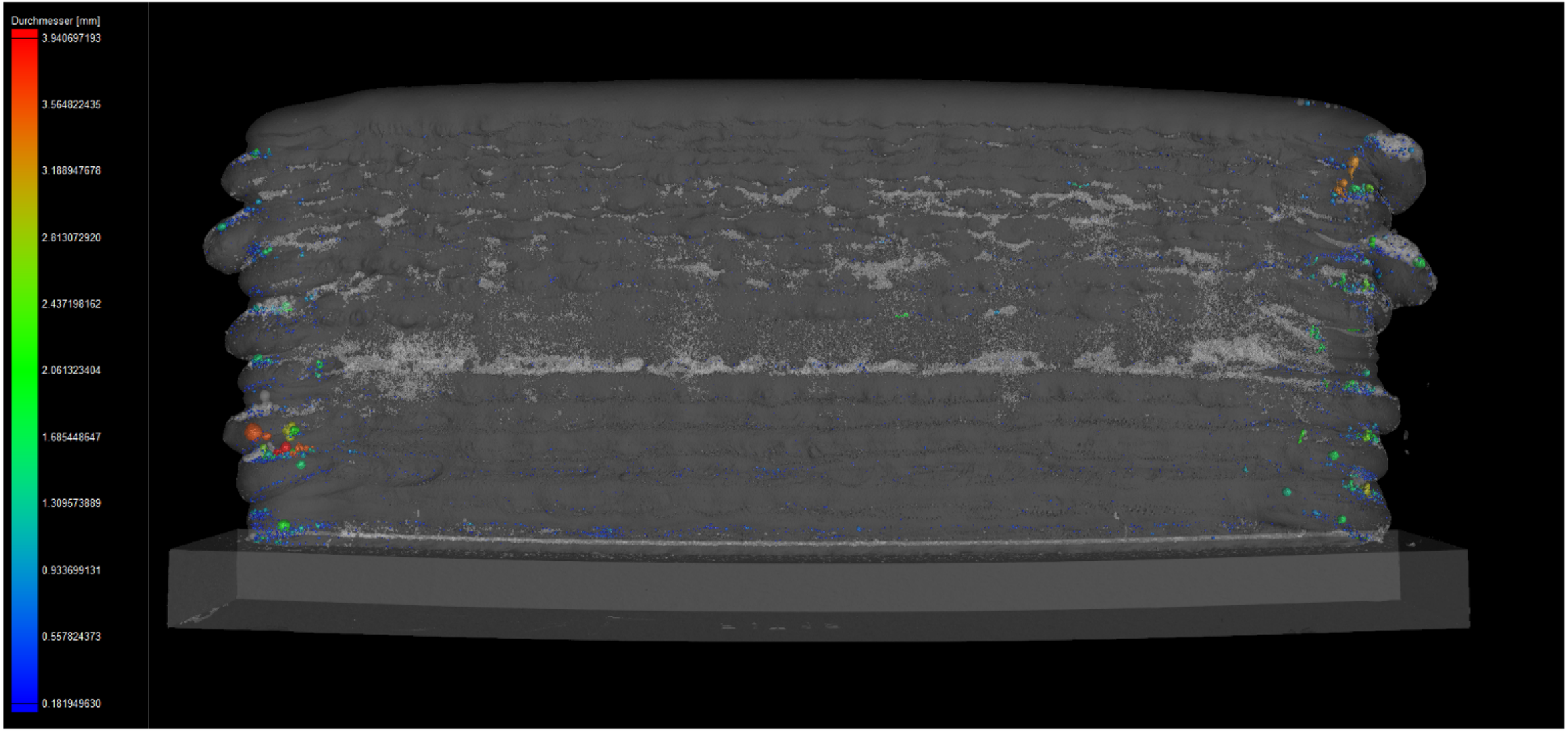
Defect generation - oil application

- Applying oil to the weld bead surface to create pores
- Oil applied twice in every 3rd layer using a brush
- Oil used: "Drilling and cutting oil CUT+COOL" from Würth

Brush, oil used for application to the surface of the weld bead


Welded stainless steel wall with oil application in every 3rd layer

CT Images


Durchmesser [mm]
3.940697193
3.564822435
3.188947678
2.813072920
2.437198162
2.061323404
1.685448647
1.309573889
0.933699131
0.557824373
0.181949630

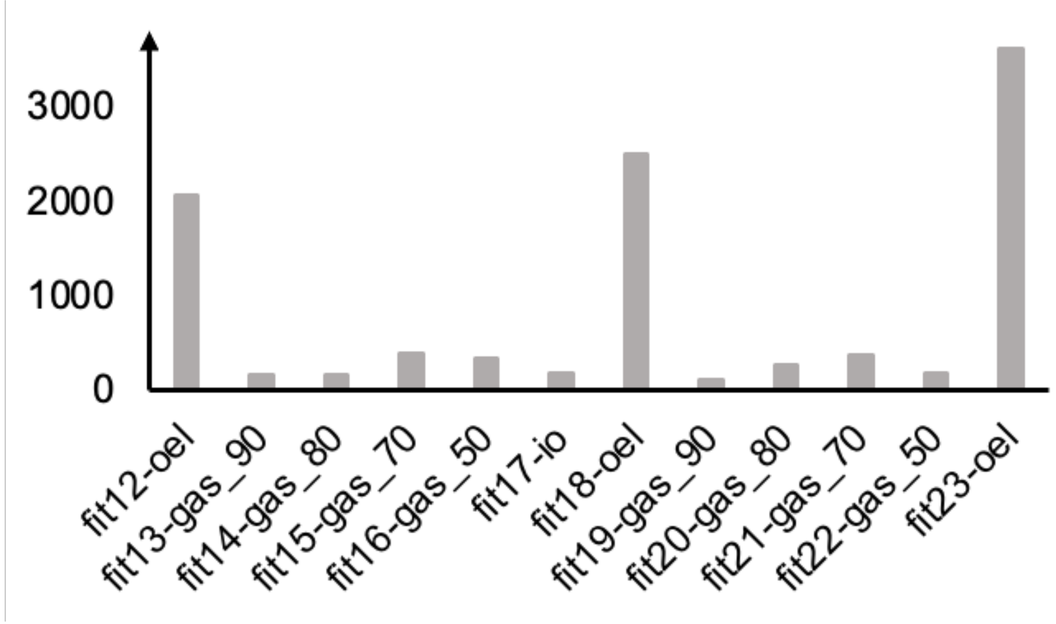
Location - Time Assignment

- Determination of the pore position in individual weld layers in relation to the welding direction and starting point
- Coordinate transformation of the CT data to the desired format
  - Wall length: 140 mm
  - Z-jumps according to process specification
- Storage of the new coordinates in a *pore_data_fit_eng* file with further information on the pores

wand_ids	layer	postion[mm]	diameters[mm]	class	pore_ids_ct
fit12	1	0,090133667	0,341915965	oel	1471
fit12	1	0,312820435	0,262490094	oel	1458
fit12	1	0,930549622	0,289895892	oel	1466
fit12	1	1,215770721	0,214100599	oel	2973
fit12	1	1,386878967	0,233853996	oel	2948
fit12	1	1,782306671	0,455848724	oel	1384
fit12	1	2,302837372	0,279549152	oel	1227
fit12	1	3,016521454	0,33439824	oel	1508
fit12	1	3,401790619	0,299553186	oel	2633
fit12	1	4,111740112	0,360378057	oel	2841
fit12	1	7,917797089	0,24103038	oel	49
fit12	1	8,564308167	0,319158494	oel	380
fit12	1	8,727844238	0,231251329	oel	3954
fit12	1	9,757575989	0,220645607	oel	3498
fit12	1	11,54088211	0,297485322	oel	200
fit12	1	12,27341461	0,214117676	oel	188
fit12	1	13,49700546	0,193814009	oel	2640
fit12	1	14,36072159	0,231259659	oel	2637
fit12	1	14,71836853	0,225679576	oel	1331
fit12	1	22,29267883	0,454162598	oel	985
fit12	1	25,09274674	0,271756113	oel	1588
fit12	1	36,48744965	0,264936179	oel	1172
fit12	1	39,14060974	0,454957008	oel	2147
fit12	1	39,42894936	0,214102387	oel	2145
fit12	1	39,47184563	0,387621462	oel	2469

Brief Evaluation

- Goal of targeted generation of pores only partially successful
- Main proportion of pores in start and end areas, only small pores in stable area
- Shielding gas variation shows contradictory behaviour



Tasks to be Investigated

- Extended analyses pending of pore distribution
- Can we hear pores?
- Apply existing techniques to recognise the pores (using MFCC-features)