Tech4H2

FOR A SUSTAINABLE HYDROGEN ECONOMY OF TOMORROW

CHALMERS UNIVERSITY OF TECHNOLOGY

Metall Additiv Tillverkning för Vätgas-baserade Bränslesystem

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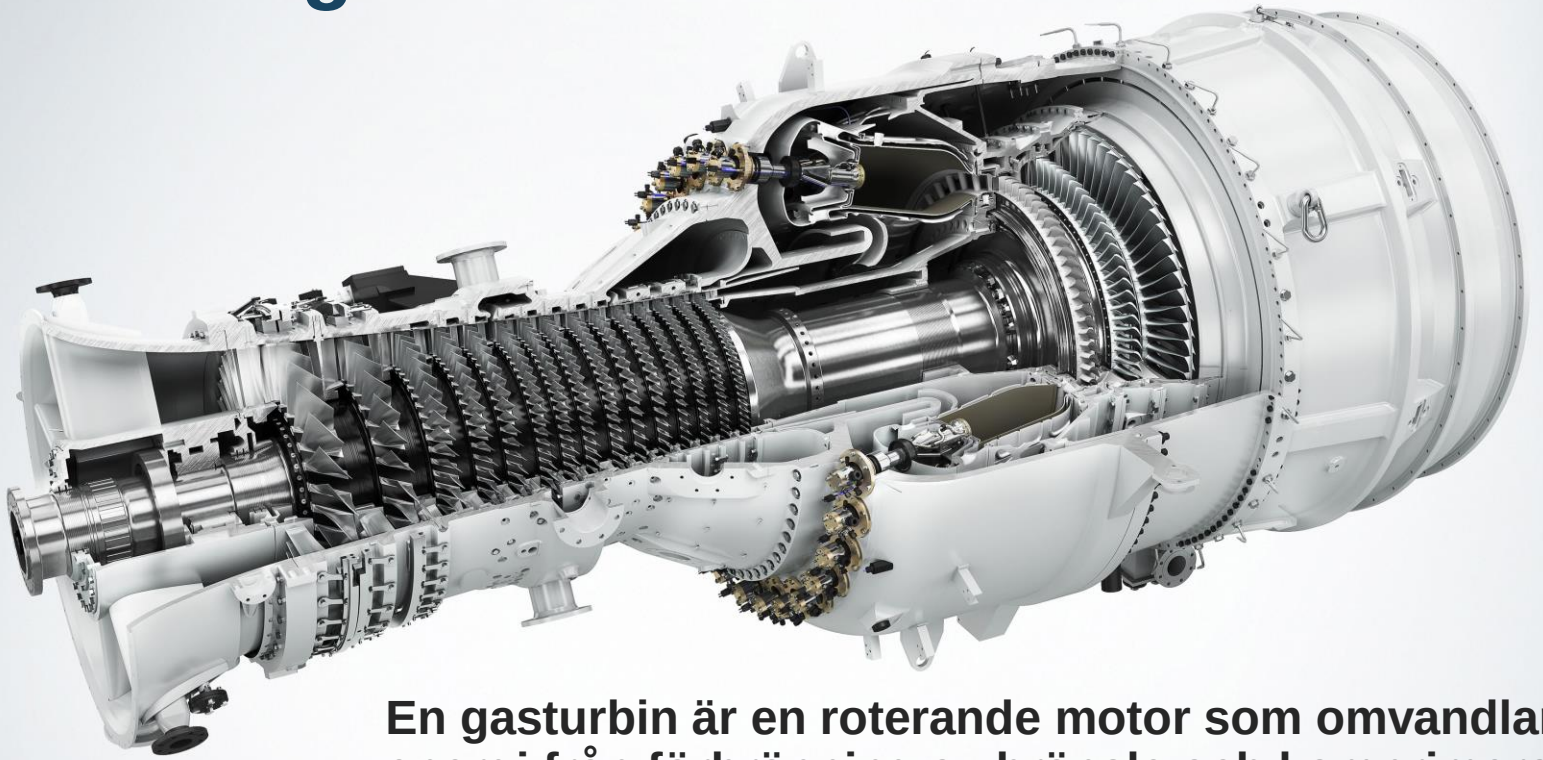
Chalmers Tekniska Högskola

Det finns ett akut behov av att öka den gröna energiproduktionen i världen

Vind- och solkraft tillför fluktuationer till elnätet

Det behövs en stabil energiproduktion som kan leverera grön energi vid hög efterfrågan

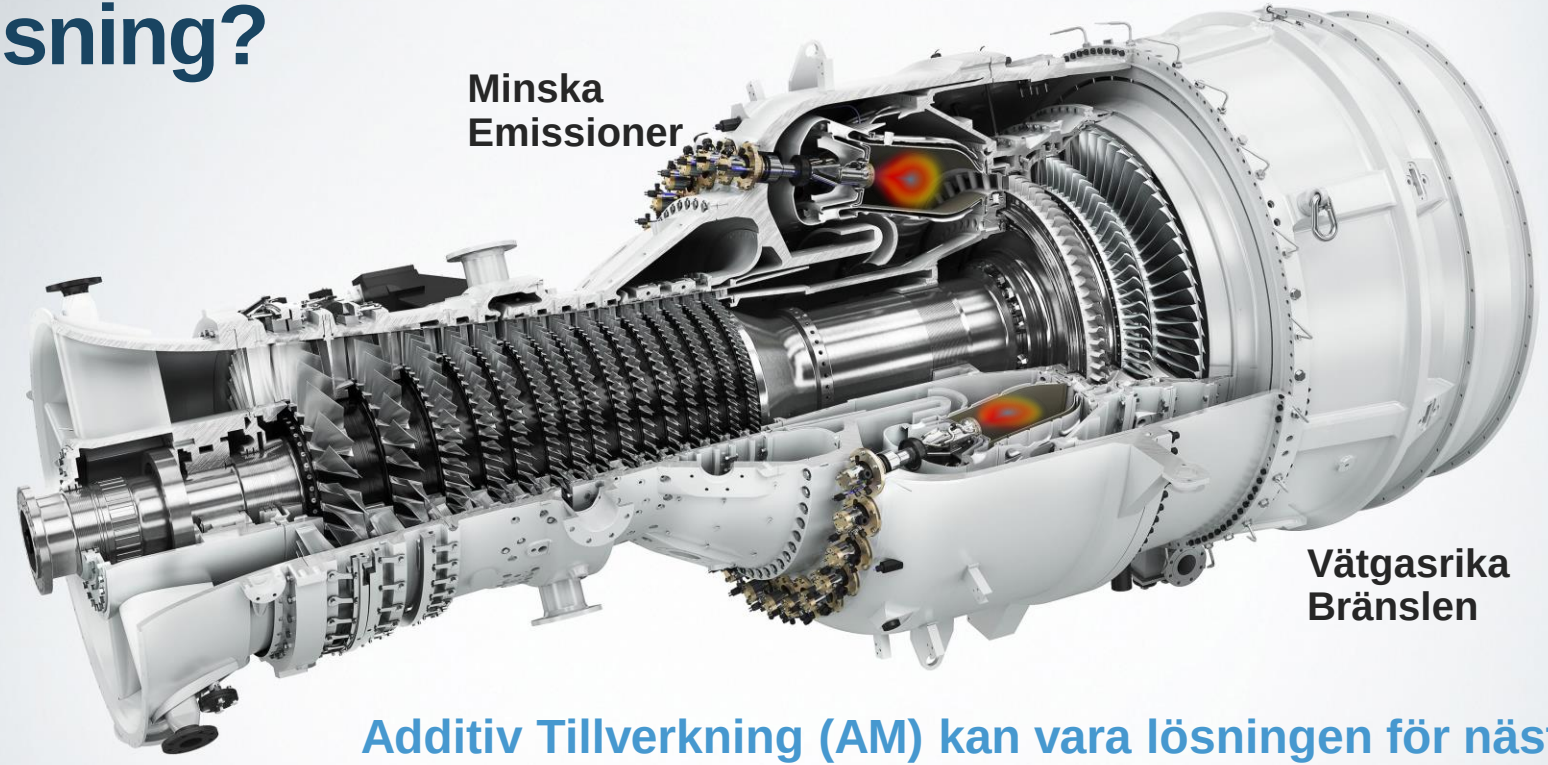
Vad är en gas-turbin?



En gasturbin är en roterande motor som omvandlar energi från förbränning av bränsle och komprimerad luft till mekanisk kraft eller elektricitet

Image: Siemens Energy

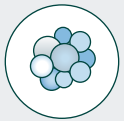
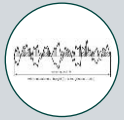
Hur kan gas-turbiner vara en del av lösning?



Additiv Tillverkning (AM) kan vara lösningen för nästa generation av bränsleinjektorer

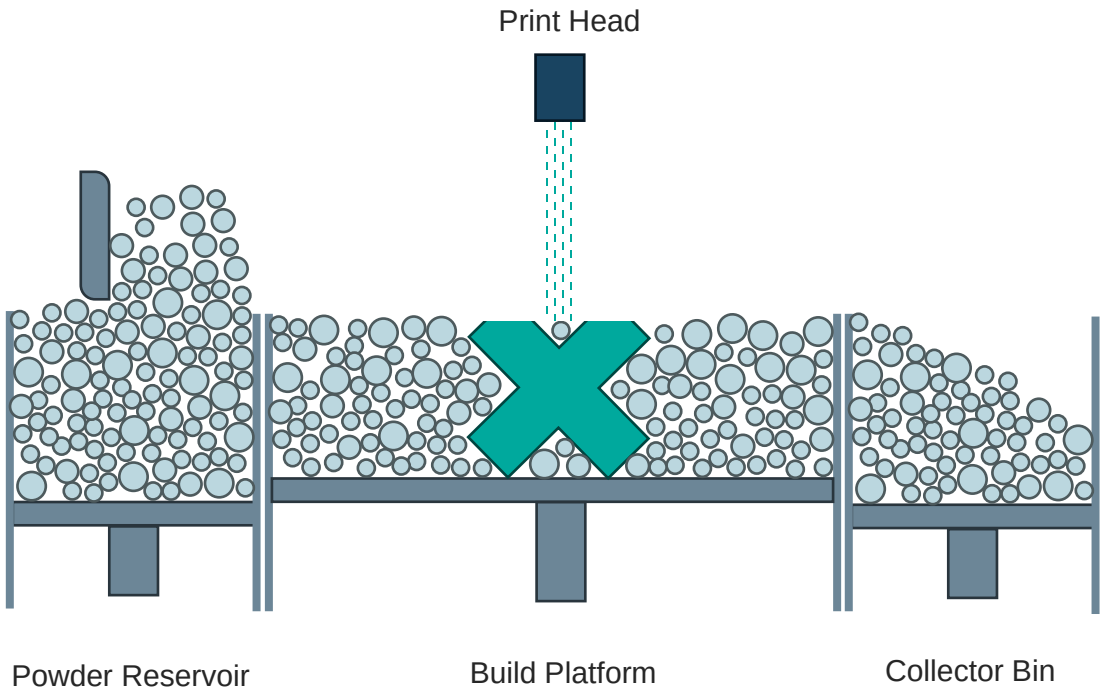
Image: Siemens Energy

AM Printing Metoder

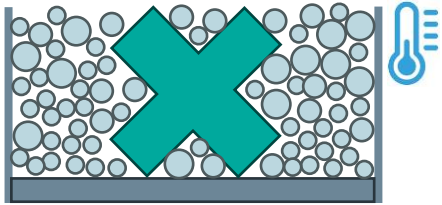
	MBJ	PBF-LB
Printing Process	Pulverbädd Två Stegs Process	Pulverbädd Enkel Process
Pulver Storlek 	5 – 20 µm	20 – 53 µm
Ytråhet 	3 – 13 µm	8 – 25 µm

Alex Huckstepp, “Surface Roughness - A Guide To Metal Additive Manufacturing By Digital Alloys - Manufactur3D,” 2021.
W. E. Frazier, “Metal additive manufacturing: A review,” *J. Mater. Eng. Perform.*

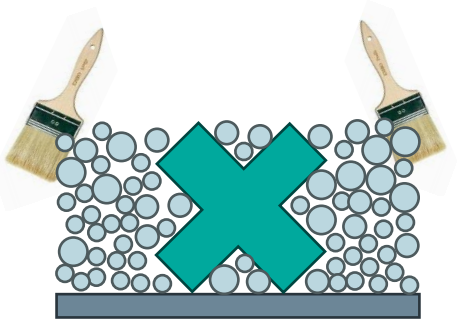
Metal Binder Jetting (MBJ)



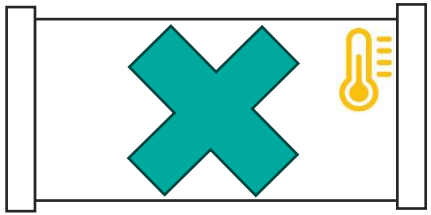
Metal Binder Jetting (MBJ)



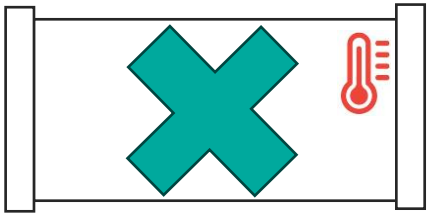
CURING



DEPOWDERING



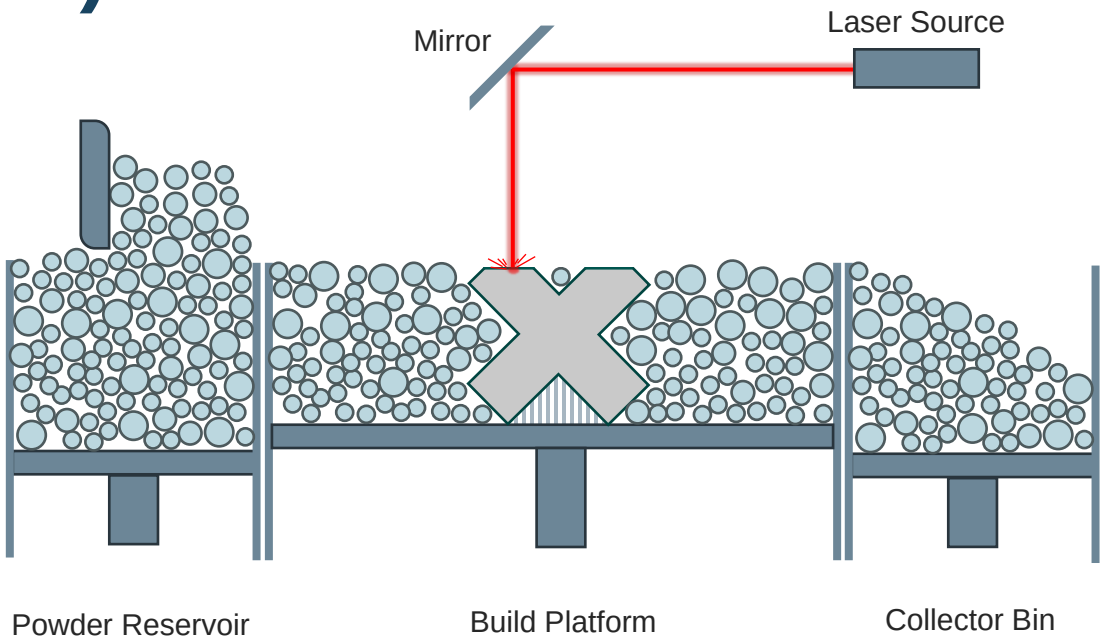
DEBINDING



SINTERING

METAL PART

Power Bed Fusion - Laser Beam (PBF-LB)

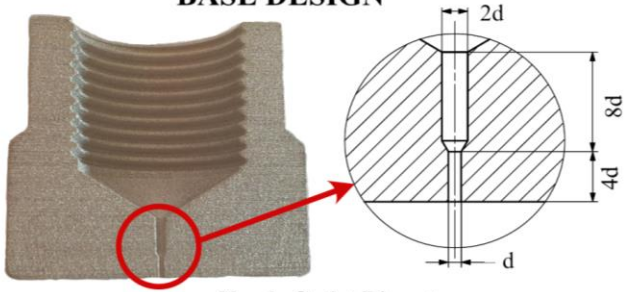


Bränsleinjektorer

Material: Rostfritt Stål 316L

MBJ-R	PBF-LB	PBF-LB+B
BASE design	BASE design	Brazing design
0.5mm	0.5mm	
0.6mm	0.6mm	0.6mm
0.7mm	0.7mm	
1.0mm	1.0mm	1.0mm

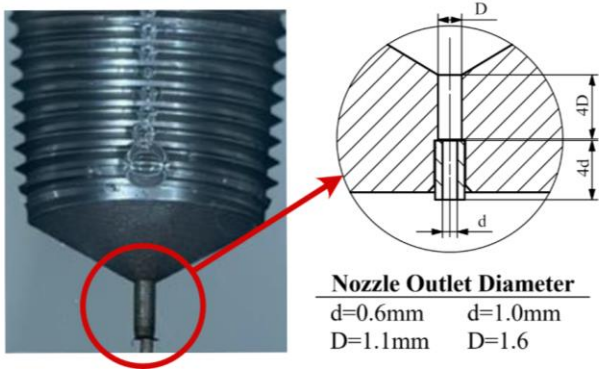
BASE DESIGN



Nozzle Outlet Diameter

d=0.5mm d=0.6mm d=0.7mm d=1.0mm

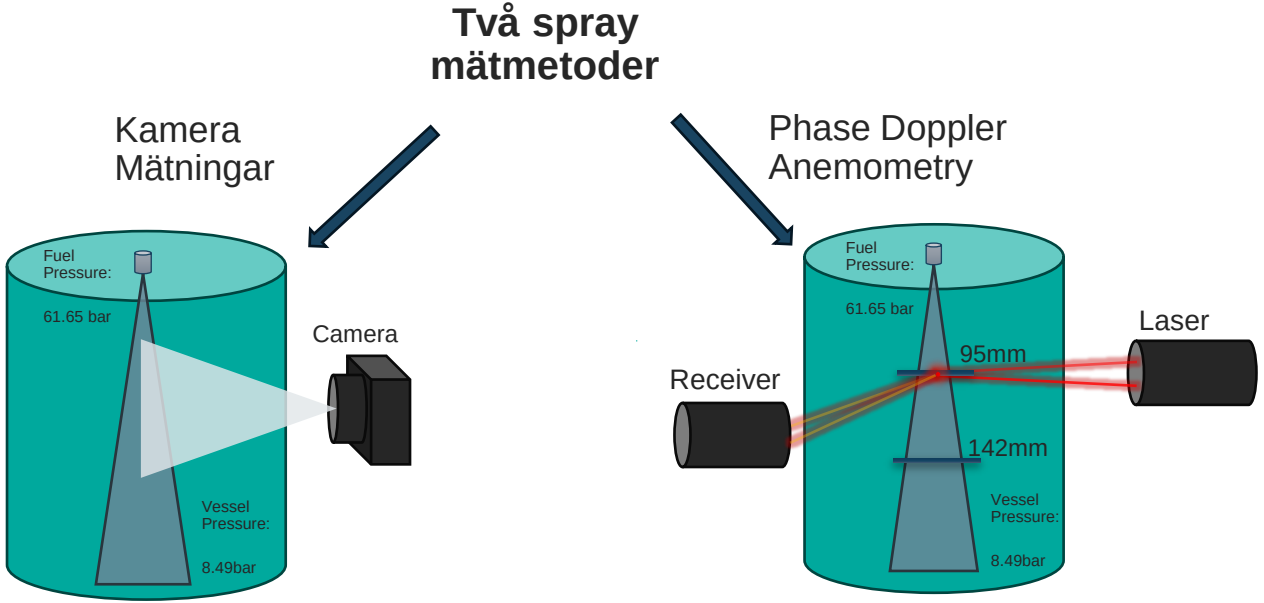
BRAZING DESIGN

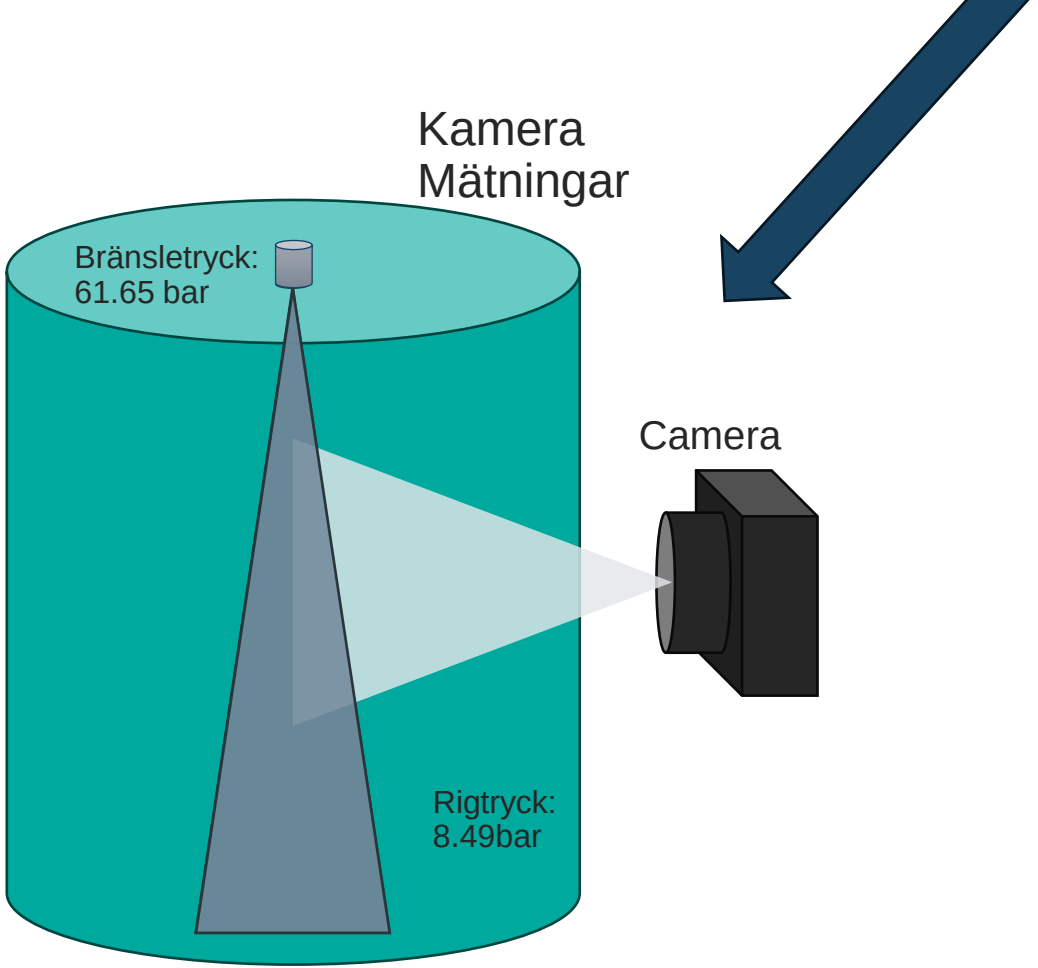


Nozzle Outlet Diameter

d=0.6mm d=1.0mm
D=1.1mm D=1.6

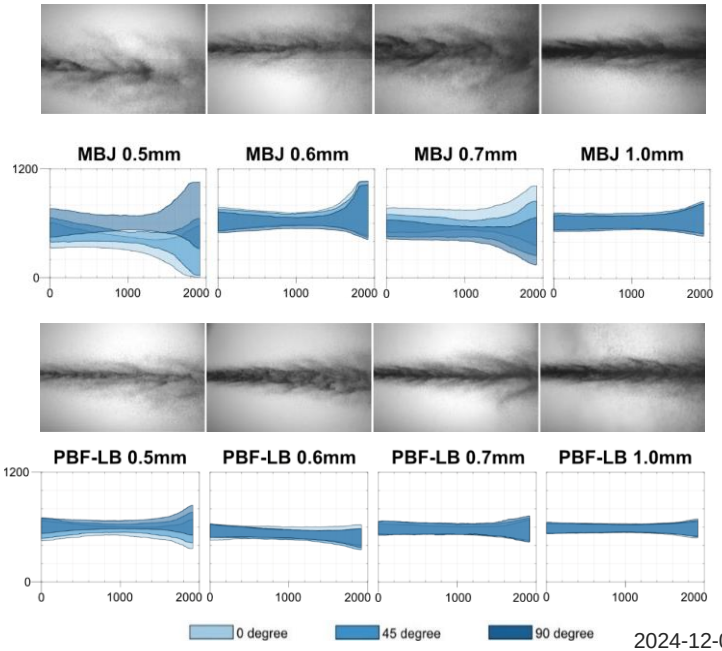
Spray Mätningar





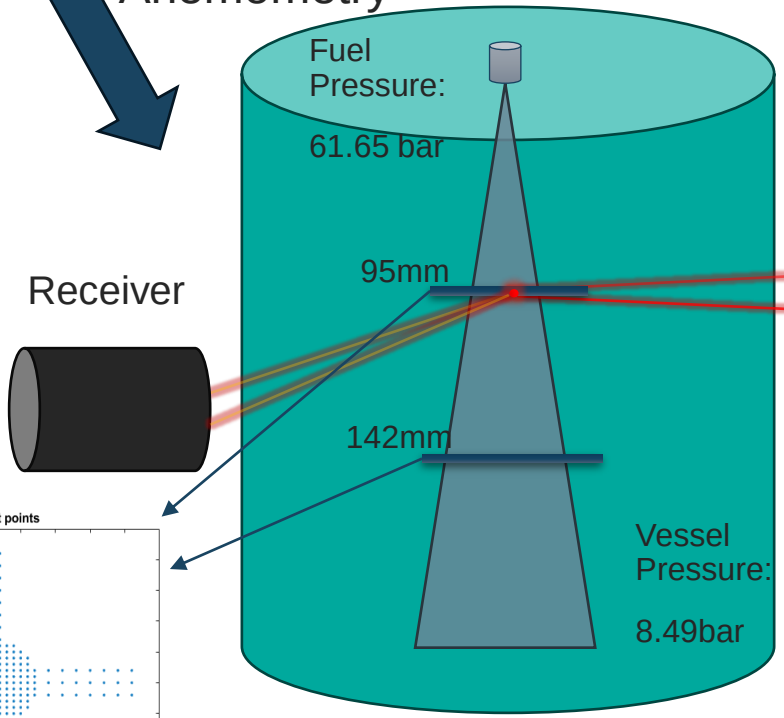
Mätresultat Resultat

Cirkumferentiell Spraykärna, Spray riktning



Source: E. Tuneskog, K. Nogenmyr, D. Moëll, M. Gullberg, and L. Nyborg, “Exploring Surface Roughness Effects on Spray Performance in Metal Additive Manufactured Fuel Injectors for Gas Turbine Applications,” in *WorldPM2024 Conference Proceedings*, 2024.

Phase Doppler Anemometry

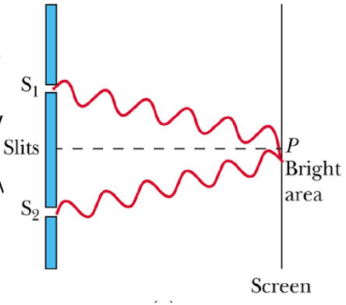


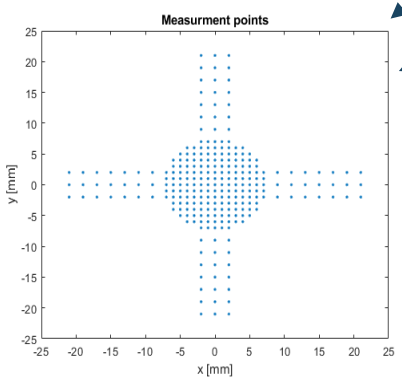
Receiver

Laser

Interference Patterns

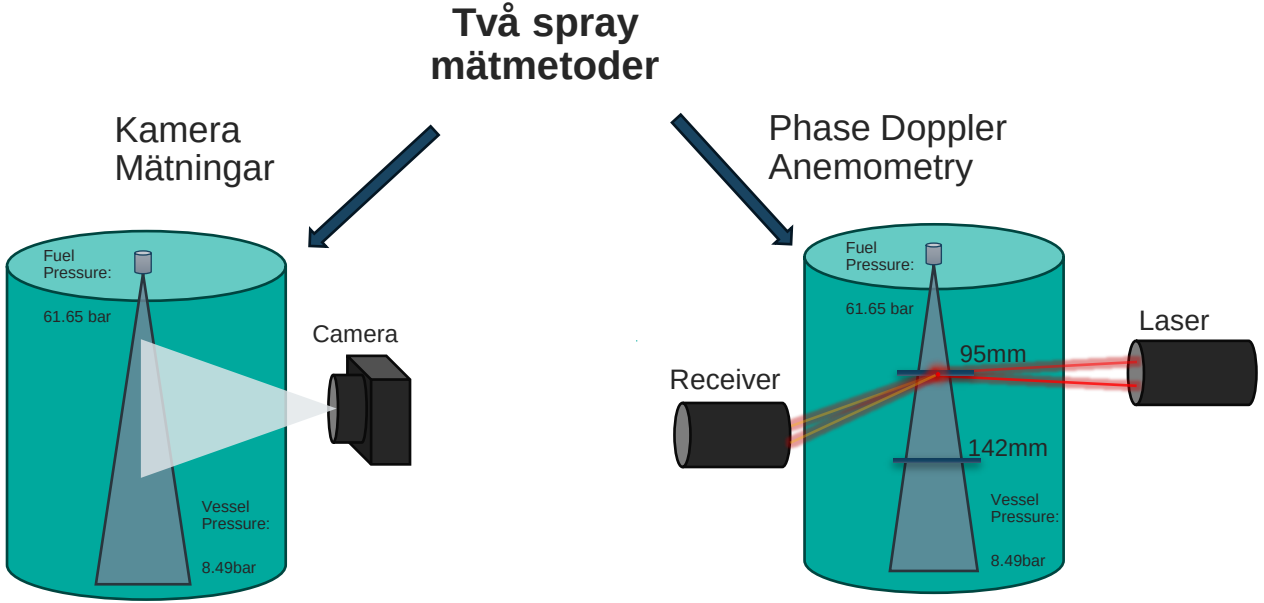
- Constructive interference occurs the center point
- The two waves trav the same distance
  - Therefore, they arri in phase



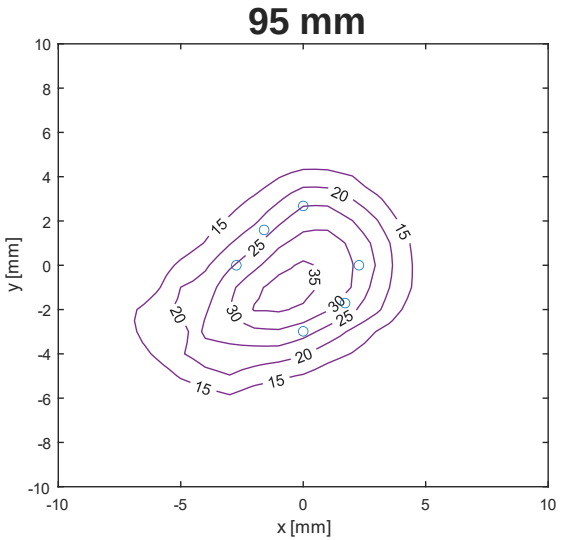


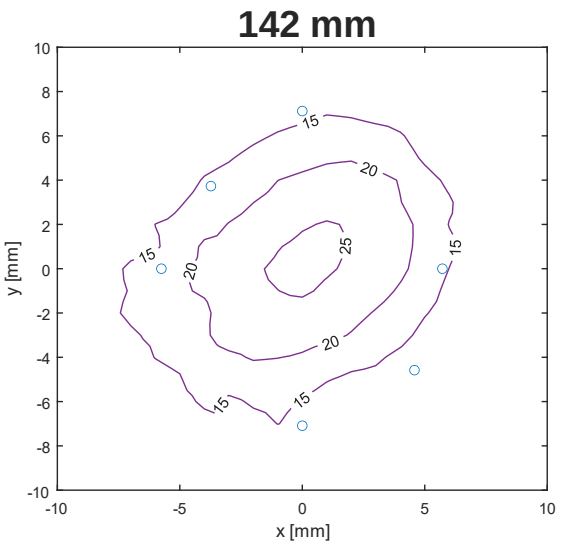
Mätpunkter för varje PDA plan.

Spray Mätningar

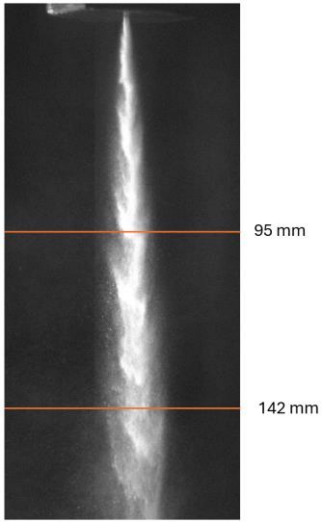


Spray och Hastighets – Jämförelse av Kamera och PDA Mätningar

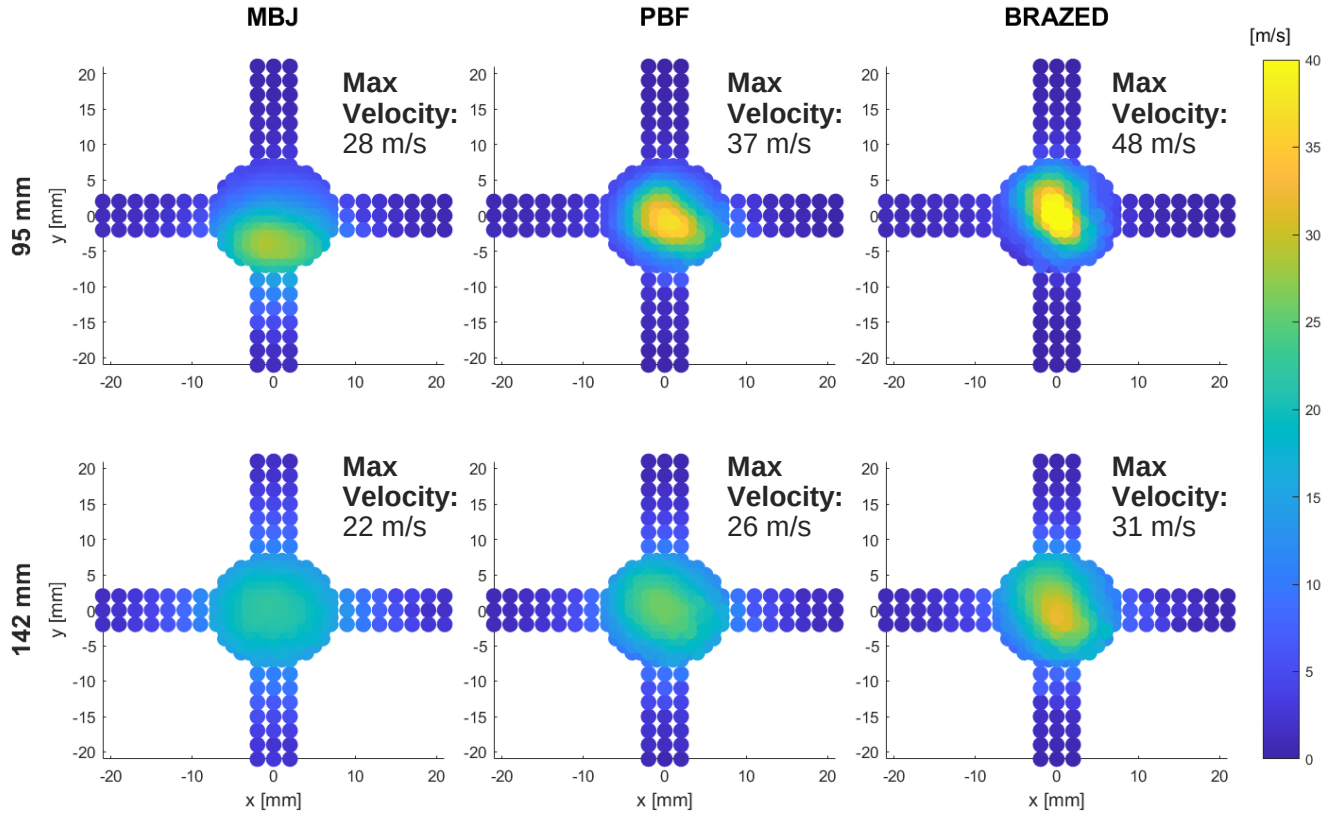




Camera
PDA

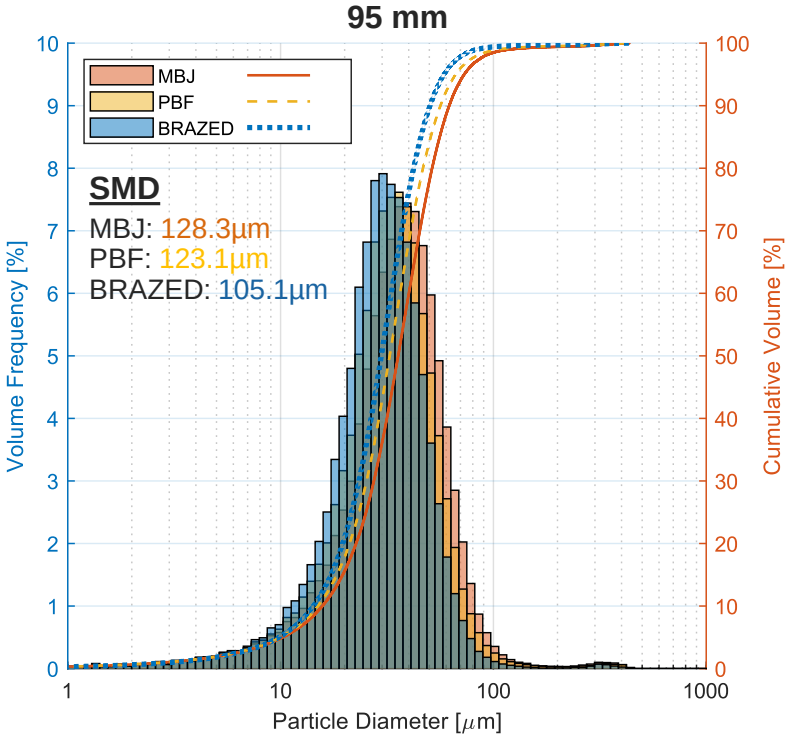


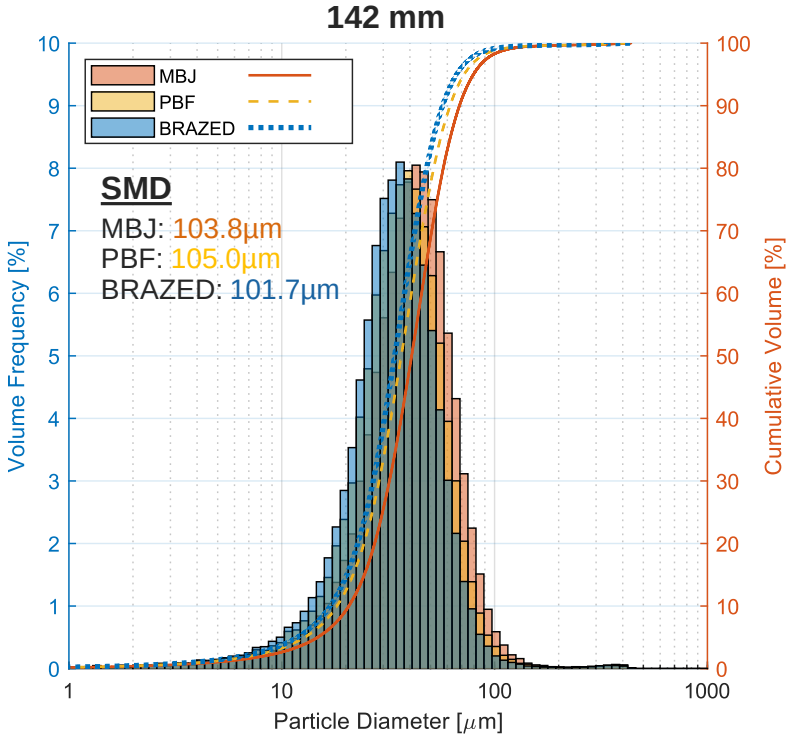
Hastighetsprofil
Diesel 8.49 Bar



Drop Distribution

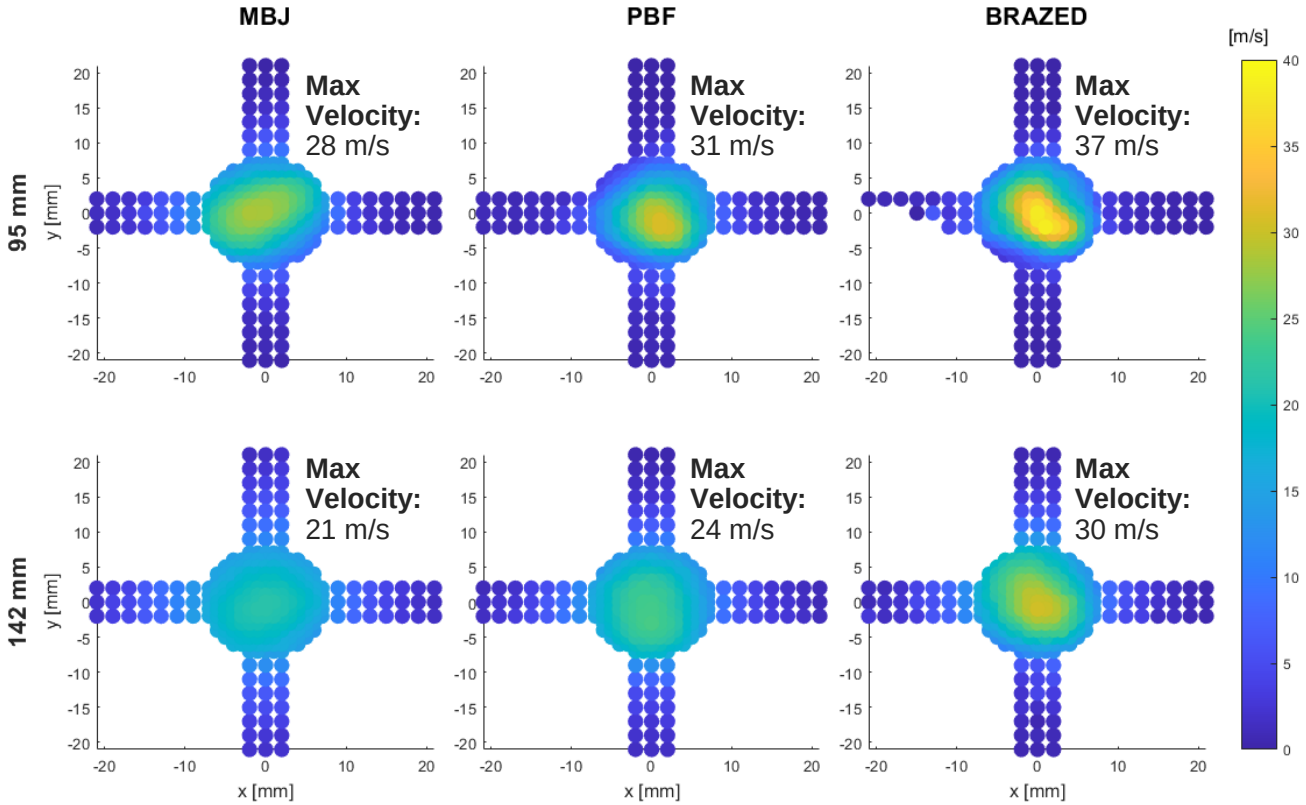
Diesel 8.49 Bar





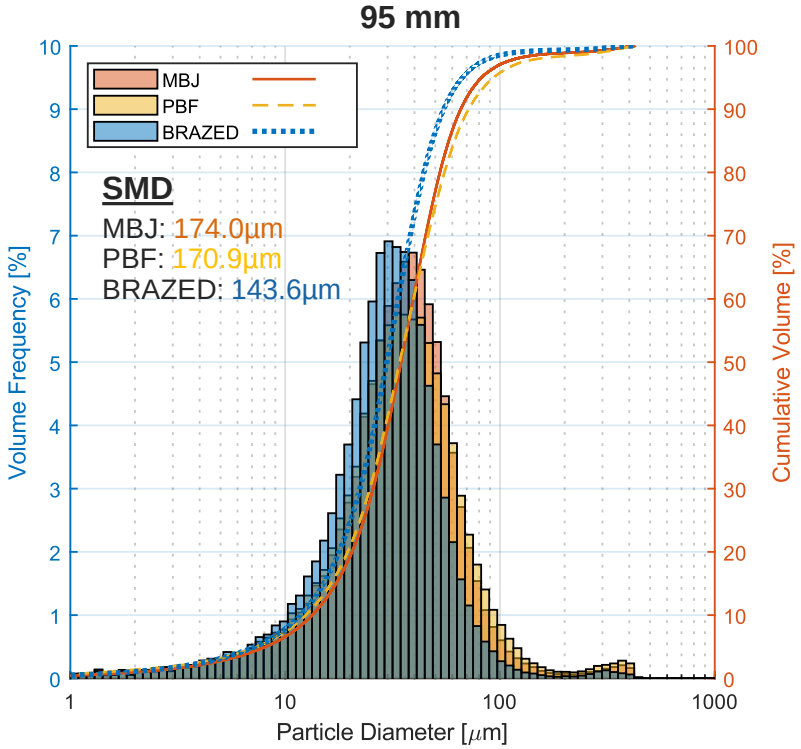
2024-12-09

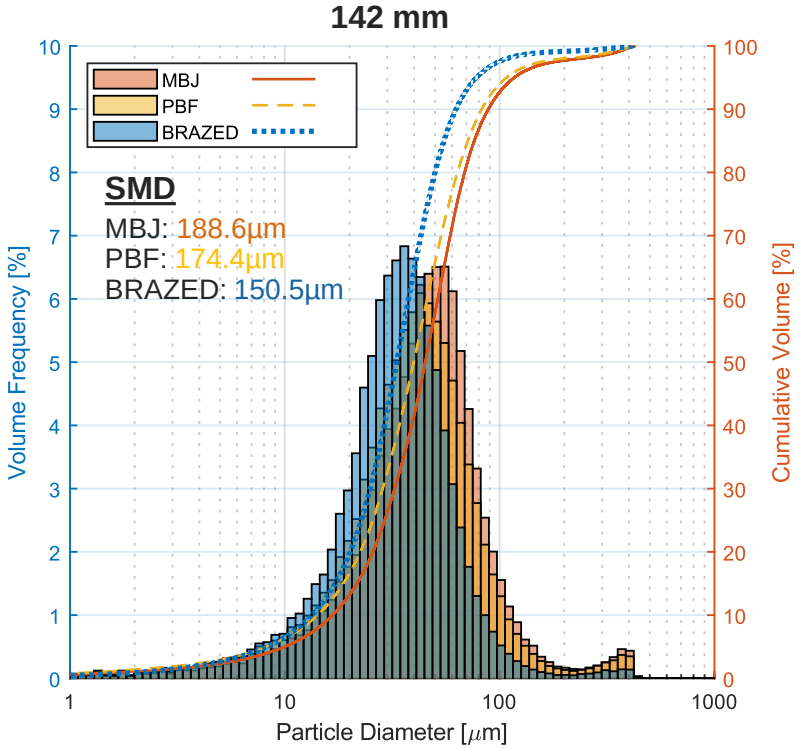
Hastighetsprofil
Methanol 8.49 Bar



Drop Distribution

Methanol 8.49 Bar





2024-12-09

Sammanfattning

1. **AM-injektorer med mindre utlopp**: Kvalitetsosäkerheter och prestandavariationer på grund av ytjämnhet.
2. **Prestandabegränsningar**: AM-injektorer har lägre hastighet och större droppstorlekar än referensinjektorn.
3. **Efterbearbetning**: Krävs för att uppnå samma kvalitet som konventionella injektorer.
4. **Metanolspray**: Vid samma volymflöde som diesel visar lägre dropphastigheter och större droppstorlekar.

Tack för att ni har lyssnat!

Finansering: Energimyndigheten

Siemens Energy AB & RISE Piteå

MC2 Workshop CHALMERS, GARD group CHALMERS, RISE Mölndal, Markforged, BOMEK AB & HANZA GROUP