Höganäs

Lightweight optimized gear design through PM manufacturing technology

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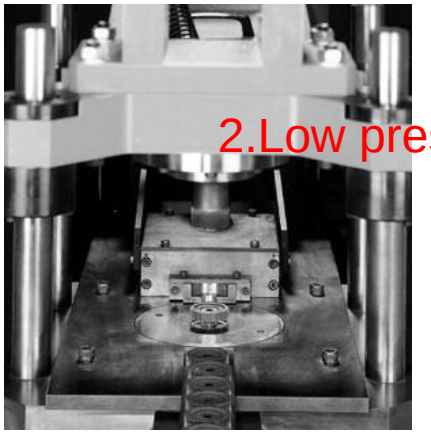
Presentation Contents

- Manufacturing of PM gears –Process steps
- Design considerations macro geometry
- Design considerations micro geometry
- NVH and vibrations
- Application examples
- Next steps

Manufacturing of PM gears

1.Compact



2.Low pressure Sinter & CQT

3. CQT

2.Sinter

4.Grind

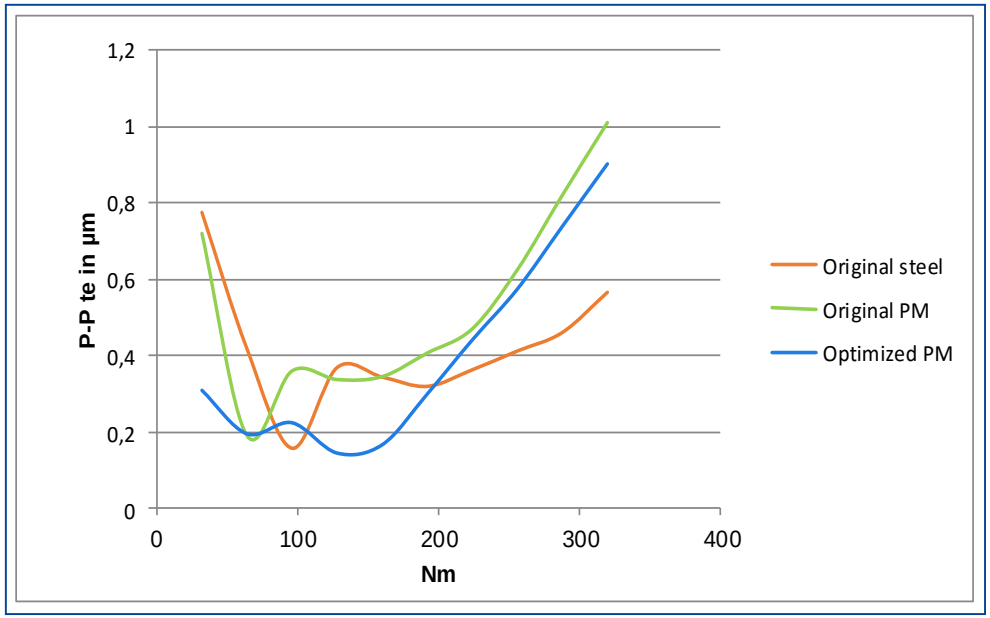
3 step process to gears compare to +10 steps for conventional gear mfg
Utilize new furnace technology –less distorsion –clean parts

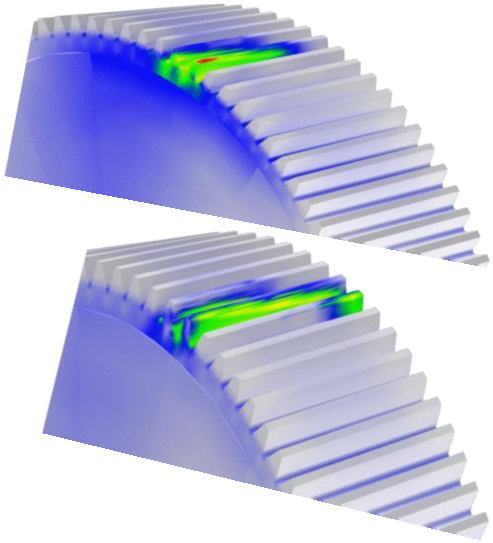
Design: Example: 4:th drive gear 6 speed manual

Steel PM

Steel	PM	
Z=48	Z=50	14% less mass
m=1,7	m=1,64	13% lower contact stress
β=30,9	β=32,2	20% lower bending stress

Example of transmission error and stress levels steel vs. PM at M32 gearbox 4th gear



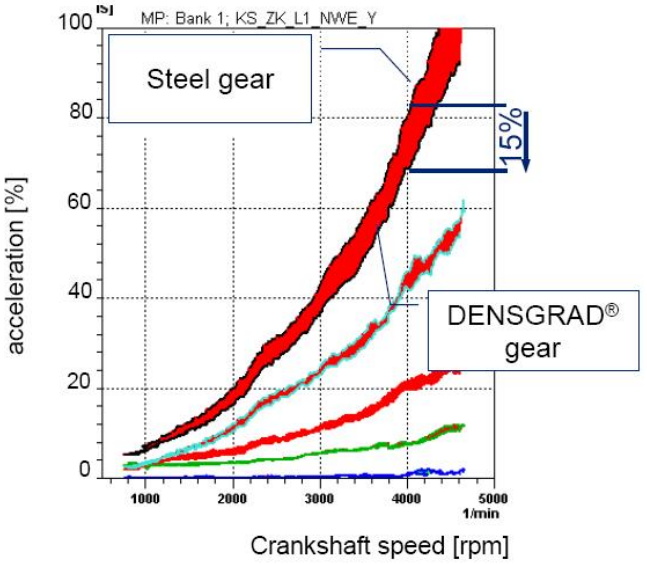


Part:	Max surface pressure:
4th original:	1284 MPa
4th original PM:	1097 MPa
Optimized PM:	1040 MPa

NVH Timing gears, source MIBA (BMW)

Noise Measurement on a running Engine

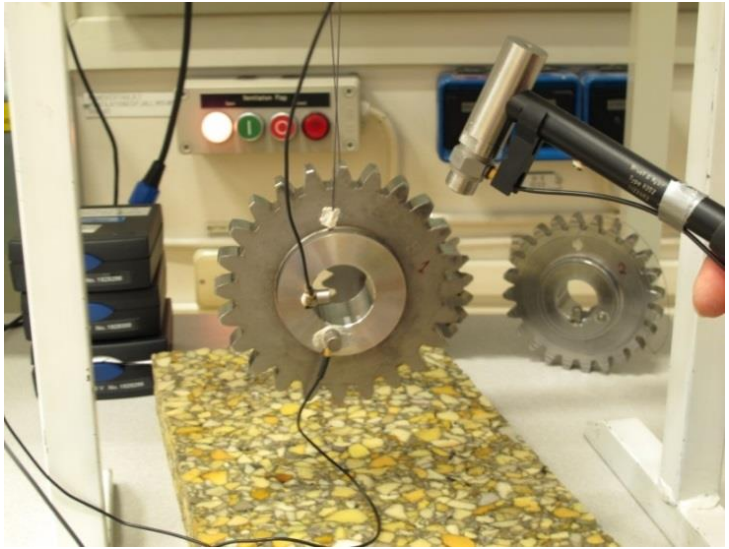
Comparison of Steel/ Sinter steel at Cylinder Head
Backlash of Teeth approx.. 150 µm



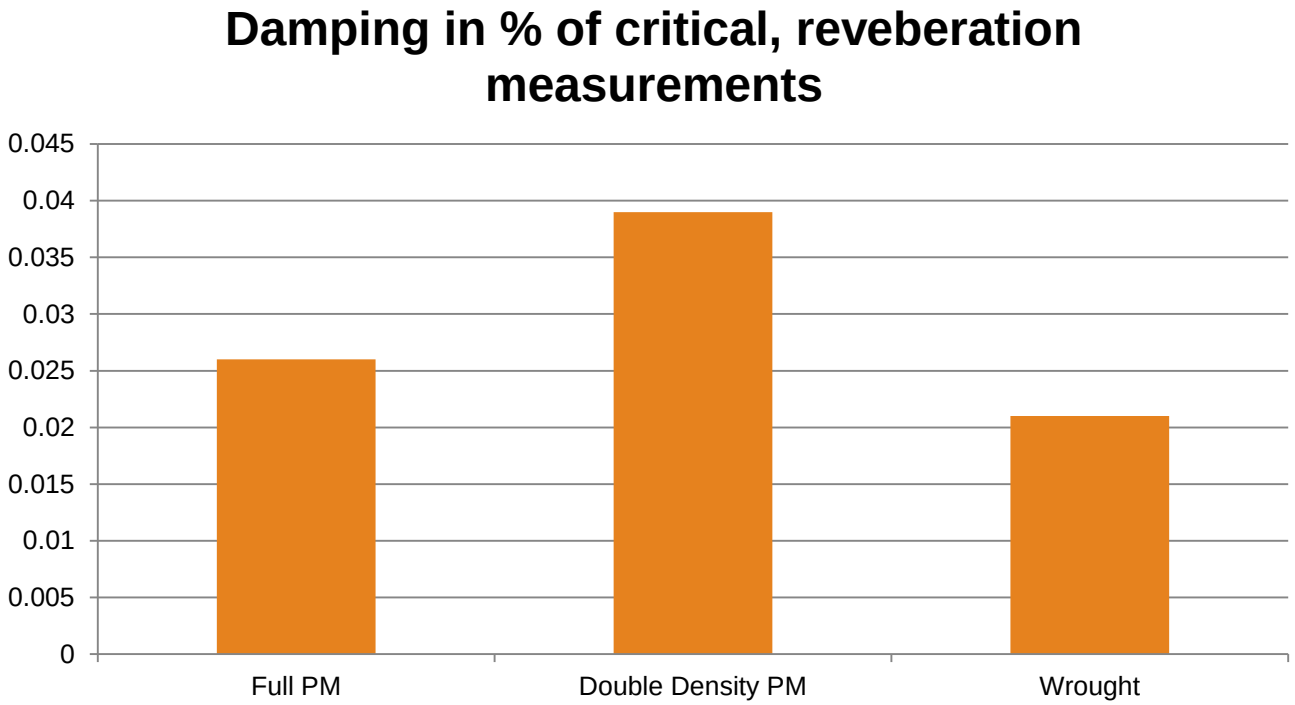
- cumulated level
- band pass 0-1 kHz
- band pass 1-5 kHz
- band pass 5-10 kHz
- 29.5 order

Sound Characteristics of PM vs. Wrought Steel (From Sosa. M)

- Sound characteristics of the following three materials tested in the MWL, Stockholm
  - Wrought Steel
  - Conventional PM
  - Double Density PM
- FZG C type gears
- Damping measurements based on:
  - Reverberation time
  - Frequency response function

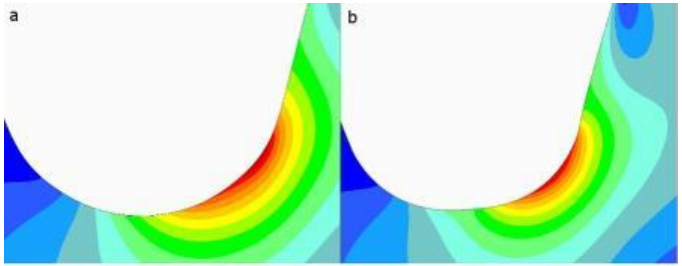


Reverberation time results (From Sosa. M)



Reducing tooth root stresses with PM

Root form	1st input	1st output	4th input	4th output	6th input	6th output
Original	1	1	1	1	1	1
Spline	1	1	0.96	0.94	0.93	0.93
Elliptic	0.92	0.96	0.82	0.76	0.83	**0.70**

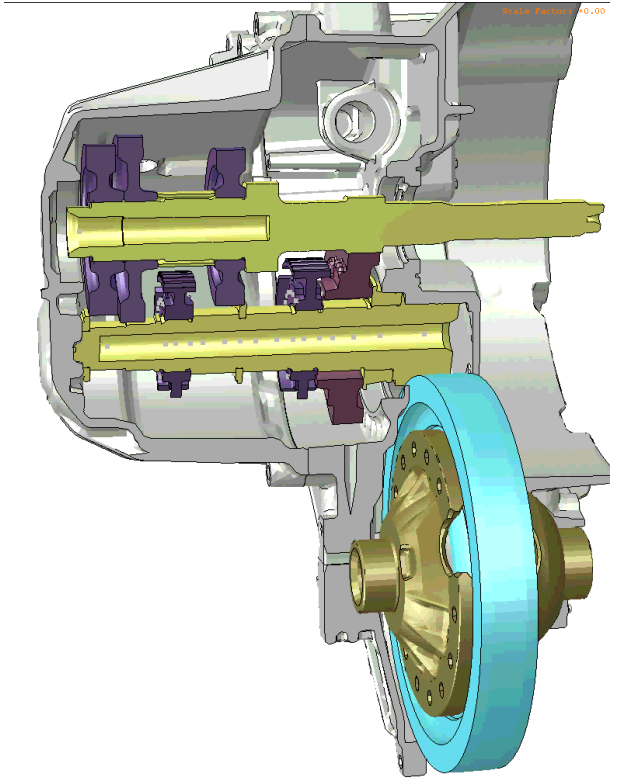


Input gear

Output gear

Redesign and testing of 6 speed manual transmission

- Complete reverse engineer and redesign of all gears
- System approach; all deformations simulated
- Prove the concept of high load carrying gears



Results from testing

- Breaking load
  - 1100Nm and higher (engine torque 230NM)
- 1:st + 2:nd order vibrations lower than stock steel gears
- 300 000Km durability test –Pass
- 1.6 Kg weight reduction on gears.
- Average 18% inertia reduction on rotating gears.

Future

- A number (3-5) of cars with different technologies
  - Hybrid
  - Range extender
  - AWD
  - E-car
  - Different sizes for different geographical markets

Powder Powered Electromagnetic Applications

- E-turbo, ABS motor
- Traction motor, inductors
- Injector cores

6,7kW/kg 16Nm/kg

Thank you for your attention!

640 Nm through PM gears; That’s Power of Powder!