Powder Metallurgy structural components: comparative overview vs other competitive technologies

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Complementary operations

- Sizing
- Impregnation/Sealing
- Machining
- Deburring
- Joining
- Cleaning
- Coating/Plating
- Steam Treatment
- Heat Treatment
PM structural components
PM soft magnetic components
Why PM for structural parts?

- Complex shapes
- High dimensional accuracy
- Reliability and repeatability in large series
- Self-lubrication
- Excellent surface finish
- Unique and isotropic materials

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### Dimensional accuracy

#### PROCESSES

<table>
<thead>
<tr>
<th>Processes</th>
<th>ISO IT TOLERANCE CLASS</th>
</tr>
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<tbody>
<tr>
<td>Sand Mould Casting</td>
<td>7 8 9 10 11 12 13 14 15 16 17</td>
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<td>Investment Casting</td>
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<td>Hot Forging - Extrusion / Deep Drawing</td>
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<td>Warm Forging - Extrusion</td>
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<td>Cold Forging - Extrusion</td>
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<td>Machining</td>
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<td>Fine Blanking / Stamping</td>
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<td>Rolling</td>
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<tr>
<td>Powder Metallurgy (P/M)</td>
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<tr>
<td>Powder Injection Moulding</td>
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</tbody>
</table>

- **Standard tolerance ranges**
- **Reachable ranges in special cases**

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# Tooling Cost

<table>
<thead>
<tr>
<th>PROCESSES</th>
<th>COST (x1,000)</th>
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<tr>
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<td>PROCESSES</td>
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- Standard production runs
- Special production runs

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**Limiting factor: SIZE**

**Limited by:**

- **Compacting surface:** Depends on powder compressibility and press size.  
  *Orientative data:* Press size 1,200 Tm max., compacting surface 180 cm$^2$ max., outer diameter 200 mm max.

- **Length:** Limited by ejection forces, density gradient and press architecture.  
  *Orientative data:* Length 80 mm max.

- **Raw material cost.**  
  *Orientative data:* Steel rod or sheet: 0.7-1.6 Eu/Kg,  
  PM steel: 1.1-2.8 Eu/Kg
Limiting factor: DENSITY

- High speed steels
- Aligned steels
- Structural steels
- Maleable cast iron
- Grey cast iron

Ultimate tensile strength (MPa) vs. Density (g/cm³)

<table>
<thead>
<tr>
<th>Sintered steels</th>
<th>Wrought steels</th>
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<tbody>
<tr>
<td>6.2</td>
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<tr>
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<tr>
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<tr>
<td>6.8</td>
<td>7.6</td>
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<tr>
<td>7.0</td>
<td>7.8</td>
</tr>
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Bending fatigue limit (MPa)

- $\alpha_k = 1$
- $\alpha_k = 2 \div 4$

Hardness Vickers

- $HV_{0.1}$
- $HV_{10}$

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Limiting factor: FORMABILITY
The compacting process

Die filling                        Compacting                           Ejection

Powder filling

Robust tooling

Ejectability
Compact integrity
Technologies comparison

Forging

Powder Metallurgy

Machining

Powder Metallurgy
Technologies comparison

Extrusion

Deep Drawing

Rolling

Powder Metallurgy

Powder Metallurgy

Powder Metallurgy

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PM self-lubricating bearings

**Economy:**
- No need of additional lubrication
- Maintenance-free

**Reliability:**
- Elimination of seizure risk
- Long life without wear

**Performance:**
- Extremely silent
- Low friction coefficient (up to 0.01)
- High dimensional precision
- Dynamic load up to 10 MPa
- Linear speed up to 8 m/s (30,000 rpm)
- Working temperature -60°C +230°C

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Bearings comparison

Rotational PV limit (orientative data)

- Hydrodynamic (with external lubrication)
- Sintered (bronze and iron)
- Ball bearing
- Bimetallic
- Plastic

PV (MPa·m/s) vs. Linear speed (m/s)
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THANK YOU

for your valuable time