PRÁŠKOVÁ METALURGIA – EKONOMICKÉ ASPEKTY

POWDER METALLURGY – ECONOMIC ASPECTS

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Abstract

The vast majority of powder metallurgy structural part applications are based on the winning of a cost competition against other routes for forming the same component shape. In turn, powder metallurgy's cost competitiveness against other technologies is based on two major issues – lower energy consumption in the process and superior utilisation of the starting raw material.

Key words

cost competitiveness, powder metallurgy process, structural part, technologies

Introduction

Powder metallurgy is an efficient and versatile method for manufacturing ferrous and non-ferrous machine parts and electrical and electronic components By mixing powders and compacting the mixture in a die, the resulting shapes are sintered, that is, heated in a controlled-atmosphere furnace to bond the particles metallurgically. [1]

Fig. 1 Powder metallurgy process [1, edited and supplemented by author]

1. Powder metallurgy – economic aspects

There are a number of considerations that determine whether a component application might be a viable target for powder metallurgy:

• <u>Product size and weight</u>

Although material utilisation is high in powder metallurgy, the powders used are a relatively expensive feedstock material compared with the steel bar or billet used in many competing processes. Powder metallurgy therefore generally competes best in relatively small and light

parts, where material costs can be contained to a relatively small percentage (perhaps around 20%) of total manufacturing costs.
Also, the larger the part is in plan view, the larger is the compaction tonnage required and the tonnage capacity of powder metallurgy compaction presses is limited to no more than around 1,000 tonnes.

• Product geometry
Powder metallurgy works best in making “prismatic” shapes with virtually unlimited shape complexity in two dimensions (the radial or plan view in the die), but much more limited complexity in the third dimension, the axial or through-thickness direction.

• Production quantity requirements
Powder metallurgy requires large production runs in order to be viable. Firstly, the required forming tooling is generally complex and relatively expensive and the tooling cost needs to be amortised over a large number of products. Similarly, the capital costs of PM processing equipment (presses, furnaces) are high and need to be amortised over a large number of products. [2]

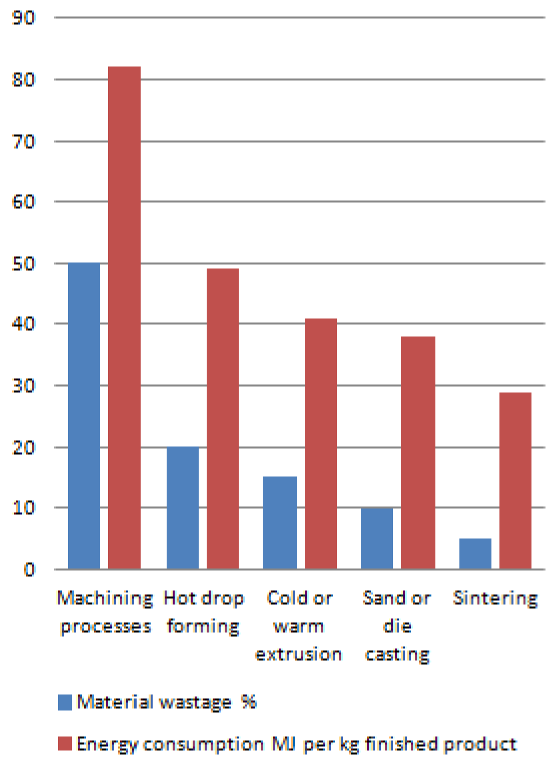

Fig. 2 Material consumption and material wastage of metal manufacturing processes
[2, edited and supplemented by author]

An issue associated with the equipment capital costs is that downtime between production jobs needs to be minimised and hence batch runs need to be relatively long in order that tool changeover/setting periods are not too frequent.
The competitive position of powder metallurgy against other technologies, in terms of both material utilisation factors and energy consumption rates, is demonstrated in Fig. 2. As shown

in this figure, the typical powder metallurgy material utilisation of 95% of the original raw material is superior to any of the competing processes. [2]
For applications that satisfy the above requirements as viable targets for powder metallurgy, the benefits of the technology in process energy saving can be demonstrated by citing some case study examples.

2. Example 1 – notch segment

A notch segment from a commercial vehicle transmission, conventionally produced by machining from steel barstock, showed an energy saving advantage for powder metallurgy of 1.24 kWh (4.46 MJ) per piece versus 2.85 kWh (10.3 MJ) per piece (a 57% saving), see tables 1 and 2 below. [3]

Tab. 1 Energy consumption of conventional machining
[3, edited and supplemented by author]

Material	16 Mn Cr 5	Annual requirement 60,000 Units
Finished part weight	300 g	
Used weight	560 g	= 33,600 kg / 60,000 Units
Material loss	260 g	= 15,600 kg / 60,000 Units

Work plan	Machines	Energy kWh / piece	Energy as % of total energy expenditure
Shearing off	Hammer shears	0.011	0.39
Annealing	Annealing furnace	0.040	1.40
Preforging	Drop hammer	0.087	3.05
Finish forging	Forging press	0.298	10.47
Hot deburning	Shears	0.010	0.35
Annealing	Annealing furnace	0.097	3.41
Descaling	Jet unit	0.024	0.84
Sizing	Sizing press	0.164	5.76
Grinding	Single pulley drive-flat grinder	0.200	7.02
Boring	Deep hole boring machine	0.578	20.30
Counter Sinking	Boring machine	0.053	1.86
Broaching	Broaching machine	0.077	2.70
Milling	Milling machine	0.108	3.79
Hardening m/c	Furnace	0.609	21.39
Cleaning	Rotary table radial operator	0.003	0.11
Grinding	Rotary table grinder	0.147	5.16
Grinding	Internal grinder	0.341	11.99
		2.847	100.00

Energy consumption / number of pieces per year 170.8 MWh = 44.5 t fuel oil S = 64,100 SKE

Tab. 2 Energy consumption of powder metallurgy production
[3, edited and supplemented by author]

Material	Sint D - 11	Annual requirement	60,000 Units
Finished part weight	312 g		
Used weight	328 g	= 19,680 kg / 60,000 Units	
Material loss	16 g	= 960 kg / 60,000 Units	

Work plan	Machines	Energy kWh / piece	Energy as % of total energy expenditure
Pressing	Powder press 180 t	0.061	2.14
Sintering	Belt Furnace	0.188	6.60
Pressing	Sizing press 360 t	0.066	2.32
Tumbling	Vibratory grinding drum	0.018	0.63
Hardening	Chamber furnace	0.778	27.33
Washing	Washing machine	0.018	0.63
Grinding	Internal round grinder	0.114	4.00
		1.243	43.65

Energy consumption / number of pieces per year 74.6 MWh = 19.4 t fuel oil S = 28,000 SKE

3. Example 2 – high volume oil pump gear

A high volume passenger car oil pump gear, conventionally produced by finish machining a forged blank, showed an energy saving advantage for powder metallurgy of 0.14 kWh (0.50 MJ) per piece versus 0.28 kWh (1.01 MJ) per piece (a 50% saving), see tables 3 and 4 below. [3]

Tab. 3 Energy advantages of powder metallurgy production of a high volume oil pump gear [3, edited and supplemented by author]

Material	Sint C-10	Annual requirement 3,800,000 units		
Finished part weight	73 g			
Weight of powder used	76.5 g	= 290.700 kg /	"	"
Material loss	3.5 g	= 13.300 kg /	"	"

Work plan	Machine	Energy kWh/piece	Energy as % of total energy expenditure in machining
Pressing	Powder press 120 t	0.018	6.41
Sintering	Belt furnace	0.07	24.91
Pressing	Sizing press 100 t	0.018	6.41
Grinding	2 disc-grinder	0.035	12.46
		0.141	50.19

Energy consumption/number of pieces per year: 536 MWh = 139.7 t fuel oil

Tab. 4 Energy advantages of machining production of a high volume oil pump gear
[3, edited and supplemented by author]

Material	9 S 20 k	Annual requirement 3,800,000 units
Finished part weight	87 g	
Used weight	192 g	= 729,600 kg / " "
Material loss	105 g	

Work plan	Machine	Energy kWh/piece	Energy as % of total energy consumption
Turning	Spindle automatic lathe	0.075	26.69
Grinding	Round table grinder	0.04	14.23
Slotting and deburring	Slotting machine	0.166	59.08
		0.281	100.00

Energy consumption/number of pieces per year: 1068 MWh = 278.3 t fuel oil S = 400,750 SKE

Summary

The energy consumption comparisons in tables 1-4 relate to the forming processes themselves and do not include the relative “embedded” energy in the starting material. Powder metallurgy has a further advantage here. The energy requirement to produce 1 tonne of press-ready atomised iron powder is around 10 GJ, compared with around 14GJ to produce 1 tonne of steel barstock for machining.

Key words

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References

[1] Jones, W. D. Fundamental Principles of Powder Metallurgy. London: Edward Arnold Ltd.
[2] Makhlouf, M. M.; Mould, A. M.; and Merchant, H. D. "Sintering of Chemically Preconditioned Tin Powder". Intern. J. Powder Metallurgy and Powder Tech. 15 (3): 231-237.
[3] Materials provided by company

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