17.7 Economics of Powder Metallurgy

Because PM can produce parts at net or near-net shape, and thus eliminate many secondary manufacturing and assembly operations, it increasingly has become competitive with casting, forging, and machining. On the other hand, the high initial cost of punches, dies, and equipment for PM processing means that production volume must be sufficiently high to warrant this expenditure. Although there are exceptions, the process generally is economical for quantities over 10,000 pieces.

As in other metalworking operations, the cost of dies and tooling in PM depends on the part complexity and the method of processing the metal powders. Thus, tooling costs for processes such as HIP and PIM are higher than the more conventional powder processing. Because it is a near-net shape-manufacturing method, the cost of finishing operations in PM is low compared to other processes. However, if there are certain features to the part, such as threaded holes, undercuts, and transverse cavities and holes, then finishing costs will increase. Consequently, following design guidelines in PM to minimize or avoid such additional operations can be more important in this process than in others.

Equipment costs for conventional PM processing are somewhat similar to those for bulk deformation processing of metals, such as forging. However, the cost increases significantly when using methods such as HIP and PIM. Although the cost of materials has increased significantly (see Table 6.1), it has actually improved the economic viability of PM, since tooling and equipment costs are a smaller fraction of the total cost of production.

Labor costs for PM are not as high as those in other processes, primarily because the individual operations, such as powder blending, compaction, and sintering, are performed on highly automated equipment; thus, the skills required are not as high.

The near-net-shape capability of PM significantly reduces or eliminates scrap. Weight comparisons for aircraft components, produced by forging and by PM processes, are shown in Table 17.6. Note that the PM parts are subjected to further machining processes; thus, the final parts weigh less than those made by either of the two processes alone.

TABLE 17.6

Forged and PM Titanium Parts and Cost Savings

Part	Weight (kg)			
	Forged billet	PM	Final part	Cost savings (%)
F-14 Fuselage brace	2.8	1.1	0.8	50
F-18 Engine mount support	7.7	2.5	0.5	20
F-18 Arrestor hook support fitting	79.4	25	12.9	25
F-14 Nacelle frame	143	82	24.2	50

CASE STUDY 17.3 Powder Metallurgy Parts in a Snowblower

Some of the parts in the freewheeling steering system of a commercial snowblower are shown in Fig. 17.29. Among the 16 PM components, the sprocket is the largest, at around 140 mm in diameter.

The final assembly incorporates a stamped steel frame, bronze and plastic bearings, and a wrought-steel axle, to produce a highly functional and low-cost machine. Unique features compatible with PM manufacturing were incorporated into the design of these parts to enhance their functionality.

The PM components in the assembly range from single-level parts with fixed features on punch faces and core rods, to intricate multilevel parts with complex die geometry, core rods, and transfer punches. These are unique features and they manage the powder for local density control. The clutch pawl, for example, is produced to a net-shape peripheral geometry that is not practical or economical with other manufacturing technologies. The material used is FLC4608-70 steel (a prealloyed powder of iron, with 1.9% NI, 0.56% Mo, and 0.8% C mixed in with 2% Cu), with a tensile strength of 480 MPa and a density of 6.8 g/cm^3.

Part numbers are pressed into the face of the components, as a simple means of identifying them. Two of the components are made with especially close tolerances: The pawl latch gear has a 0.15-mm tolerance on the pitch diameter (PD), with 0.11 mm PD to ID run-out and 0.025 mm tolerance on the bore. The 32-tooth sprocket has a thin-walled 57.75 mm ID with a 0.05-mm tolerance. Both the pawl latch gear and the sprocket acquire a density of 6.7 g/cm^3 and a tensile strength of 690 MPa.

All components shown passed normal life-cycle testing and product-life testing, including shock loading by engaging the drive in reverse, while traveling at maximum forward speed down an incline. Clutch components, which were also subjected to salt-spray corrosion resistance, and proper operation in subzero temperatures, experienced no failures. No machining is required on these parts, as these are sufficiently net-shape components. The only additional operations, prior to final assembly, are vibratory deburring and honing of the 32-tooth sprocket, in order to produce a close-tolerance bore and surface finish. The clutch pawls, produced with sinter-hardened steel, are quenched in an atmosphere so that the porosity present can be filled with a lubricant, to provide lubricity at the interface of mating parts (see also Section 33.6).

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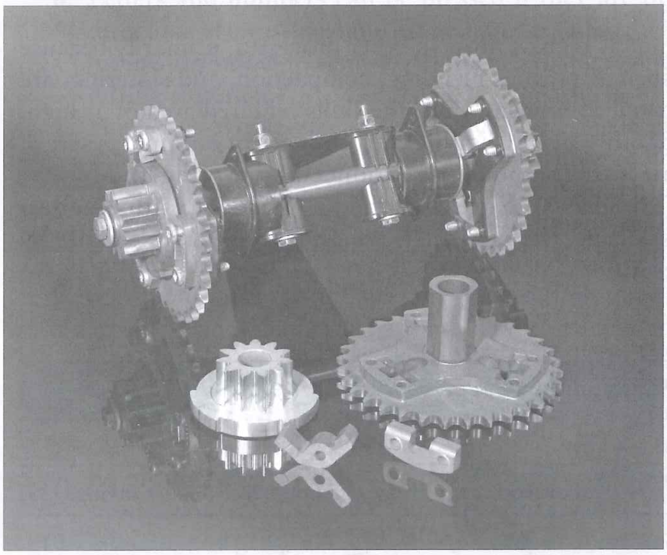

FIGURE 17.29 Powder metallurgy parts in a commercial snowblower.