Chapter 13
Practical Applications in Use Today

Prediction is difficult, especially about the future, said J.D. Barrow; amusing and very true. However, there is no doubt that in today's manufacturing business world one cannot avoid the fact that the rate of change is accelerating. Apart from conventional incremental innovation, radical innovation has become strategically very important and used as a source of competitive advantage in the global market place.

The development of semisolid metal processing is an example of the full spectrum of experiences involved in turning a "research idea" to a successful "commercial product".

Following an unsuccessful attempt to exploit the technology directly by forming an entrepreneurial company, located on the famous Route128 ring road around Boston, the original MIT technology patents eventually were licensed to International telephone and telegraph corporation (ITT Corp.) in the late 1970s. ITT Corporation held the technology very closely, a practise which was also adopted by Alumax Inc., which acquired the technology from ITT Corporation around 1985. The philosophy of both corporations was to maintain tight secrecy around all developments of semisolid processing and to resist request for licensing or joint venture without stringent demands, which effectively eliminated all opportunities for the type of cross-fertilization, which in turn so greatly evolves as technical innovation.

However, by around 1985, ITT Teves, a subsidiary of ITT Corporation and a leading manufacturer of braking systems, had established a semisolid manufacturing facility in Northern Germany, which sparked interest in a number of European manufacturers. As a consequence, in the late 1980s, a number of European manufacturers, having been rebuffed by Alumax, began to develop their own independent approaches for both raw material production and parts forming.

Buhler, a leading European die casting press manufacturer, began to promote their real-time controlled machines as suitable for semisolid processing and their partner at the time Alusuisse developed an electromagnetic stirring system and horizontal continuous caster to produce raw material. Similarly, Pechiney, in France (now a division of Alcan Aluminium) began their work on a vertical continuous caster, for raw material using a combination radial and longitudinal electromagnetic stirrer. Also in Italy, Magnetti Marelli developed a convective slug heating system in combination with machines from IdraPresse for the production of automotive fuel rails.

David H. Kirkwood et al., *Semi-solid Processing of Alloys*,
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DOI 10.1007/978-3-642-00706-4_13,

Of these European developers, by far the most aggressive proponent of semisolid processing was Buhler, who used the opportunity to increase the sales of their horizontal die casting machines. In relatively quick succession, Buhler assisted first Stampal S.p.A in Turin and then Hot Metal Molding Inc. in Arkansas, USA, to enter production of automotive components using raw material from either Pechiney or Alusuisse or one of the several "copycat" producers, who quickly ramped up raw material production. By the mid 1990s, Buhler had more than 40 machines installed around the World for the production of SSM parts.

Stampal S.p.A. in Turin invested in a number of horizontal Buhler machines and Fiat became a keen supporter of the process subsidizing some exciting innovative parts for its Punto, Panda and Alfa Romeo models (see Fig. 13.1).

However, the automotive market is exacting on price and before long, the premium price of raw material produced by the various electromagnetic casting systems was too much for the market to bear and many of the so-called billet based producers could no longer compete. It could be argued that in some instances it was largely because of poor choices of target parts, but at any rate, the interest has turned to slurry-based systems, which promise to eliminate all premiums and facilitate on-site recycling. By the late 1990s, UBE, a Japanese die casting machine manufacturer entered the market with the new rheocasting process (see Sect. 9.6).

Fig. 13.1 Parts produced by Stampal S.p.A for various automotive manufacturers using the MHD feedstock route

Currently, more companies appear to develop parallel production routes that allow in-situ re-cycling, such as the SSR (Sect. 9.6.2) and other developments are on the way by the aluminium manufacturer Alcan [11] and the die casting machine producers Buhler. While UBE's new rheocasting technology grabbed a lot of attention in the opening years, commercial operations using this approach outside of Japan appear to be limited to Stampal S.p.A in Italy. Those installations originally imported in the USA are either mothballed or ceased entirely and semisolid processing is in a "wait-and-see" mind frame while several other slurry-based systems are evaluated. In the meantime, two significant producers continue to use billet-based technology in the US: Madison Kipp Corporation (Wisconsin) focusing mainly on automotive applications with four cells, Vforge (Colorado) focusing primarily on non-automotive applications, and SAG in Austria continuing to produce automotive products using its two SSM cells.

Semisolid metal Processing has become a widely accepted industrial manufacturing route for the production of near net-shape of aluminium and magnesium alloy components. Recently, there have been published quantitative data in support of the assertion of near net-shape. Being a relatively "new process", thixoforming had to establish itself by exploiting alloys that were already available. It would have been extremely difficult for thixoforming as a relative new process to establish itself in the market, if it required from industry to accept the use of new and unfamiliar alloys, as well as having to cope with the novelty of the manufacturing process itself. As a result, the widely tried and tested 356, 357 and A357 aluminium–silicon alloys were chosen as the materials, on which the process could demonstrate its potential. This phase is now over and millions of automotive parts are now in everyday use in the cars we drive [12].

It should be borne in mind that total production of aluminium castings is in the order of 1,500,000 m in North America and Europe and 1,000,000 m in Japan. However, thixoforming represents only around 1% of the total in this vast market where die casting and permanent mould casting are still overwhelmingly dominant.

In order to grow out of its current minor niche status, SSM processing has to overcome restrictions on three fronts:

- In dynamic applications for load bearing components (fatigue properties)
- In alloy development – expanding the existing portfolio of thixoformable alloys (better mechanical properties)
- In materials recycling

Although the position of the MHD route of feedstock production had been virtually unchallenged throughout the development of the thixoforming process, its inherent drawback of non-direct recyclability, involving added costs, has attracted the main challenge from NRC, and now from the other rheocasting variants discussed above.

In parallel with all these activities, Thixomoulding, the injection moulding of thixotropic metal alloys (magnesium to date) in a semisolid or plastic-like state, developed by Dow Chemical (see Sect. 10.6), is used today for cell phone and laptop computer covers, photo and video cameras and many other applications (Figs. 13.2–13.15).

Fig. 13.2 220t-Thixomoulding®-machine from Japan Steel Works at Neue Materialien Fürth GmbH (NMF)

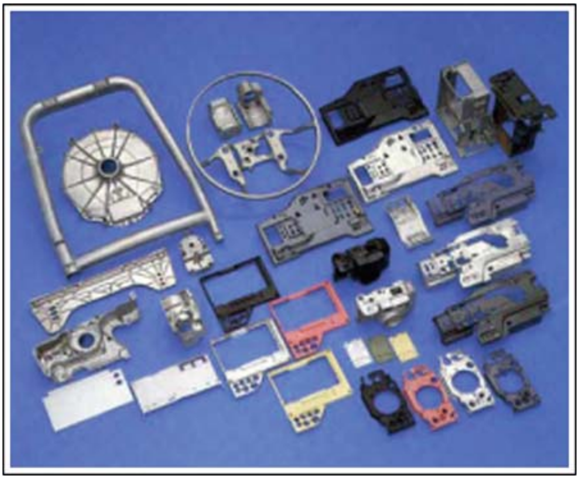

Fig. 13.3 Examples of magnesium thixomoulded parts from JSW Inc

Fig. 13.4 Off-road motorcycle head-tube, alloy 357-T6 welded to a 6061 extrusion to make the complete frame (Vforge)

Fig. 13.5 Small gasoline engine cartridge plate formed from alloy 357-T5, which replaced a machined alloy 6061-T6 piece (Vforge)

Fig. 13.6 Small gasoline engine containing a number of SSM aluminium alloy parts including the entire crankcase, which is formed from alloy 357-T5 using a 2,500 ton machine and 5 in. diameter billet material. The cartridge plate in the previous figure and a companion SSM formed plate can be seen installed within the mechanism (Vforge)

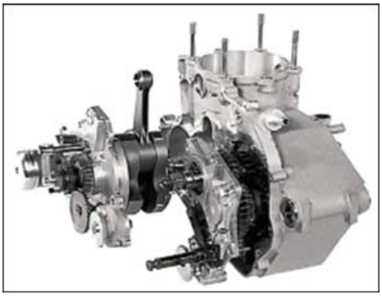

Fig. 13.7 Rheocast high strength safety parts: engine bracket (*left*) and Lagerbock (*right*) both using A 357 alloys (courtesy of Stampal S.p.A)

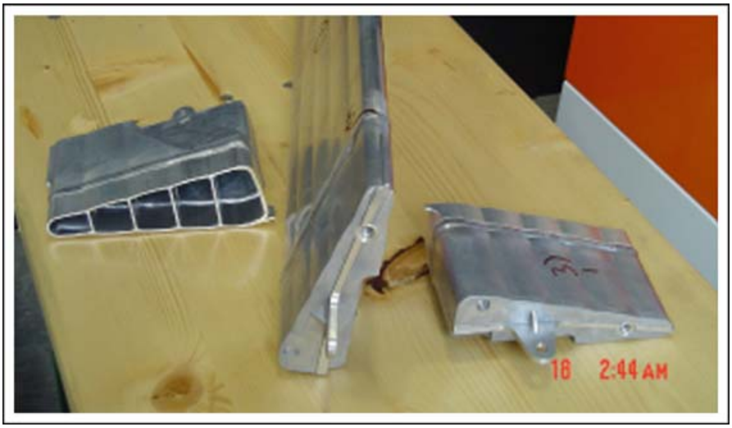

Fig. 13.8 Air tank side parts for extruded tank profile; operating pressure 16 bar, very thin walls, 240 g each part using the MHD route. Material: New alloy, high YS (290 MPa) and E 12 (%) no H.T, low porosity, weldable, Audi. (Courtesy of SAG GmbH)

Fig. 13.9 *Left*: Air manifold harness weldable on hydroformed part, thin wall, high ductility (VW and Audi) 130 g, replaces two parts previously produced by stamping. Front part of engine, vibration issues (fatigue); *Centre*: Antenna housing for tower mounted amplifier (TMA). Corrosion resistant, precision near net-shape, good surface quality, easy to coat (3–5 μm silver), with good electrical and inter-modulation properties; *Right*: Flange energy crash absorber; near net-shape component for AUDI A6 V8 energy management system for bumpers (Courtesy of SAG GmbH)

Fig. 13.10 Decorative pen and cover SSM formed from aluminium alloy 6061 in order to achieve a very high lustre polish. Aluminium alloy 357 polished to a low lustre finish because of the silicon content, and so this was one of the very first wrought aluminium alloy production applications (courtesy Vforge)

Fig. 13.11 Golf putter formed from alloy 357-T5 over a brass rod acting as a weight (Vforge)

Fig. 13.12 One of the very first SSM copper alloy production parts. A golf driver sole plate formed from aluminium bronze alloy replacing a stamped and machined alloy 377 piece. This application offered improved wear resistance from the superior alloy as well as a near net-shape without machining requirements (Vforge)

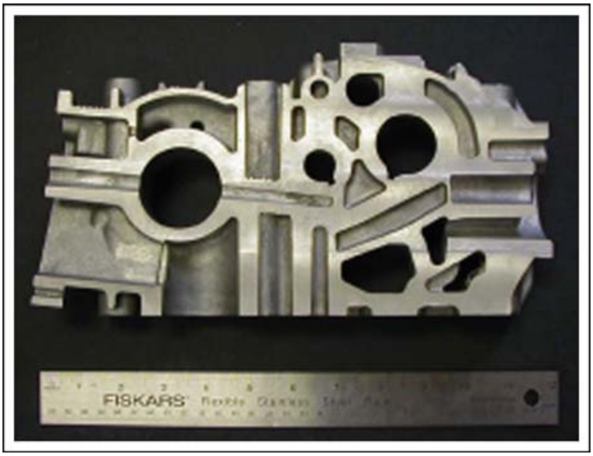

Fig. 13.13 Section views of the oil pump filter housing produced by SSR (Courtesy Idra Prince)

Fig. 13.14 Orthopedic knee joint piece replaced an investment cast steel piece saving 0.25 lb weight per knee! Alloy 357-T5 (Vforge)

Fig. 13.15 Some die cast dies can be converted to SSM forming provided the gating is acceptable for SSM die design as discussed above. This centre-gated die was converted relatively easily and runner volume saved by moving the shot position to dead centre (Vforge)