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An overview of Blend of Casting Process and Powder Metallurgy Technique as an alternative for manufacturing

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ABSTRACT

The combination of Casting and Powder Metallurgy can promote refined and more uniform microstructures which can result in improved properties and higher isotropy of material. The potential of such blending can be studied by using three important processes viz. Osprey Process, Ceracon Process and Slip Casting Process. These processes can be compared on the basis of microstructure, Austenitizing temperature, and Hardness with Scanning electron microscopy and can be related with conventional processes of manufacturing.

Introduction

Casting processes basically involve the introduction of a molten metal into a mold cavity, where upon solidification, the metal takes on the shape of the mold cavity. In Powder Metallurgy, the powders made from scrap are compressed into the desired shape and then heated to bond the particles into a hard, rigid mass. With normal casting process the dimensional accuracies and surface finish is less. It is also not suitable for small production. Molten metal problems like porosity, shrinkage etc. arises in casting. Powder metallurgy parts can possess inferior mechanical properties, poor ductility, variable density and shrinkage during sintering.

Osprey Process

Osprey Process is unique in combining a rapid solidification process (gas atomization) with a direct method for making bulk components. Since its development, Osprey process has been widely studied in several types of alloys. There are several reports of its use for high speed steel production. Besides, Osprey process has been used industrially applied in Rolling Mill Rolls, of high speed steels, definite chilled iron or spheroidal graphite iron [1]. In this process the concept of atomization is used but instead of making powder, the droplets of atomized metals are deposited onto the substrate until the final thickness is achieved. The microstructure thus becomes uniform and homogeneous as compared to conventional techniques. This gives excellent properties to the material. The density of such material can be 97%. The substrate is rotated to produce an even deposit and as the thickness increases the substrate is lowered. It has been used to produce parts of automotive applications like wear resistant Al-Si cylinder liners, connecting rods and pistons made from Al-Si alloys [6].

Ceracon process

The Ceracon process (Ceramic Consolidation) was originally developed in the mid 1970's to consolidate powder metals. The process has been successfully applied to near-net-shape production of oil drilling and other mechanical tools using conventional materials such as steel or tungsten carbide. The basic concept of the Ceracon process to consolidate powder material is still applicable in the preparation of fully dense forms. The Ceracon consolidation process is recognized as an enabling technology by the advanced materials processing community. With its use in a broad range of conventional materials leading to cost reduction, significant commercial applications are emerging for this process. The major advantage is that consolidation is carried out below the solidus temperature of the material thus removing a problem in composites processing. [4].

Rapidly solidified powders were successfully consolidated using this process. Full density can readily achieve in canned powders. Rapid densification is facilitated by the enhanced plasticity associated with the presence of a significant volume fraction. Microstructure evolution during consolidation is elucidated and related to the relevant process parameters [5].

Slip casting

Slip casting refers to the filling of a mould, a negative of the desired shape, with a slip consisting of a suspension of micrometre size ceramic particles in liquid. The capillary action due to the pores in the mould withdraws the liquid from the slip. As the liquid filters into the mould a cast is formed on the mould surface. Stable slips with high solids contents and low viscosity's can be prepared by careful adjustments of the chemistry of the slip by adding Deflocculants [9].

Working Principles

The working principles of all above processes are as follows.

Osprey Process

There are four main stages in Osprey Process, including melting and dispersing, gas atomization, deposition and collector manipulation. An overview of the Process, with a single atomizer and applied to high speed steel billet production, is shown in figure 1 [2].

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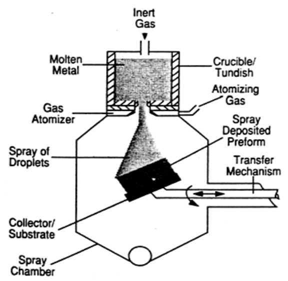


Figure 1. Osprey Process

Ceracon process

It consists of four major steps as shown in figure 2. Fabrication of green preform, heating, transfer of form to the die, consolidation, part removal and grain recycling [7]. An 80% dense preform is preheated to approximately 1095°C. The preform is then placed in a die cavity containing preheated pressure transmitting medium. A ram applies pressure to the medium which consolidates the preform to full density [8].The significant advantages of this process can be use of conventional materials like steel which are larger in size, easy thermal management of specimen and easy setup and operation of equipment.

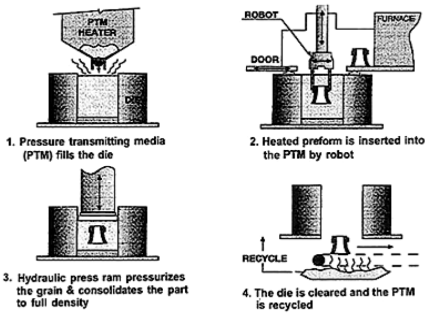


Figure 2. Steps in Ceracon Process

Slip casting

Two principal variations in slip casting (figure 3) are, Drain casting where the mold is inverted to drain excess slip after a semi-solid layer has been formed, producing a hollow product and Solid casting where adequate time is allowed for entire body to produce solid products [10].

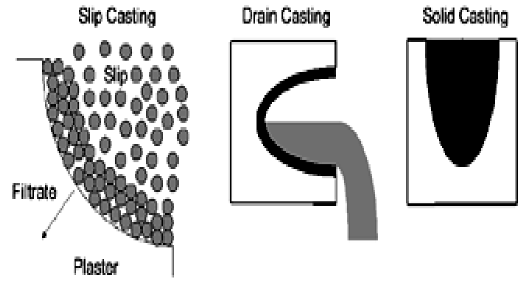
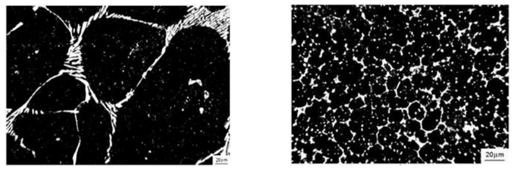


Figure 3. Slip casting methods [11]

Inherant characteristics of the processes

The Osprey material cast microstructure shows considerable differences compared to conventional casting material. Osprey microstructure is considerably finer than that of conventional material as shown in figure 4. This results from the better capacity of heat extraction, during solidification. The ability of production of such fine microstructures in a single process is the main goal of Osprey process [3].

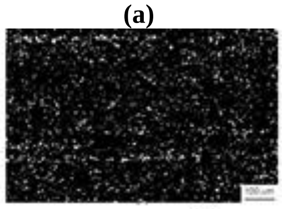


(a) (b)

Figure 4. Microstructure of (a) Conventional Casting and (b) Osprey Process

Annealed microstructures of Osprey and Conventional cast material are shown in figure 5. Conventional casting material remains coarsely distributed or Hooky arranges which is not desired because of crack propagation [3].

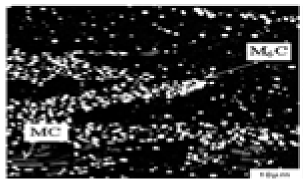
(a)



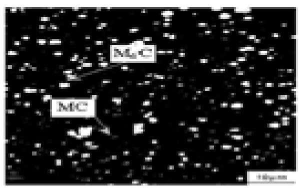
(b)

Figure 5. Annealed Microstructure of (a) Conventional Casting and (b) Osprey Process

Scanning electron microscopy of Conventional and Osprey material is shown in figure 6. The microstructural variation of Osprey shows the coarsening occurrence after hot working, possibly during the heating treatment. Osprey is shown to be able to present more refined microstructures if lower temperatures were employed [3]



(a)



(b)

Figure 6. Scanning electron microscopy of (a) Conventional Casting and (b) Osprey material

Hardness after tempering is shown in figure 7 in relation to austenitizing temperature. Osprey material presents the same hardness levels as conventional material, in spite of having considerably smaller equivalent carbon content [3].

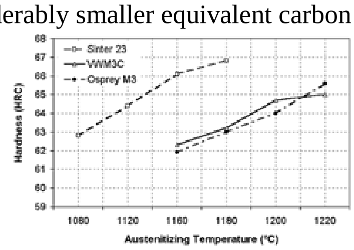


Figure 7. Hardness v/s Austenitizing temperature

Figure 8 presents bend test results for all materials, heat treated for hardness between 64.0 and 65.3 HRC. Bend strength results for conventional and Osprey material shows the relative difference on longitudinal and transverse directions results indicates isotropy degree which is 88% for Osprey material and 53% for conventional material [3].

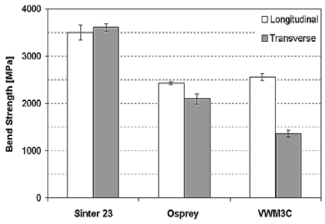


Figure 8. Bend strength comparison

Conclusion

Experiments are showing improved wear behaviour compared with conventional material due to fine and uniform grain structure. Osprey material showed better resistance to wear than powder metallurgy samples. The material showed reduced fretting wear. Many of the steps between atomization and consolidation are eliminated, thus reducing not only cost, but also the opportunity for inadvertently contaminating the powder. This offers an alternative to materials that cannot be forged as conventionally cast ingot. In Cercon process there is no need of canning and decanning the parts, the compacted part and pressurizing medium can be easily separated and the granular material can be reheated and reused. The density of the products increases. The advantages slip casting process are shapes and sizes that could not be possibly pressed, no expensive equipment requirement and excellent properties of finished products. The development of technique made it possible to produce a product economically, and today it occupies an important place in the field of manufacturing.

References

[1] Sumitomo ’Ospreys" Rolling Mill Rolls. Article in magazine Metal Powder Report, December 1990, p. 813.

[2] Ogivy, A. J.W, in The metallurgy of the Osprey Process. Internal publication of Osprey Metals Limited.

[3] R. A. Mesquita and C. A. Barbosa. High Speed Steel Produced through Conventional Casting, Spray forming and powder metallurgy. 6th International Tooling Conference, Rua Alfredo Dumont Villares, n. 155, Sumar´e-SP, Brazil.

[4] H.W. Chan.The Ceracon process for P/M technology: A review of recent developments Materials & Design, Volume 9, Issue 6, Pages 355-358

[5] C. G. Levi, R. Mehrabian, B. Oslin, R. L. Anderson, S. M. L. Sastry. Consolidation of rapidly solidified intermetallic powders using the Ceracon® process. Journal of Materials Shaping Technology, June 1988, Volume 6, Issue 2, pp. 125-132

[6] Handbook of Aluminium: Vol. 1: Physical Metallurgy and Processes edited by George E. Totten, D. Scott MacKenzie.pp1268.

[7] M. Martinez Pacheco. Self-sustained High-temperature Reactions: Initiation, propagation and synthesis. ISBN 978-90-77172-27-8, pp21-23

[8] Reference Book. Nickel Development Institute, Toronto, Ontario, Canada. pp. 13, 37

[9] http://www.dynacer.com/processing/slip-casting/

[10] http://www.slideshare.net/vinayakmayank/slipcasting?qid =3c6cccb0-0f70-4ed3-8ed1 ff6738522dd2&v=default=&from_search=1

[11] http://www.algonet.se/keram/pdf/Slip%20Casting.pdf