Potential Application of Solid Free-Form Fabrication (SFF) Process
in Ceracon P/M Forging

R.V. Raman, S.V. Rele, and R.L. Anderson
Ceracon, Inc.
1101 N. Market Blvd., Suite 9
Sacramento, California 95834

The Ceracon Process

The Ceracon Process is a patented[1], low cost powder metallurgy process for achieving near-net-shape, full density parts. It is a simple consolidation technique which utilizes conventional powder metallurgy equipment and set-up. The Ceracon Process is a quasi-isostatic, hot consolidation technique, that utilizes a ceramic particulate material as a pressure transmitting medium instead of a gas media as is used in hipping. Pressures up to 200 Ksi can be used and a broad range of metallic, ceramic, and polymeric materials and composites have been successfully processed[2-6].

The Ceracon™ Process steps are schematically detailed in **Figure 1**.

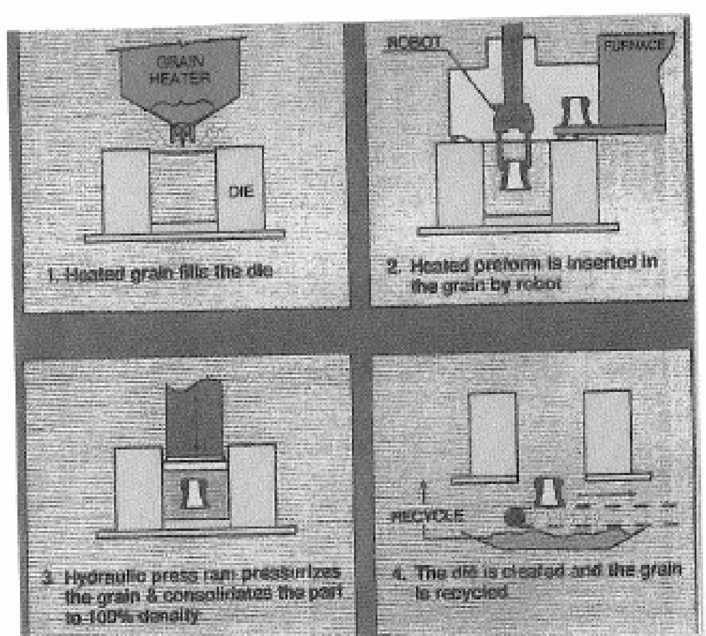

Figure 1: The Ceracon Process[1]

Ceracon has licensed its technology to several companies including Reed Tool Company of Houston, Texas. Reed Tool is currently setting up to manufacture these parts. The five step process used by Ceracon and Reed in producing the rolling cutter rock bit is shown above in **Figure 2** and outlined below:

1. An engineering drawing is prepared from anticipated deformation in the Ceracon process.
2. An aluminum mold pattern of this engineering design is made.
3. A flexible elastomer tool (rubber bag) is fabricated around the aluminum tool.
4. The rubber bag is filled with metallic powder and pressurized via a hydrostatic medium in a pressure vessel, to obtain a preform that is 80% of theoretical density.
5. The preform is consolidated by Ceracon forging process to 100% of theoretical density.

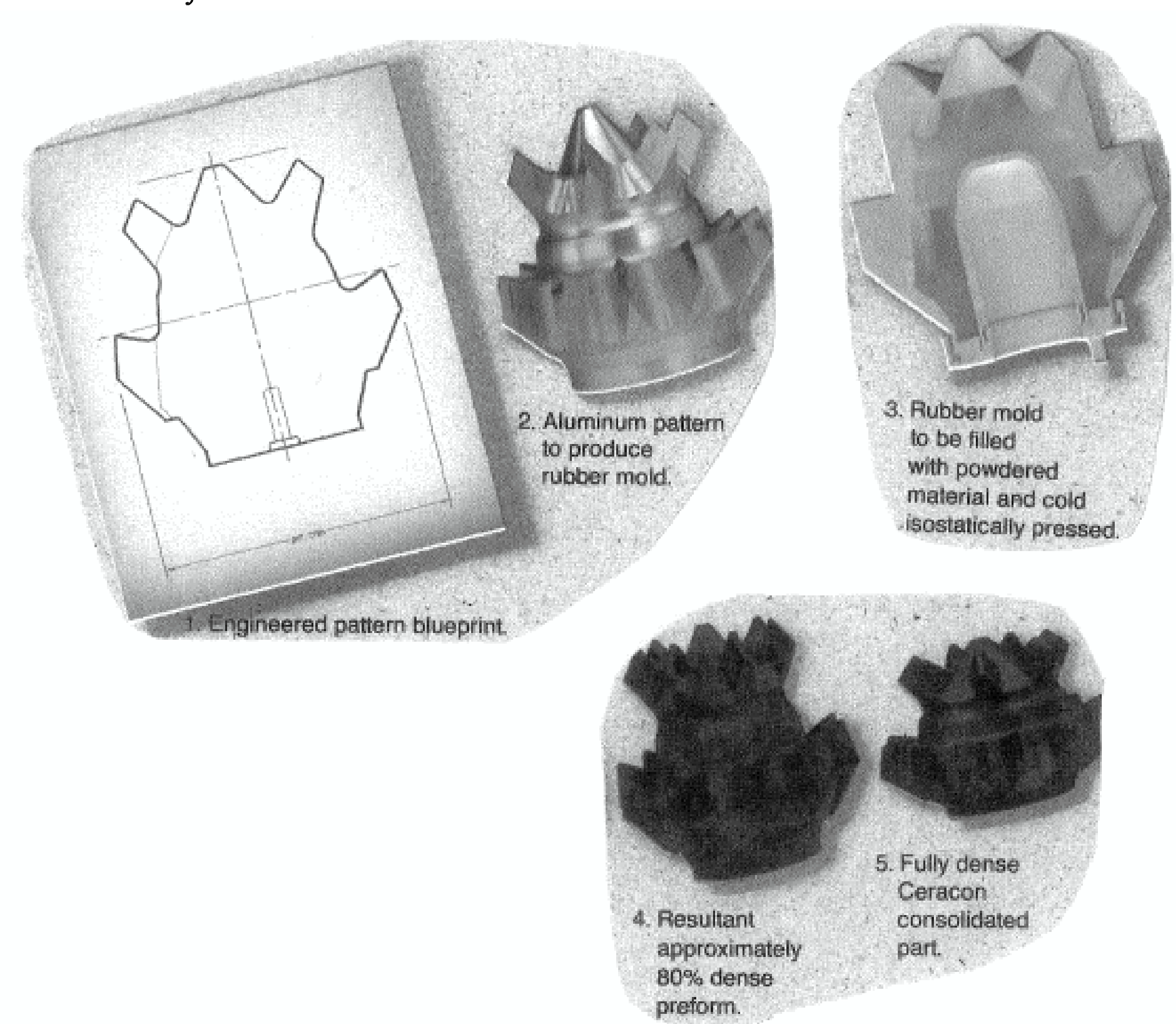

Figure 2: Five Step Process Used for the Rolling Cutter Rockbit

The conventional processing technique previously used for manufacturing this part required significant machining and welding. The Ceracon powder metallurgy approach not only significantly reduced the machining required, but also eliminated the welding step. The Ceracon process has allowed reduction of cost to manufacture the part, while also enhancing drilling performance.

The solid free form (SFF) process[1] was developed by the University of Texas at Austin by Marcus and colleagues. This process as shown schematically involves layer by layer application of polymeric powder, and superimposing of a laser beam driven by CAD/CAM program to etch out melt polymer particles, and bond to each layer. This process is commercially being provided by DTM Corp. of Austin, Texas, under a license of U.T., Austin **(Figure 3)**.

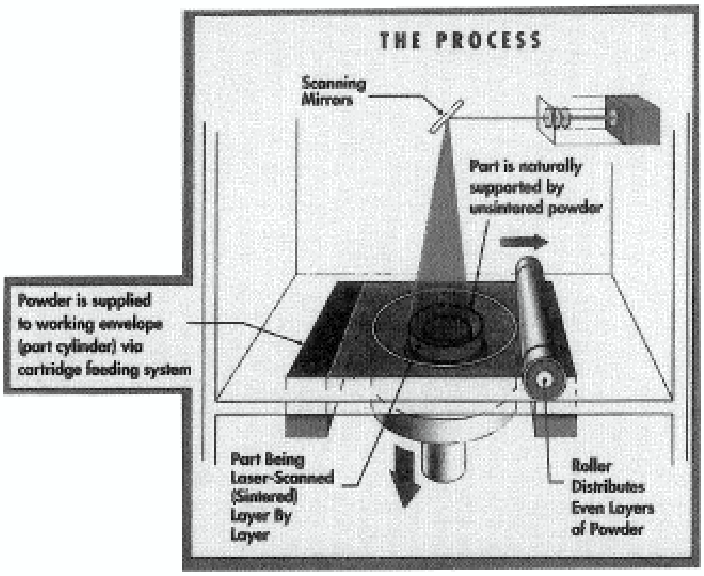

Figure 3: The Solid Free Form Process[7]

The solid free form (SFF) process offers a potential to be integrated into the preform fabrication steps of the Ceracon forging process. The ultimate goal is to build the preform directly in one step via SFF. But, the SFF process has not been developed to a level of being feasible for direct forming of steel preforms. The current state-of-the-art of the SFF technology allows only for low temperature and small specimens. While the ultimate goal is to use a preform made by the SFF process directly in the Ceracon process, there are other areas in the preform fabrication process, i.e., mold and tooling where the SFF process appears to have potential and could be evaluated for feasibility. One such area is the elastomeric bag used in the cold isostatic processing (CIP) method. Currently, the bag is molded from a metallic mold. The SFF process has already shown that it can produce complex shaped preforms from nylon powder. Thus, the substitution of nylon by polymer for use in the fabrication of CIP bags, and applying the Ceracon process to make the part should enable bypassing of the metallic mold making operation. Thus significant reduction in machining of molds and iterations required in the process could be obtained.

In conclusion, the preforming capability of the SFF process could be coupled with the complimentary full-density capability of the Ceracon forging process. This should result in significantly reducing the time required time for prototype and manufacturing of net-shape powder metallurgy parts. The Ceracon forging powder metallurgy process and the SFF process appears to offer complimentary capabilities for rapid prototype of powder metal parts for a variety of applications.

References:

1. The Ceracon Process is protected by 25 U.S. patents.

2. Oxidation Resistance of Powder Metallurgy Zirconium Aluminide Densified Using the Ceracon Process, R.V. Raman, S.V. Rele, and D.L. Hunn, presented at the International Conference & Exhibition on Powder Metallurgy & Particulate Materials, May 16-19, 1993.

3. A Novel Processing Route for the Fabrication of Monolithic and Composite Silicon Nitride, R. V. Raman and S. V. Rele, Proceedings of the MRS Meeting, Vol. 289, April, 1993.

4. In-Situ Synthesis and Rapid Consolidation of $MoSi_2$ to Full Density, R. V. Raman, S V. Rele, and M. J. Paskowitz, Journal of Metals, January, 1993

5. Advances in Full Density Consolidation of Engineered Materials, R. V. Raman, Advances in Powder Metallurgy and Particulate Materials - Vol. 2, 1992, Pages 401-420

6. Powder Consolidation In The 1990's: Recent Advances at Ceracon, Inc.", Powder Metal Report, April, 1990 issue entitled, "Advances in Powder Consolidation".

7. DTM Corporation Brochure,"The SLS Process, Rapid Prototyping and The Selective Laser Sintering Process".