change, the powder compacts are inherently resistant to grain growth treatment operations.

However, the Structures and Materials Laboratory of NRC has developed a technique whereby alloys having coarse grained microstructures can be produced directly from pre-alloyed powders by a simple hot isostatic pressing operation.

The Laboratory is also investigating the application of high-pressure cold-forming operations to powder metallurgy processing. The object is to circumvent costly vacuum canning operations or the stringent requirements for controlled furnace atmospheres that are needed to prevent excessive oxidation of powder particle surfaces during high-temperature processing. The work is being supported jointly by NAE and the Department of Mechanical Engineering of McMaster University. The principal investigator is Roy Hewitt, a graduate student from McMaster who is working with Dr. Wallace. The project was initiated by Dr. M.C. de Malherbe, Professor in the Department of Mechanical Engineering at McMaster.

Two important high-pressure metal forming techniques have been combined in this work. The first is cold isostatic pressing in which the metal powder is compacted by a pressurized fluid. Since the process is carried out at room temperature, much higher pressures are used than for hot isostatic pressing.

The second process is hydrostatic extrusion, in which a high fluid pressure is used to force a solid metal billet through a die. This new metal working process has attracted much interest since the frictional force which acts between the billet and the extrusion container in conventional extrusion no longer exists. For hydrostatic extrusion the billet is supported on all sides by the pressurized fluid; therefore it does not touch the walls of the container and therefore lower extrusion forces are required and more uniform plastic deformation is achieved in the product. It also is possible to cold extrude quite brittle materials such as beryllium, molybdenum and even cast iron to produce sound products.

The high-pressure equipment built at NRC allows the two processes of isostatic compaction and hydrostatic extrusion to be performed in one apparatus. The work has shown that cold compacted metal powders can be consolidated by hydrostatic extrusion to produce sound products without any intermediate sintering (diffusion bonding) treatment. For example, bar stock produced by hydrostatically extruding aluminum powder through an extrusion ratio of 6.2 (ratio of the original cross sectional area of the billet to that of the product) has produced tensile strengths 20 per cent higher than those obtained from cast aluminum hydrostatically extruded at much higher extrusion ratios (about 100). This is because strain hardening (the increasing resistance to plastic deformation which occurs during cold forming operations) that is developed during compaction is lost during a normal sintering treatment but when the compact is consolidated by hydrostatic extrusion the strain hardening properties are retained and even enhanced.

The interesting aspect of this work is that it has demonstrated that high-temperature sintering treatments are not necessary for consolidating metal powders; this consolidation can also be achieved by mechanical means wherein the bonding between particles occurs by frictional welding.

The main requirement for full consolidation of metal powders by this technique is a high extrusion ratio which necessitates the use of high forming pressures. This problem is of particular importance for high-strength metal powders. The need for high pressures will probably be the main difficulty with the commercial exploitation of this type of powder processing. However, Dr. Wallace expects that the two processes of high-pressure isostatic compaction and hydrostatic extrusion used in conjunction with intermediate sintering treatments will prove useful for forming brittle refractory metals and possibly for intermetallic compounds. □ Earl Maser

Dr. Roy Hewitt, a post-doctoral fellow of the Department of Mechanical Engineering, McMaster University, attaches piston to a high-pressure cold-isostatic compaction and hydrostatic extrusion apparatus. Pressures up to 250,000 pounds per square inch can be developed from the compaction and extrusion of metal powders. • Le Dr Roy Hewitt, boursier post-doctorat du Département de génie mécanique de l'Université McMaster, attache le piston d'une presse dont la pression peut atteindre 250 000 livres par pouce carré et servant au frittage et au filage en compression iso et hydrostatique à froid.

High pressure can be used to convert metal powders (A) to compacted billets (B) which can then be consolidated by hydrostatic extrusion to produce bar stock (C) having greater strength than similar cast and wrought (extruded) material. • Il est possible d'utiliser des hautes pressions pour convertir des poudres de métaux (A) en lopins compacts (B) qui peuvent alors être consolidés par extrusion hydrostatique pour prendre finalement la forme de barres (C) plus résistantes que celles qui sont moulées ou extrudées.