L. Ti-6Al-4V Billet Feedstock Manufacture and Evaluation

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Objectives

- Develop low-cost Ti-6Al-4V billet feedstock using a blend of titanium (Ti) and alloy powders and inexpensive Ti-6Al-4V machine turnings, or using 100% turnings.
- Evaluate this low-cost Ti alloy feedstock as a starting billet material for casting, forging, and extrusion operations.

Approach

- Develop a procedure for producing low-cost Ti billet using a combination of inexpensive Ti alloy machine turnings and Ti and alloy powders, or 100% machine turnings. Evaluate the billet for density and microstructure.
- Subject the feedstock billets to casting, forging, and extrusion operations. The three operations will yield Ti-6Al-4V test bars.
- Evaluate the quality of the test bars produced through chemistry and mechanical testing.

Accomplishments

- Produced a high-density billet containing 60% turnings/40% Ti alloy powder that was produced using a core of 100% turnings, surrounded by a "can" made from Ti alloy powder.
- Produced a billet using 100% turnings, achieving full density, using cold+hot isostatic pressing (CHIP) technology with conventional canning in mild steel for the HIP operation.
- Extruded a billet, composed of 100% turnings surrounded by a "can" made from Ti alloy powder, to high density barstock.
- Cast plates from a billet of 100% Ti-6Al-4V machine turnings. The tensile strength and ductility of the resultant cast plate exceeded the specified properties for Ti-6Al-4V castings.
- Determined that contaminants in the turnings caused low ductility in the extruded barstock and characterized these contaminants by metallographic analysis and analysis of tensile fracture surfaces using SEM/EDS.
- Demonstrated that the contaminants can be eliminated by melting the low cost feed stock.

- Preformed economic analyses that showed that extruded bar can be produced from billet cast from low cost feedstock at a savings of 48 to 58% over conventional extrusions.

Future Direction

- Demonstrate that bar meeting the typical mechanical properties of conventional Ti-6Al-4V can be extruded from cast extrusion billet produced by the low cost feedstock process in order to realize the commercial potential of this technology.

Summary

Dynamet Technology has developed a novel method of producing low-cost Ti alloy billet from Ti scrap turnings by powder metallurgical processing. Dynamet's process consists of consolidating the turnings using a combination of cold isostatic pressing and vacuum sintering, followed by HIP, if necessary (Figure 1).

The result is feedstock that can be used to produce cast extrusion billet that can then be used to produce extrusions. This process promises to produce extrusions that are a low-cost alternative to extrusions produced from conventional ingot. Dynamet's economic analysis estimates the cost savings in producing extrusions at 48 to 58%. The use of low-cost billet made by Dynamet's process in manufacturing Ti alloy parts for heavy duty vehicles will save energy, increase payloads, and reduce emissions. Indeed, the availability of low-cost Ti would make Ti attractive to any industry that can

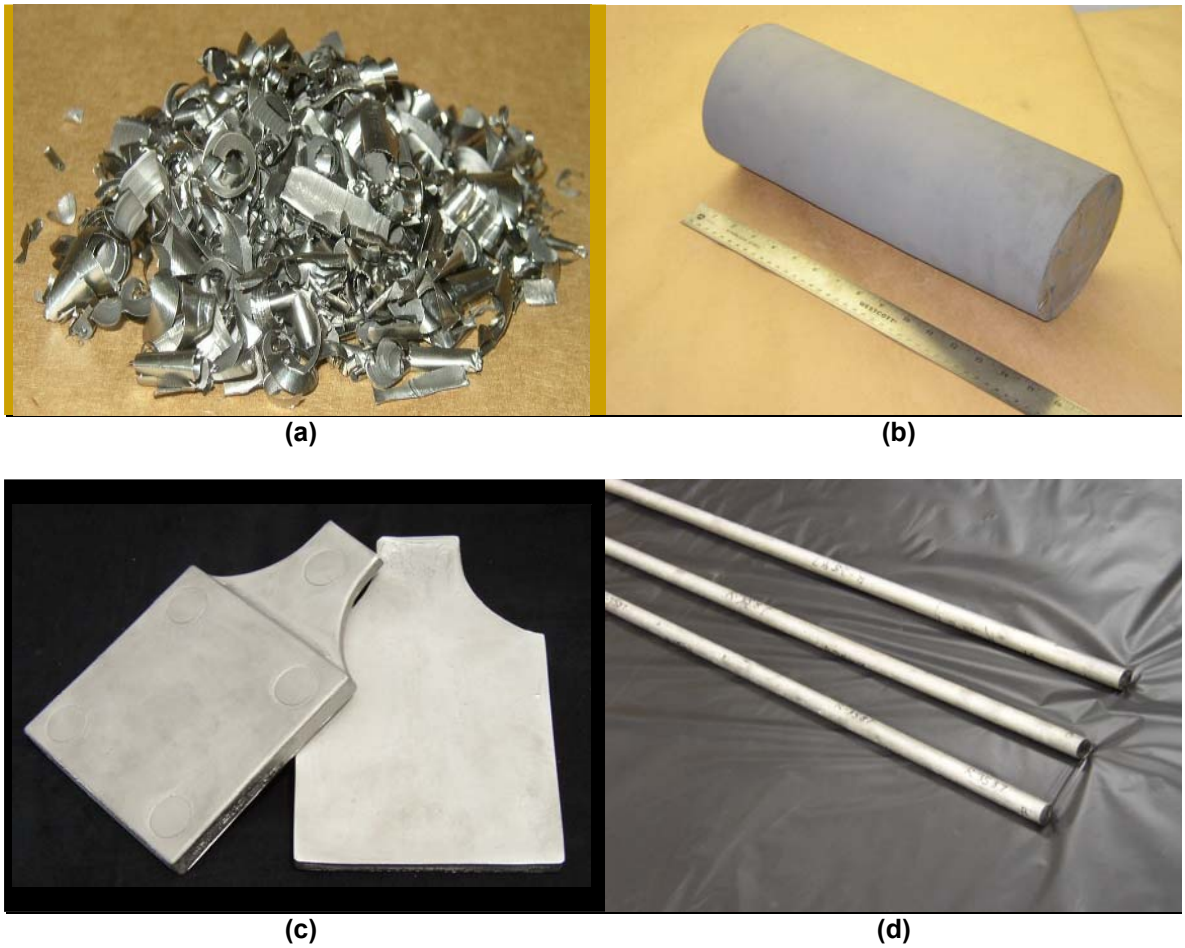

Figure 1. The dynamet powder metallurigical process (a) Ti-6Al-4V turnings, (b) LCFP billet, (c) cast test plates, and (d) extrusion produced from LCFP billet.

benefit from the metal's advantages as a structural material. Dynamet's process would also result in significant energy reduction by recycling Ti turnings and thus reducing the industry's dependence on energy-intensive Kroll process sponge and the subsequent more extensive metalworking.

The next step is to demonstrate that bar meeting the typical mechanical properties of conventional Ti-6Al-4V can be extruded from cast extrusion billet produced by the low cost feedstock process in order to realize the commercial potential of this technology (Figure 2).

Presentations and Publications

Dynamet Technology, Inc., *Ti-6Al-4V Billet Feedstock Manufacture and Evaluation—Final Report*, Burlington, Massachusetts.

Figure 2. Bar with the properties of Ti-6 Al-4V can be developed from cast extrusion billets produced by the low-cost feedstock process.