DEVELOPMENT OF THE MANUFACTURING CAPABILITIES OF THE HYDROSTATIC EXTRUSION PROCESS

by

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INTRODUCTION

The purpose of the present research program is to develop the manufacturing capabilities of the hydrostatic extrusion process with the aim of extruding high-quality shapes from materials of interest to the Air Force. It is a continuation of the recently completed program on Contract No. AF 33(600)-43328. The current program is divided into two phases with the following general objectives:

Phase I. Process-Development Studies

Part 1. (a) To study the effect of critical process variables on pressure requirements and surface quality in hydrostatic extrusion of AISI 4340 steel, Ti-6Al-4V titanium alloy, and 7075 aluminum alloy.

(b) To correlate all available hydrostatic-extrusion-pressure data with material properties wherever possible in order to assist direction of the experimental effort and maximize the information developed in the present program.

Part 2. To explore the hydrostatic extrudability of TZM molybdenum alloy (cast and wrought), beryllium, Cb-752 columbium alloy, powder compacts, and other materials to be selected later in the program.

Part 3. To conduct a design study for high-temperature, high-pressure hydrostatic extrusion tooling based on (1) estimated pressure requirements for high-ratio extrusion of materials of interest to the Air Force, (2) latest high-pressure-vessel technology, and (3) latest tooling materials available.

Part 4. To conduct a process economic study on the construction, installation, and operation of equipment with the same operational and size requirements as the tooling developed in the previous program on Contract No. AF 33(600)-43328.

Phase II. Process-Application Studies

Part 1. To evaluate the application of the hydrostatic extrusion process for sizing and finishing conventionally hot-extruded (or rolled) structural shapes by various combinations of drawing and extruding. Primary emphasis will be on AISI 4340 steel, although some effort will be devoted to Ti-6Al-4V, 7075 aluminum, and selected refractory metals.

Part 2. To determine the feasibility of producing wire and filaments from TZM molybdenum alloy and beryllium by combinations of hydrostatic extrusion and drawing.

Part 3. To develop tooling and define process parameters necessary for the reduction of tube blanks to finish tubing from AISI 4340 and a selected columbium alloy.

Experimental trials to study the critical process variables for hydrostatic extrusion (Part 1 of Phase I) and fabrication of tubing (Part 3 of Phase II) were continued during this report period. Also, initial attempts to extrude beryllium (Part 2 of Phase I) were made. In addition, preparations for hydrostatic extrusion at elevated temperatures were completed. Important variables investigated included lubrication, stem speed, extrusion ratio, die design, and billet surface finish. Information for certain of the variables was obtained for AISI 4340 steel, 7075-0 aluminum, and Ti-6Al-4V titanium alloy.

In addition to extrusion trials, extrusions produced during the fifth interim report period were evaluated. Also, tool design and material procurement preparatory to experiments designed to fabricate wire (Part 2 of Phase II) were initiated.

EQUIPMENT AND EXPERIMENTAL PROCEDURE

Extrusion Tooling

The major components of the hydrostatic-extrusion tooling used during this report period were previously described (1, 2, 3, 4). Minor modifications such as die design are discussed in the appropriate sections of this report.

Materials

Except for beryllium, billet materials used during this report period were described in Interim Report No. 1[3]. The beryllium billets were made from Brush Beryllium S-200-C powder grade containing 98.9 percent Be and 1.54 percent BeO. The mechanical properties of the as-received beryllium were reported to be: