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 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, 7075-0 aluminum, and selected refractory metals.

Part 2. To determine the feasibility of producing wire and filaments from beryllium and TZM molybdenum alloy 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.

The study of critical process variables for hydrostatic extrusion (Part 1 of Phase 1) was continued during this report period. Extrusion trials were made both at room temperature and at 500 F as follows:

(1) Cold hydrostatic extrusion of tubing and T-sections from AISI 4340 and Ti-6Al-4V titanium alloy.

(2) Warm hydrostatic extrusion of rounds from AISI 4340, Ti-6Al-4V alloy, and beryllium.

Important variables investigated during the interim period included extrusion ratio, billet surface finish, lubricants, and high-temperature fluids.

In addition, initial experiments in the hydrostatic extrusion and drawing of beryllium wire were begun.

The mechanical properties of selected hydrostatic extrusions of 7075-0 aluminum and AISI 4340 steel were determined in this report period.

EQUIPMENT AND EXPERIMENTAL PROCEDURE

Extrusion Tooling

With one exception, the major components of the hydrostatic extrusion tooling as well as accessory equipment used during this report period were previously described (1,2,3,4,5)*. A high-temperature, high-pressure gage (HTHP) was designed to measure fluid pressure during trials made at 400 and 500 F. For the most part, the HTHP gage performed within expectations and will be described in the report on the next warm-extrusion trials.

*References are listed at the end of the text.