FE-2465-7

Dist. Category UC-90f

EROSION STUDY IN TURBOMACHINERY AFFECTED BY COAL AND ASH PARTICLES

Phase 1

Interim Report for the period

March 1, 1978 - May 31, 1978

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Date Published - June 1978

PREPARED FOR THE UNITED STATES

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Under Contract No. E(49-18)-2465

REA

Contract No. E(49-18)-2465

Dist. Category UC-90f

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ABSTRACT

Turbomachinery operating with a working fluid containing coal ash particles are exposed to erosion. The problem of predicting erosion in the rotating and stationary blade rows is complex. Basic research work is necessary to identify the significant factors involved in such erosion and to quantify their effects. Initial tests in the cold erosion wind tunnel facility have yielded results useful in predicting the erosion characteristics of coal ash.

OBJECTIVE AND SCOPE OF THE WORK

The objective of this research is to perform an experimental and theoretical study of the erosion of potential turbine materials caused by coal and ash particles. Attempts will be made to determine the factors which are significant in such erosion, and a computer model will be developed which will facilitate the prediction of potential for erosion in future turbomachinery design.

SUMMARY OF PROGRESS TO DATE

The results from the cold wind tunnel test facility have been presented in the previous quarterly reports. The influence of particle impact angle on the erosion of 2024 aluminum alloys, 6Al-4V titanium alloys and 304 stainless steel for different angles of attack and different particle velocities was experimentally determined. Using this data, we have developed basic equations which may predict the erosion of ductile alloys.

PRESENT WORK AND ACCOMPLISHMENTS

(1) The design and construction of "high temperature wind tunnel" was completed and now the tunnel is under operation for erosion testing of various target materials. This facility has the capability of providing two phase flow at subsonic velocities as high as 1000 ft. per second and at temperatures between ambient and 2,000°F. To date, erosion data has been obtained for three target materials at different particle velocities, impingement angles and target temperatures. The figure (1) below shows the erosion data for Ti 7Al-4V at different temperatures with particles at different velocities at an impingement angle of 25°.

(2) A new two color Laser Anemometer Systems facility is under construction which will be very useful for determining the exact particle rebound and impacting velocities on the blades for different target materials. We have used mostly high speed photography up till now.

(3) Effect of Specimen Length on Erosion: To study the effects of the specimen size on the local particle impingement angle and its consequential influence on the erosion characteristics of various materials by abrasive particles, special experiments were performed. The target materials were chosen to include current alloys used in turbomachinery. The abrasive particles used were alumina, silica and Kingston coal ash from West Virginia. The results obtained to the date indicate that the length of the specimen influenced the degree of erosion. Figures 2, 3 and 4 show the erosion results for aluminum, titanium and stainless steel using Kingston coal ash as abrasive particles. Inspection of Figure 2 shows that the larger size aluminum alloy specimen, 1.0" x 1.0", experiences less erosion than the smaller 0.5" x 1.0" specimen for the same angle of attack, particle concentration and particle velocity. Opposite trends were observed from the results obtained for the erosion of the titanium alloy as shown in Figure 3. Similar specimen sizes and the same particle concentrations and velocities were used as in the case of the aluminum target material. The last Figure 4 shows the results obtained for stainless steel material with the similar conditions as the previous two figures. The trends of change in the degree of erosion with the target material size is similar to those of titanium at all angles of attack. Further experiments are planned in order to understand the basic cause for this phenomenona.

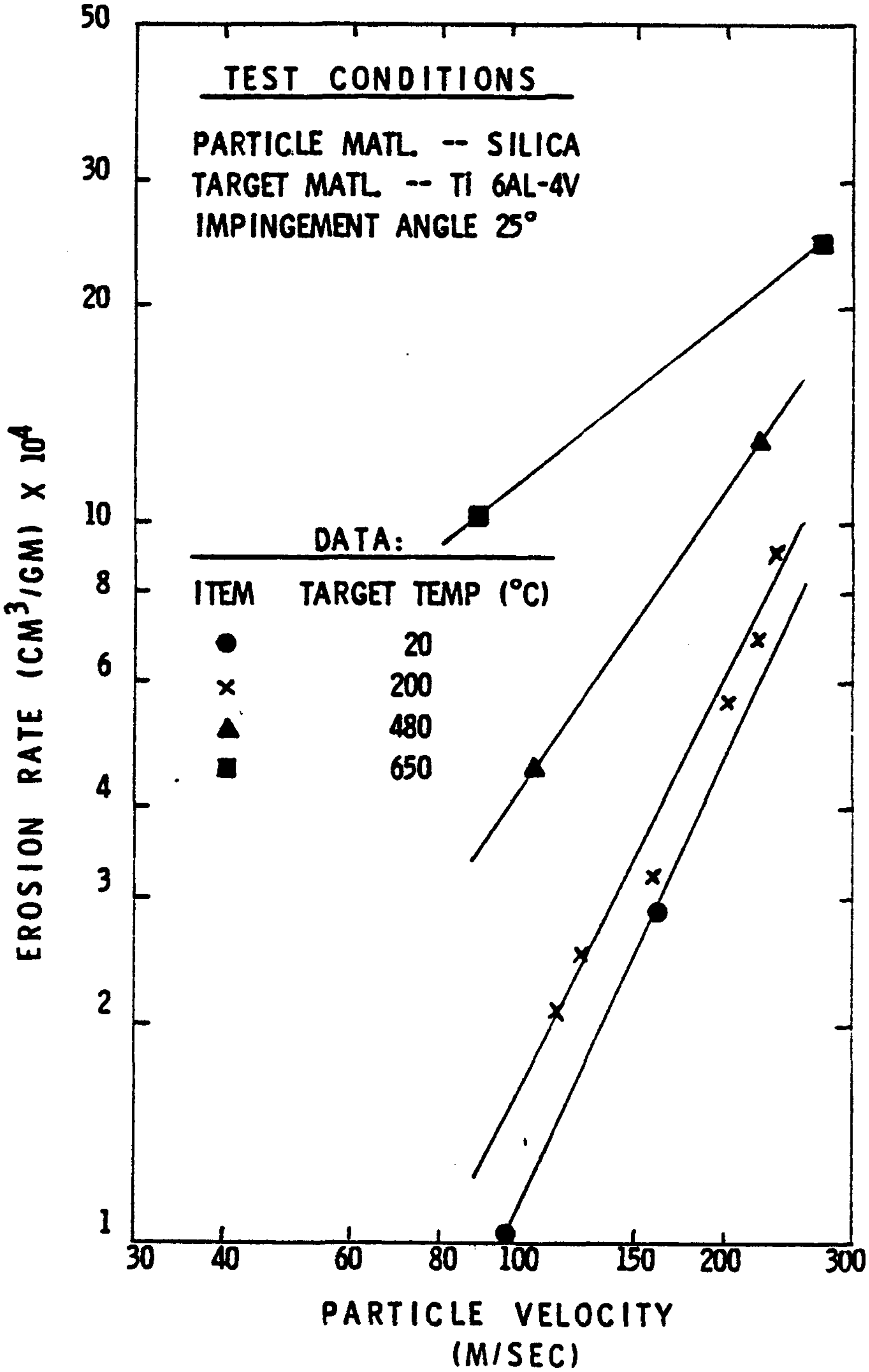

FIG. 1. EROSION RATE VS. PARTICLE VELOCITY FOR DIFFERENT TEMPERATURES.

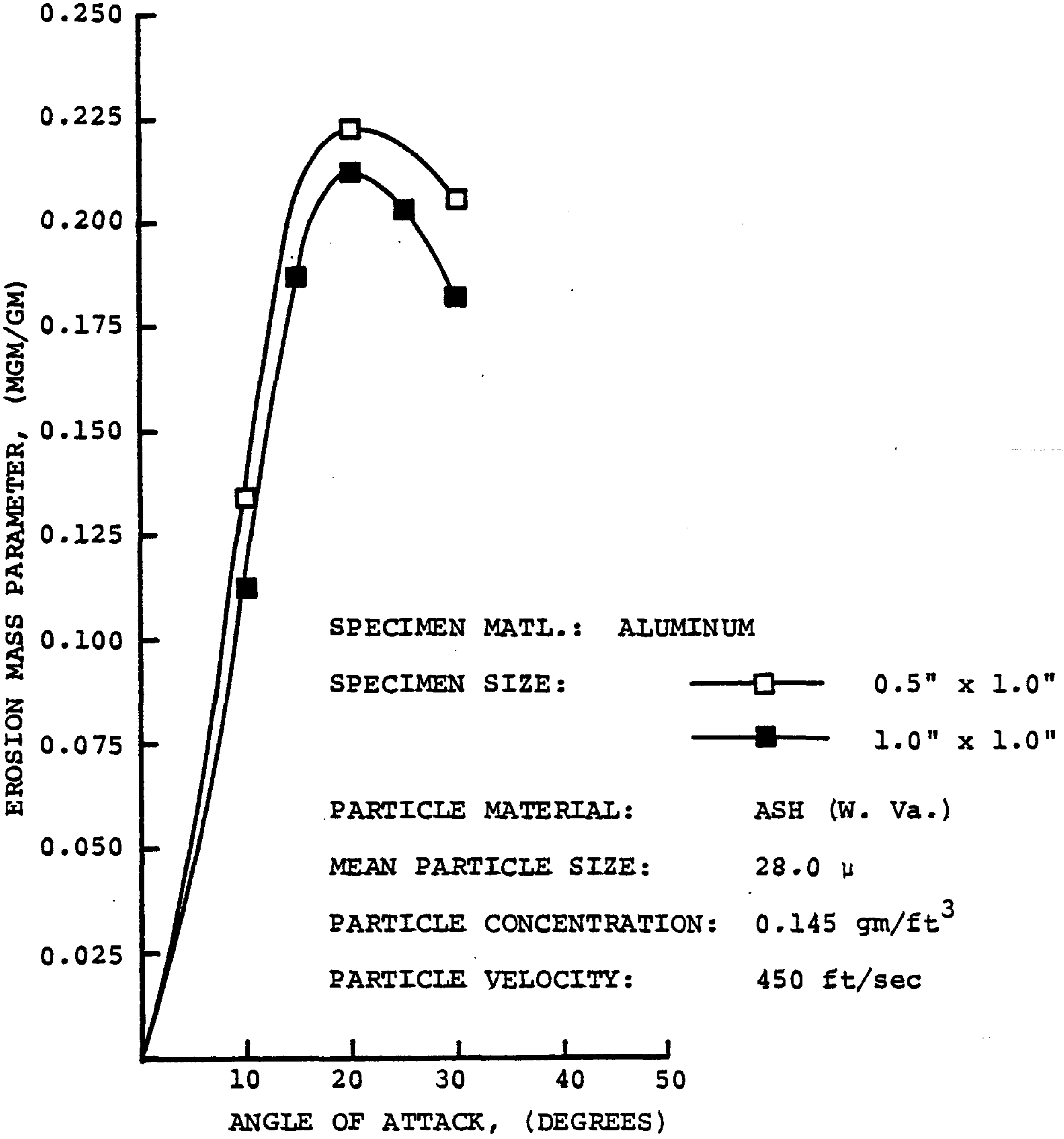

FIGURE 2 : EFFECT OF PARTICLE IMPACT ANGLE AND SPECIMEN LENGTH ON EROSION OF 2024 ALUMINUM ALLOY (EXPERIMENTAL RESULTS).

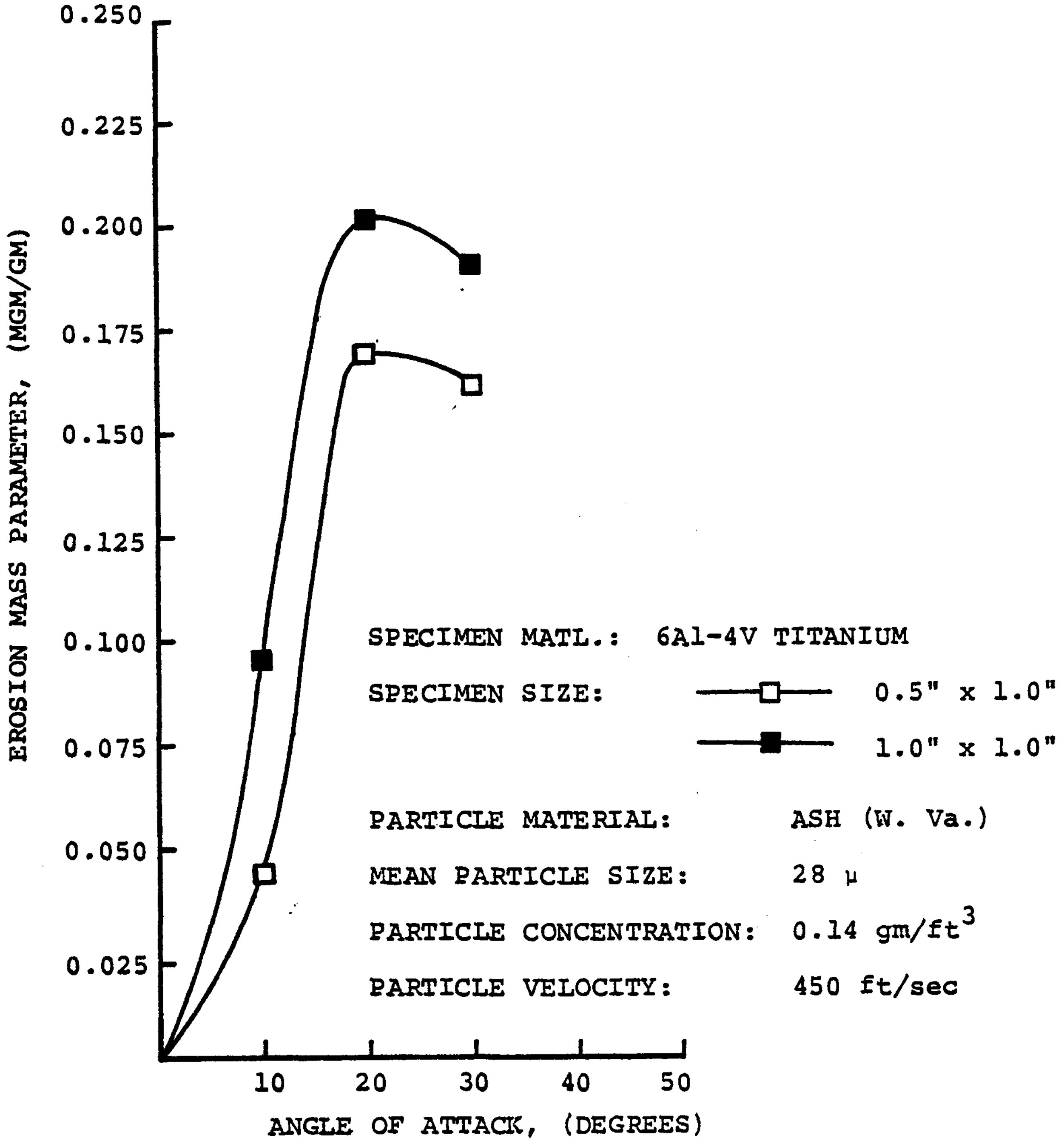

FIGURE 3. EFFECT OF PARTICLE IMPACT ANGLE AND SPECIMEN LENGTH ON EROSION OF 6A1-4V TITANIUM ALLOY, (EXPERIMENTAL RESULTS).

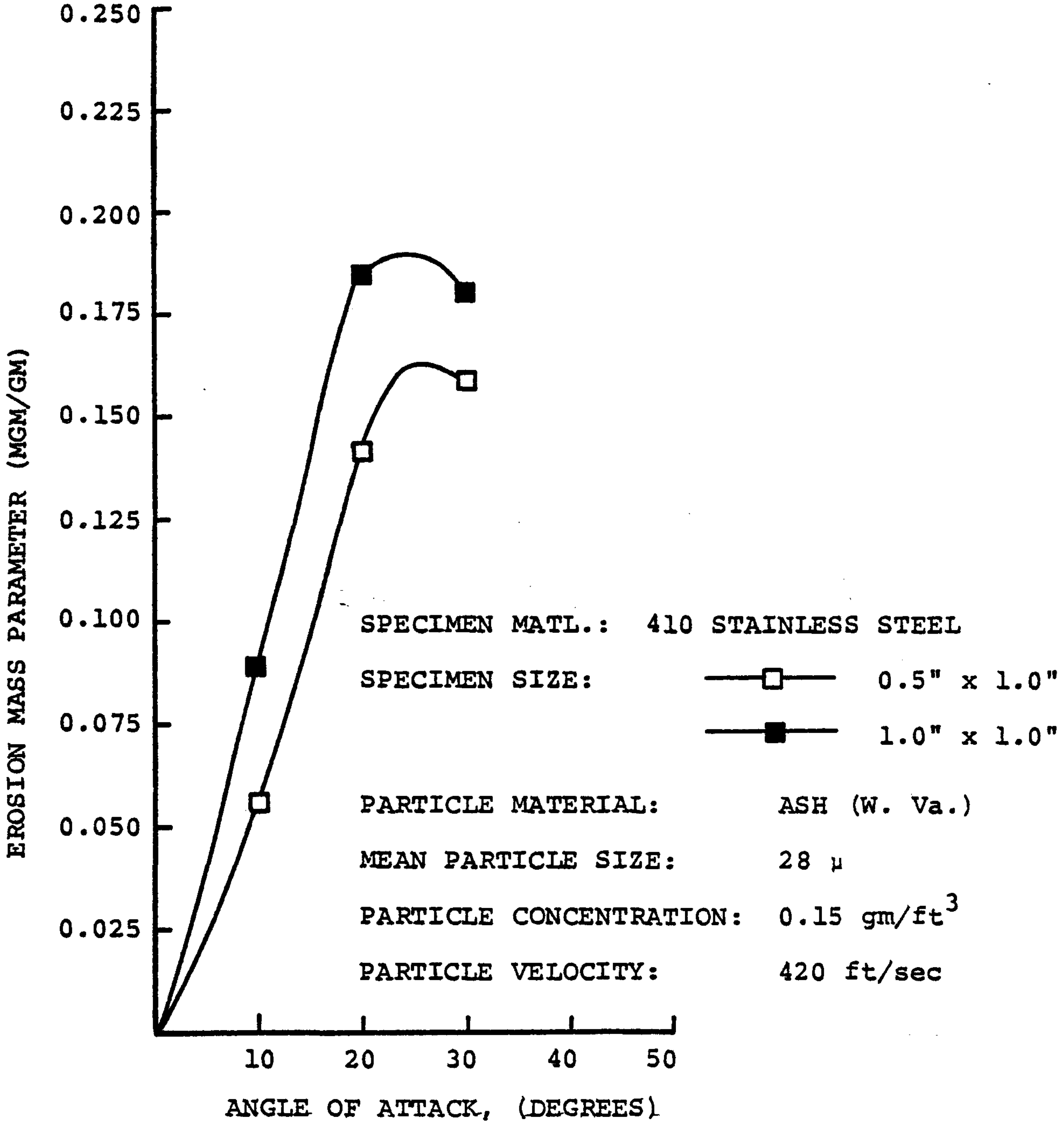

FIGURE 4 : EFFECT OF PARTICLE IMPACT ANGLE AND SPECIMEN LENGTH ON EROSION OF 410 STAINLESS STEEL, (EXPERIMENTAL RESULTS).