Final Report of
Ns G - 533

West Virginia University

# PRODUCTION OF DISPERSION ALLOYS WITH THE AID OF ULTRASONICS

Submitted by

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June, 1966

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Theses completed under this grant:

1. "Dispersion of Inerts in a Molten Matrix by Ultrasonic Energy," by Junior H. Landes, II.
Thesis used for Master's degree.

2. "Ultrasonic Treatment of Alloys to Produce Dispersion Strengthening," by Won Kak Lee.
Thesis used for Master's degree.

Papers submitted:

A paper entitled "Effect of Ultrasonic Insonation on Some Selected Metallurgical Processes" has been submitted for publication in the IEEE Transactions on Sonics and Ultrasonics. A portion of this paper presents the results of the NASA Ns G - 533 research project.

Papers presented:

Two papers have been presented which included some of the results obtained from the NASA Ns G - 533 research grant.

1. "Effect of Ultrasonic Insonation on Some Selected Metallurgical Processes," presented at the 1965 Annual Symposium on Sonics and Ultrasonics sponsored by the Sonics and Ultrasonics group of the IEEE in Boston, Massachusetts on December 1, 1965.

2. "The Effect of Ultrasonics on Some Metallurgical Processes," presented at the symposium on the Effects on Ultrasonic Energy on Metallurgical Phenomena sponsored by Lockheed-Georgia Company and Georgia Institute of Technology in Marietta, Georgia on January 24, 1966.

Scope of Investigation:

The objective of the research carried out under the thesis entitled, "Dispersion of Inerts in a Molten Matrix by Ultrasonic Energy" was to explore a procedure for mixing finely divided inert materials into molten metal for production of a dispersion-strengthened material. Molten aluminum was used with alumina, thoria, and silica powder being used for the inert materials. The particle size of the inerts used was between 1 and 5 microns.

The objective of the research carried out under the thesis entitled, "Ultrasonic Treatment of Alloys to Produce Dispersion Strengthening," was to study the effect of ultrasonic energy in producing a dispersed phase during the metallurgical processing of alloys. Three systems which were investigated included: the effect of insonation during the solidification of gray cast iron on the distribution of graphite and pearlite formation; the effect of insonation on the decomposition of iron carbide in white cast iron during heat treatment; and the effect of insonation upon the dispersion strengthening of aluminum alloys during solution and precipitation heat treatment.

Summary of Results:

I. Ultrasonic Dispersion of Inerts in Molten Aluminum

The results of mixing an inert material into molten aluminum indicated that a nearly uniform dispersion by the use of ultrasonics could be obtained (See Fig. 1.). In order to have a stable dispersion, it was found that the molten metal should have some affinity for the inert material.

Statistical analysis of the results produced the following information:

a. Temperature of the melt above solidification temperature was of major importance in the separation of the inerts from the molten metal.

b. In all the systems evaluated, the interactions between the variables were important. These variables included: intensity of insonation, duration of insonation, and the ratio of alloy to inerts.

c. The amounts of inerts capable of being dispersed into the liquid metal varied with the intensity and duration of insonation.

II. Ultrasonic Dispersion Strengthening During Solidification and Heat Treatment

Insonation during the solidification of gray cast iron produced more ferrite, less pearlite, and some graphite particles than the non-insonated reference specimen(See Fig. 2.).

Insonation during the decomposition of white cast iron by heat treatment produced spindle-type ferrite grains (See Fig. 3.), retarded pearlite formation and gave higher hardness (10 points Rockwell "B") when compared to the non-insonated reference specimen. It was also noted that an adherent corrosion resistant film was formed on the insonated sample (See Fig. 4.).

The following results were obtained upon insonation of aluminum alloy 2024 during various heat treating processes:

a. Insonation during annealing slightly decreased the hardness when compared with a non-insonated reference specimen (2 points Rockwell "F").

b. Insonation during the solution treatment process produced a slightly higher hardness (2 points Rockwell "F") when compared to the non-insonated reference specimen.

c. Insonation during solution treatment prevented cracking of the specimen during subsequent cold workings (See Fig. 5.).

d. Insonation during the precipitation heat treatment process increased the hardness of the alloys very rapidly in respect to the non-insonated reference specimen. The maximum difference in hardness was reached in approximately 3 hours, with a hardness difference of 6 points Rockwell "F". At the end of 96 hours the hardness difference was only Rockwell 3 "F" between the insonated and non-insonated reference specimen.

e. Statistically, it was found that there were interactions between time, tepmerature, and intensity of insonation during solution heat treatment.

Recommendations for continued study:

I. Explore further the feasibility and efficiency of mixing of inerts into molten metal by:

1. Use of smaller diameter inert particles eg. 0.1 to 0.01 microns.
2. Use of inert fibres separately or with inert powder.
3. Flowing the metal and/or the inerts through an orifice placed at the end of the ultrasonic horn.
4. Studying the adherence of the inert materials to the metal.

II. Study further the influence of insonation on preventing internal cracks in aluminum and other alloys during plastic deformation.

III. Study further the influence of insonation during malleabilization of white cast irons. (Research under consideration)

IV. Study further the influence of insonation upon corrosion. (Research underway)

V. Study the influence of insonation upon size of graphite spheres during the production of nodular Cast Iron.

Expenditures made for project:

| | |
|---|---|
| Salaries: | $ 5,600.00 |
| Supplies: | 523.30 |
| Travel: | 213.83 |
| Computer: | 56.60 |
| Publication: | 81.00 |
| Total | $ 6,474.73 |

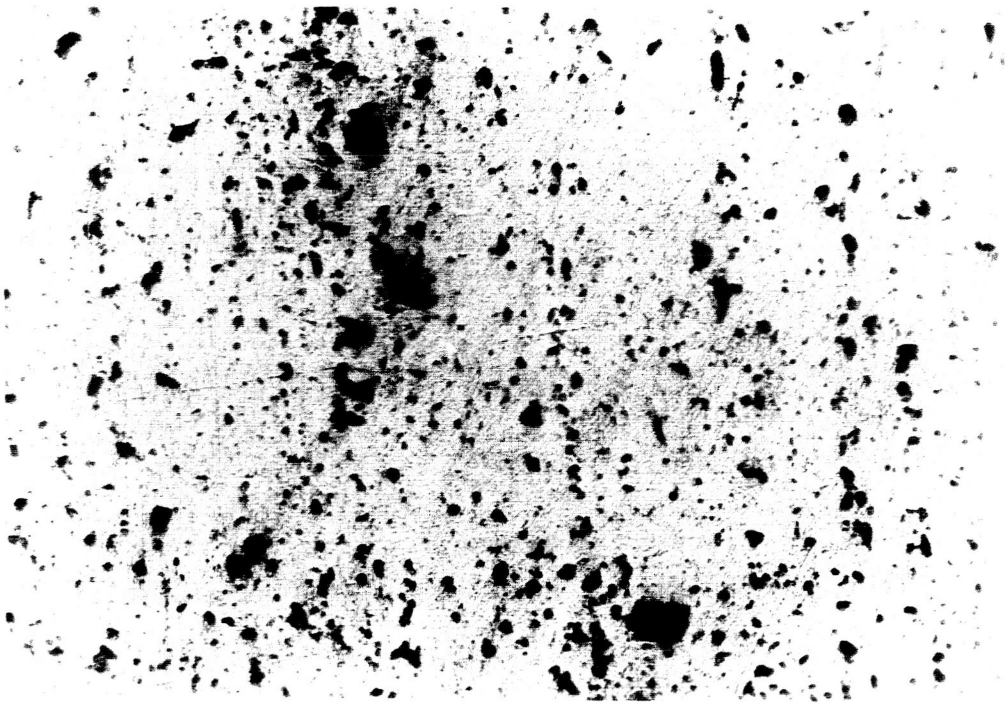
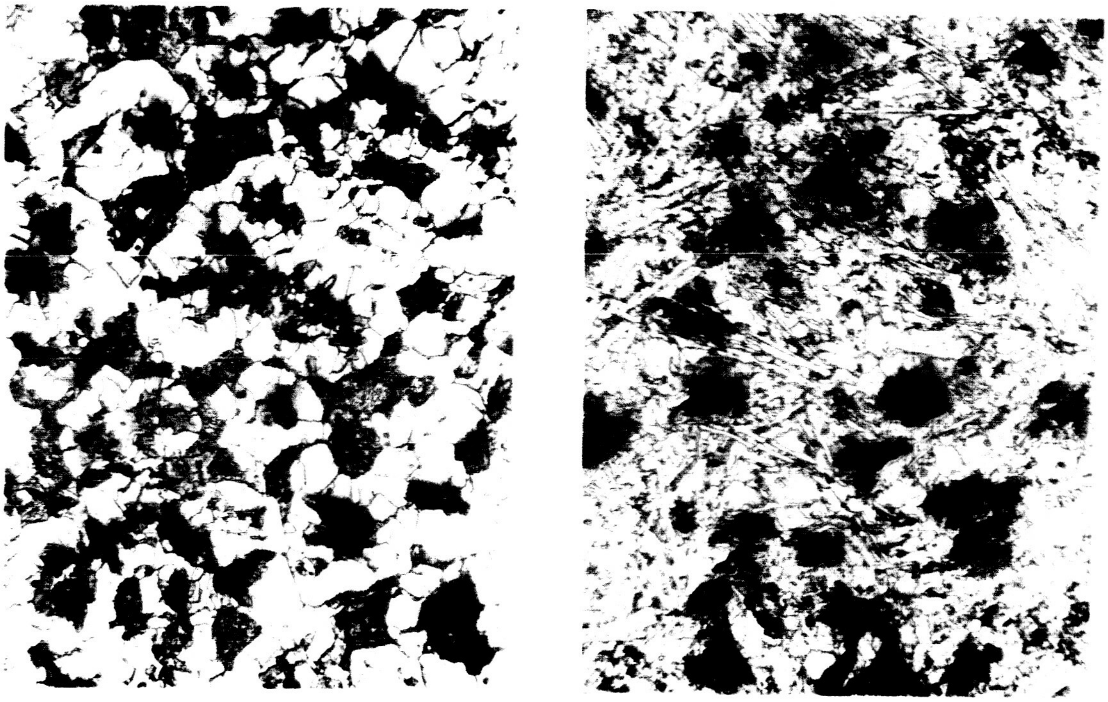


Fig. 1. General appearance of 1 to 5 microns of silica powder dispersed by ultrasonic mixing in aluminum. Magnification 100X, ultrasonic frequency used was 20,000 cps with 150 watts input.

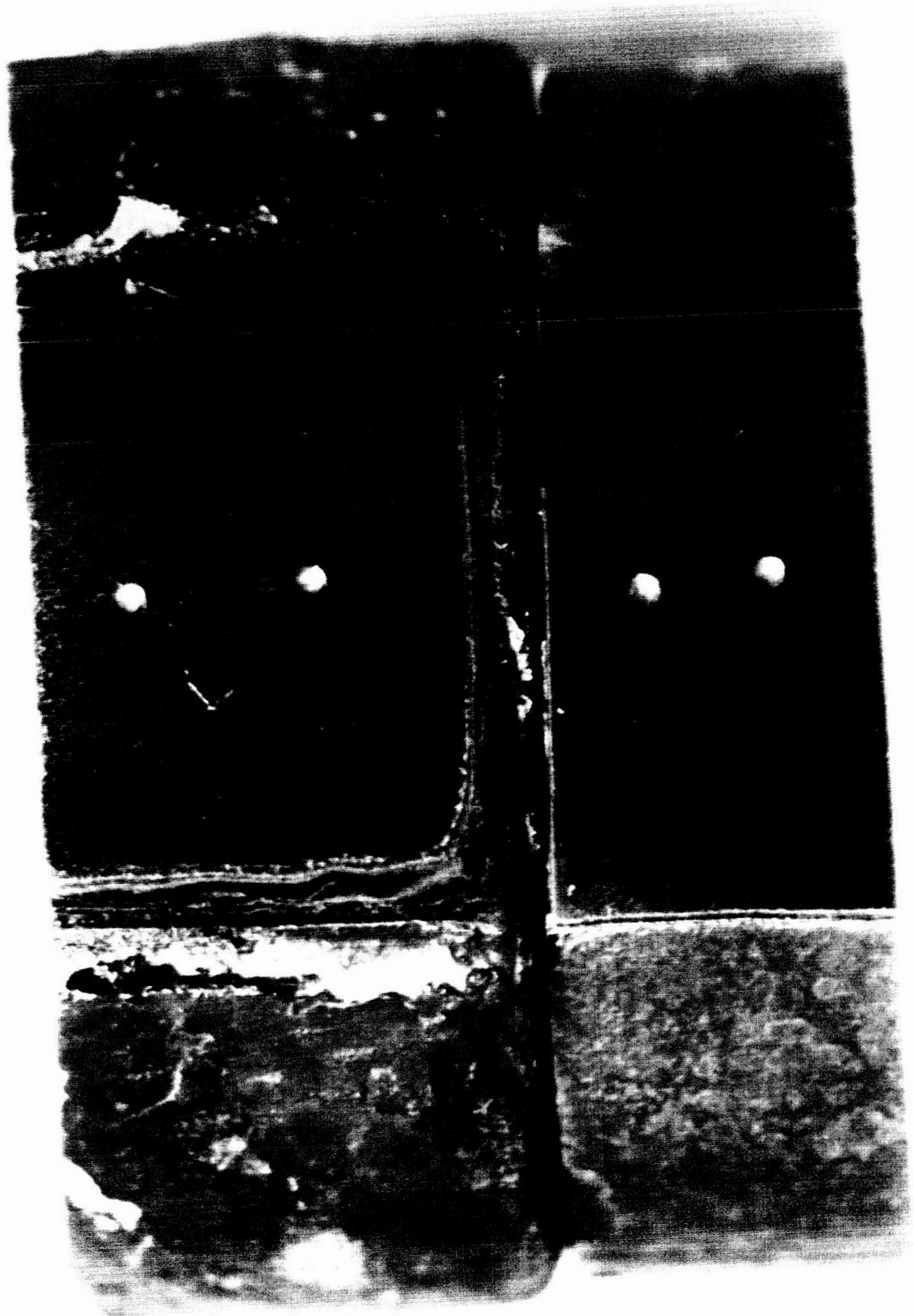
Not insonated — Insonated

Fig. 2. Photomicrographs showing the influence of insonation during the solidification of gray cast iron. Insonation retarded pearlite formation. 250X. Nital etched. Ultrasonic frequency used was 20,000 cps with 45 watts input.



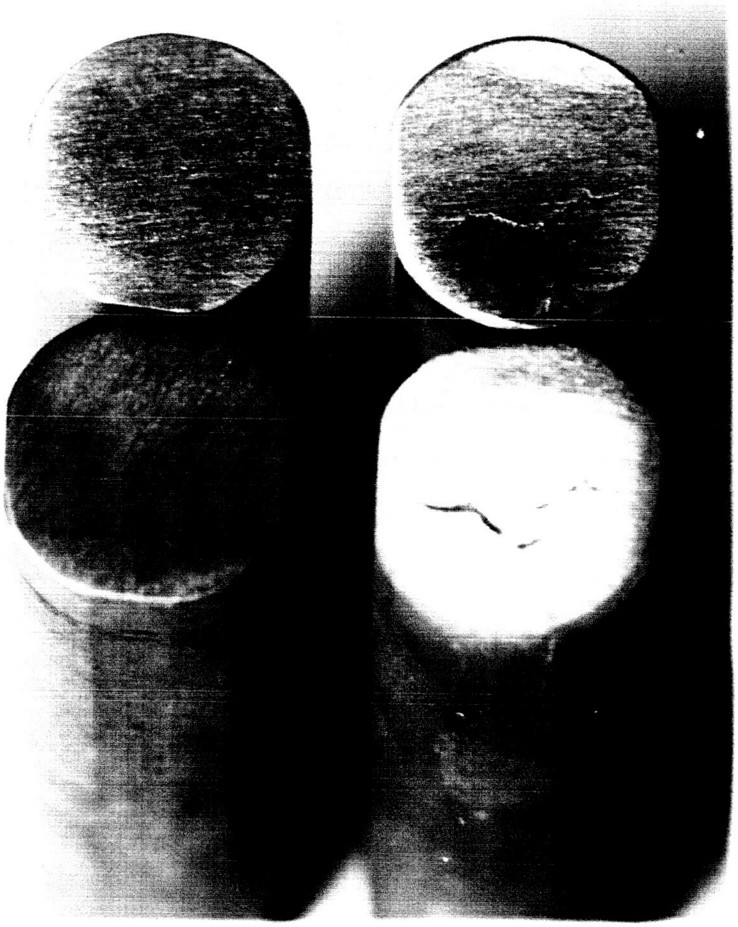
Not insonated Insonated

Fig. 3. Photomicrographs of white cast iron heat treated at 1700°F for four hours and furnace cooled. Note difference in carbon masses and lack of pearlite in insonated specimen. 250X. Nital etched. Ultrasonic frequency used was 20,000 cps with 56 watts input.



Not insonated                    Insonated

Fig. 4. Photograph of white cast iron specimens showing the influence of insonation upon oxide formation . The specimens were heated at 1700°F for 24 hours.



Insonated Not insonated

Fig. 5. Photograph of 1/2" rounds 1" long of 2024 aluminum after being cold worked under 30,000 pounds pressure. Insonated specimens were pressed twice.