Research Programs

Alloy Development for SSM Processing of Copper Alloys

Research Team:

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Introduction

Driven by the needs for lighter weight, lower cost, and more reliable materials, the main objectives of the three-phased, four-year copper-based casting technology (C-BCT) program are to develop, demonstrate, and deploy applications of copper-based alloys to make significantly lighter, more efficient components for use in defense systems. Through copper's unique combinations of physical properties, C-BCT will accomplish these objectives by developing and testing the use of cast copper rotors for AC induction motors and semi-solid metal casting applications for new and replacement component parts. WPI is involved in the latter effort through the Metal Processing Institute (MPI), and will play a crucial role in the modeling and selection of alloys for adaptation to SSM processing.

The semi-solid metal casting thrust of the program will utilize new net-shape tooling technologies available for copper-based materials to make significantly lighter, high integrity, wear resistant and corrosion resistant components applicable to both weapons systems and industrial applications. These efforts, which include the development and testing of new alloys and feedstock materials will significantly advance the state of knowledge in this field.

Objectives

As a key partner of the C-BCT program, the WPI team is taking the lead on the development of copper alloys for SSM. The team's responsibilities include the following four tasks:

Task 1: Identify Existing Alloy Compositions:

WPI will coordinate with the alloy producer to identify alloys currently available, and also suitable for semi-solid forming when processed appropriately. The selection of current alloys will be based at least in part on freezing range, conventional castability, experience to date, and ease of acquisition.

Task 2 - Existing Alloy Modeling and Analysis:

Based on the criteria for SSM alloy design established by the research team, we will further optimize the chemical composition of the alloy (s) identified from Task 1 for semi-solid processing.

Task 3 - Identify New Alloy Makeup:

WPI will coordinate with alloy producer to identify the appropriate features needed in new copper alloys in order to both improve SSM casting ability and achieve good alloy properties.

Task 4 - New Alloy Modeling and Analysis:

Based on the results from Tasks 1 through 3, the WPI team will use thermodynamic simulation tools to develop with new copper alloys that have improved castability, excellent SSM formability, as well as good mechanical properties.

Methodology

The objectives will be achieved through computational analysis combined with twin thermocouple experiments to confirm the computational predictions. Since grain refinement is understood to be crucial to obtain an SSM microstructure, investigation will be undertaken on passive and active grain refinement techniques which are compatible with both copper and subsequent SSM processing. While multiple existing copper alloys have been investigated in this work, the specific alloys to be investigated will be selected based upon the needs of project partners. Previous experience with Aluminum SSM will serve as a guide throughout the process. Examples of the ongoing work are presented below in Figures 1 and 2.

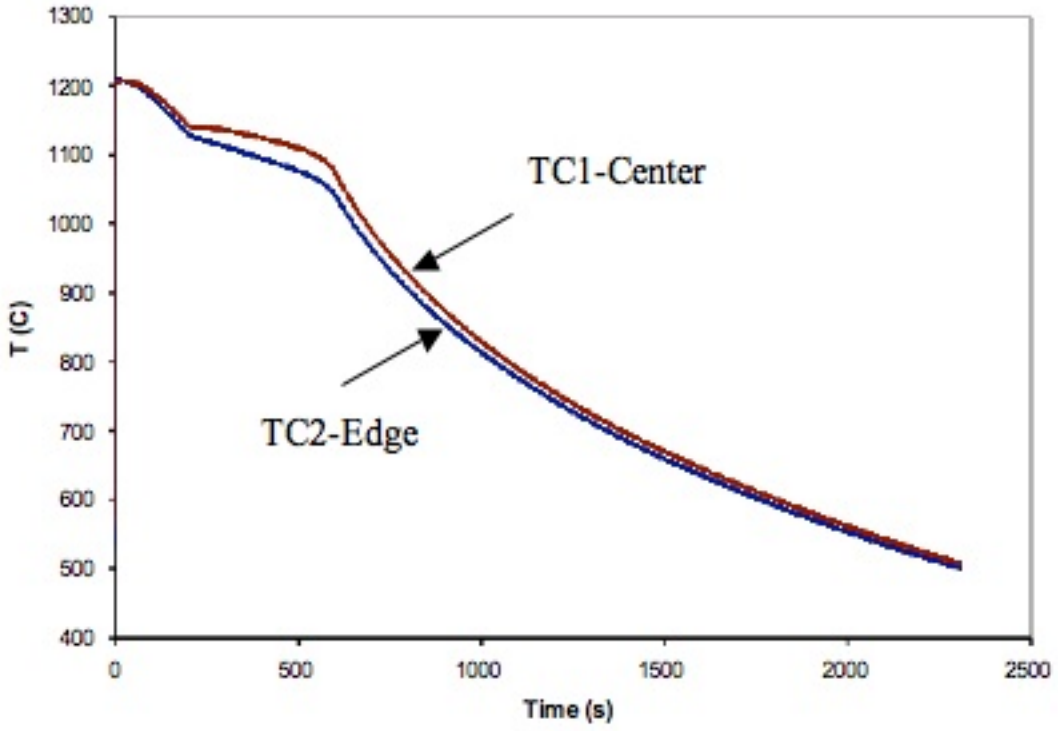

Figure 1. Example of time-temperature curve from twin-thermocouple experiment with C706 alloy

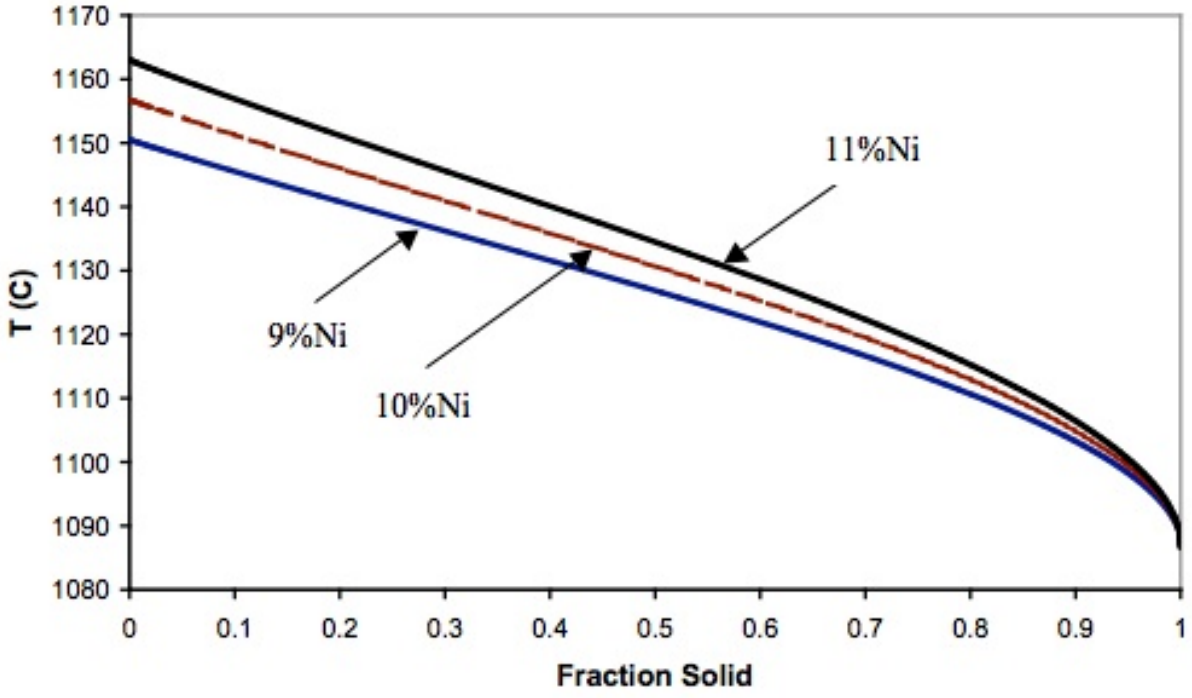

Figure 2: Effect of Ni Content on C706 Alloy