11:13:17 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 01/04/96

Active

Project #: E-25-M39 Cost share #: Rev #: 7
Center # : 10/24-6-R7373-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: EID-9023561 Mod #: AMENDMENT 004 Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : N CFDA: 47.041
Main project #: PE #:

Project unit: MECH ENGR Unit code: 02.010.126
Project director(s):
MEYERS C W MECH ENGR (404)894-3264

Sponsor/division names: NATL SCIENCE FOUNDATION / GENERAL
Sponsor/division codes: 107 / 000

Award period: 911101 to 970430 (performance) 970731 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	250,000.00
Funded	50,000.00	250,000.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: FACULTY AWARDS FOR WOMEN

PROJECT ADMINISTRATION DATA

OCA contact: Jacquelyn L. Bendall 894-4820

Sponsor technical contact	Sponsor issuing office
MARGRETE S. KLEIN	BETH STRAUSSER
(703)306-1640	(703)306-1217
NATIONAL SCIENCE FOUNDATION	NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD	4201 WILSON BOULEVARD
ARLINGTON, VA 22230	ARLINGTON, VA 22230

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A NSF supplemental sheet
Equipment title vests with: Sponsor GIT X

Administrative comments -
AMENDMENT NO. 4 ADDS $50,000 TO PROJECT.

PROJECT CLOSEOUT - NOTICE

U

Closeout Notice Date 06-NOV-1997

Project Number E-25-M39 | Doch Id 38441

Center Number 10/24-6-R7373-0A0

Project Director MEYERS, CAROLYN

Project Unit MECH ENGR

Sponsor NATL SCIENCE FOUNDATION/GENERAL

Division Id 3393

Contract Number EID-9023561 | Contract Entity GTRC

Prime Contract Number

Title FACULTY AWARDS FOR WOMEN

Effective Completion Date 30-APR-1997 (Performance) 31-JUL-1997 (Reports)

Closeout Action:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	N	
Final Report of Inventions and/or Subcontracts	N	
Government Property Inventory and Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments
PI transferred to NC A&T State University.

Distribution Required:	
Project Director/Principal Investigator	Y
Research Administrative Network	Y
Accounting	Y
Research Security Department	N
Reports Coordinator	Y
Research Property Team	Y
Supply Services Department/Procurement	Y
Georgia Tech Research Corporation	Y
Project File	Y

E25-M39

Georgia Tech

THE GEORGE W. WOODRUFF SCHOOL OF
MECHANICAL ENGINEERING

Georgia Institute of Technology
Atlanta, Georgia 30332-0405

July 27, 1992

Dr. Lucy C. Morse
Faculty Awards for Women Program
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

Dear Dr. Morse:

Enclosed please find an unofficial copy of the Progress Report for Year 1 for the Faculty Awards for Women Program. The official document is in the channels here at Tech and should be received by you next week. Please share your comments regarding the progress of this research and of this report with me. I can include more details if desired.

I apologize for the lateness of this report and request for next year's funds. As you know, I am the newcomer with the SUCCEED coalition. Getting up to speed has taken me quite a while but the work is fun.

Thanks for your attention and interest. I look forward to hearing from you.

Sincerely,

Carolyn W. Meyers
Associate Professor

PROPOSAL BUDGET

FOR NSF USE ONLY			
. PROPOSAL NO.	DURATION (MONTHS)		
	Proposed	Granted	
AWARD NO.			

RGANIZATION
Georgia Tech Research Corporation

RINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Carolyn W. Meyers

SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (list each separately with title, A.6. show number in brackets)	NSF Funded Person-mos. CAL.	ACAD	SUMR	Funds Requested By Proposer	Funds Granted By NSF (If Different)
. Carolyn W. Meyers			2	$ 12,000	$
.					
.					
.					
. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
. (1) TOTAL SENIOR PERSONNEL (1-5)				12,000	
OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
. ( ) POST DOCTORAL ASSOCIATES					
. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
. (1½) GRADUATE STUDENTS (1 full time/1 for summer to supplement fellowship				20,000	
. (1) UNDERGRADUATE STUDENTS				4,500	
. ( ) SECRETARIAL CLERICAL					
. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				36,500	
FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) (26.3%)				3,156	
TOTAL SALARAIES, WAGES AND FRINGE BENEFITS (A+B+C)				39,656	
PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000:) Materials - (glass, copper, thermocouples, imaging system) to build metal solidification analog. . . . . 4,500 Computer to record displacement, temperature and morphology data. 1,400					
TOTAL PERMANENT EQUIPMENT				5,900	
TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				335	
2. FOREIGN					
PARTICIPANT SUPPORT COSTS . STIPENDS $ ____ . TRAVEL ____ . SUBSISTENCE ____ . OTHER ____					
( ) TOTAL PARTICIPANT COSTS					
OTHER DIRECT COSTS					
. MATERIALS AND SUPPLIES				100	
. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
. CONSULTANT SERVICES					
. COMPUTER (ADPE) SERVICES					
. SUBCONTRACTS					
. OTHER					
TOTAL OTHER DIRECT COSTS					
TOTAL DIRECT COSTS (A THROUGH G)				45,991	
INDIRECT COSTS (SPECIFY RATE AND BASE)					
OTAL INDIRECT COSTS (10%)				4,009	
TOTAL DIRECT AND INDIRECT COSTS (H + I)				50,000	
RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPM 252 AND 253)					
AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 50,000	$

/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Carolyn W. Meyers	7/11/92	INDIRECT COST RATE VERIFICATION		
IST. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date of Rate Sheet	Initials-DGC

SF Form 1030 (8/90) *Supersedes All Previous Editions* *SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233)

PROGRESS REPORT-YEAR ONE
FACULTY AWARDS FOR WOMEN
Carolyn W. Meyers
Grant Number EID-9023561

Summary of Research Activities:

In addition to summer support for the PI, a Post Doctoral Associate, Dr. Jung-Hyun Kim, was supported partly by this award. Ongoing research in the area of solidification processing focused on two areas:

1) the development of computational strategies to allow the accurate predictions of composition gradients during the processing and

2) the continued refinement of an irregular grid generation scheme for use in simulations of the solidification process in molds of irregular geometries.

Both efforts allow the examination of the transient solidification of binary alloys. This is a necessary step in the development of our planned simulation of the solidification of metal matrix composites, in an effort to understand settling and therefore, segregation effects in this category of cast materials.

Numerical techniques for the solution of phase change problems require the simultaneous solution of the energy, momentum and continuity equations with the interface boundary conditions. For numerical convenience, the conventional grid schemes are widely used. A successful approach to such simulations depends on an accurate discretization of the given domains. For cases having irregular or intricate geometries, use of the rectangular grid often results in computational difficulties near the boundaries. Triangular meshes overcome these difficulties. Research this year resulted in the development and the testing of an automatic grid generation/smoothing algorithm based on the Dirichlet tessellation. Results for a common quadrilateral mold undergoing directional solidification are shown in Figure 1. The ensuing effects of the use of the algorithm on the temperature profiles during this directional solidification appear in Figure 2; the percent error incurred by the numerical solutions is reduced using this adaptive grid algorithm as shown in Figure 3. Other geometries under study are shown in Figure 4. This mesh generation scheme will be used in the solutions for temperature and composition profiles during the solidification process in fixed and moving molds (as in continuous casting).

A major task of any simulation of solidification is the treatment of the evolution of the latent heat. The enthalpy method was employed, requiring no explicit conditions on the heat flow at the interface. For the finite difference method used with the irregular triangular mesh, the following assumptions were made:

1) The boundaries of the interfaces of the region are approximated by straight line segments.

2) The region can be triangulated.

3) The values of the temperatures are defined at the triangle vertices and these temperatures vary linearly over each triangle.

4) The thermal conductivity, k, is constant over each triangle.

It is also further assumed that solid and liquid fractions in the mushy zone vary linearly with temperature. Using the phase diagram and the further assumption of instantaneous redistribution of solute, phase boundaries can be defined for the transient case. Easy applications of these techniques are for the continuous casting processes in which the speed of the mold and the feed rate of the molten material vary. Results for the Hazellet process are shown for various non-dimensional speeds in Figure 5. Similar results were obtained for wheel casting and roll casting processes.

Two refereed conference papers are scheduled to be printed in the Proceedings of the NSF Conference on Transport Phenomena in Processing. The proceedings are in press. Abstracts of the papers are included; finished preprints will be forwarded when received from the publisher.

Research Plans for the Upcoming Year

In addition to continued development of computational techniques by another Post Doc, new research on the simulation of solidification of metal matrix composites has been undertaken and will continue. Specifically this project is a combined experimental and analytical study of entrapment in hybrid cast metal matrix composites. Hybrid MMCs are reinforced with particulate material and whiskers or short fibers. Construction is underway of an apparatus to allow the experimental determination of solidification interface characteristics as influenced by the reinforcing agents. The material to be used is a common metal analog. Using a high speed video camera and thermocouples, interface locations, shapes and temperatures will be measured. These data will be incorporated into a predictive relationship for the velocity of the solidifying interface. It is expected that this work will be completed in two years.

A minority female doctoral student is engaged in this work and is partly supported by this award. A more detailed description of this effort is appended to this report. It is anticipated that one journal paper will be prepared in the upcoming award year.

Additionally, an undergraduate female student is supported as a research assistant.

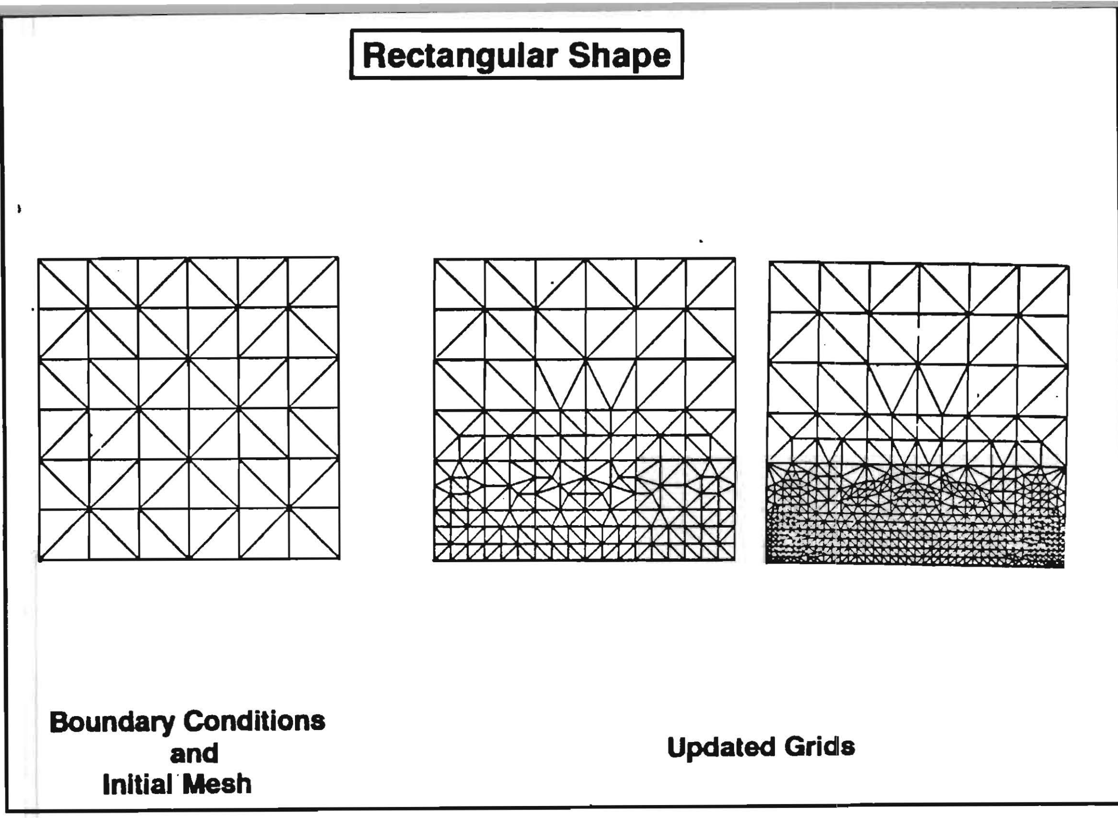


Figure 1. Grid Refinements Using the Smoothing Algorithm Quadrilateral Geometry

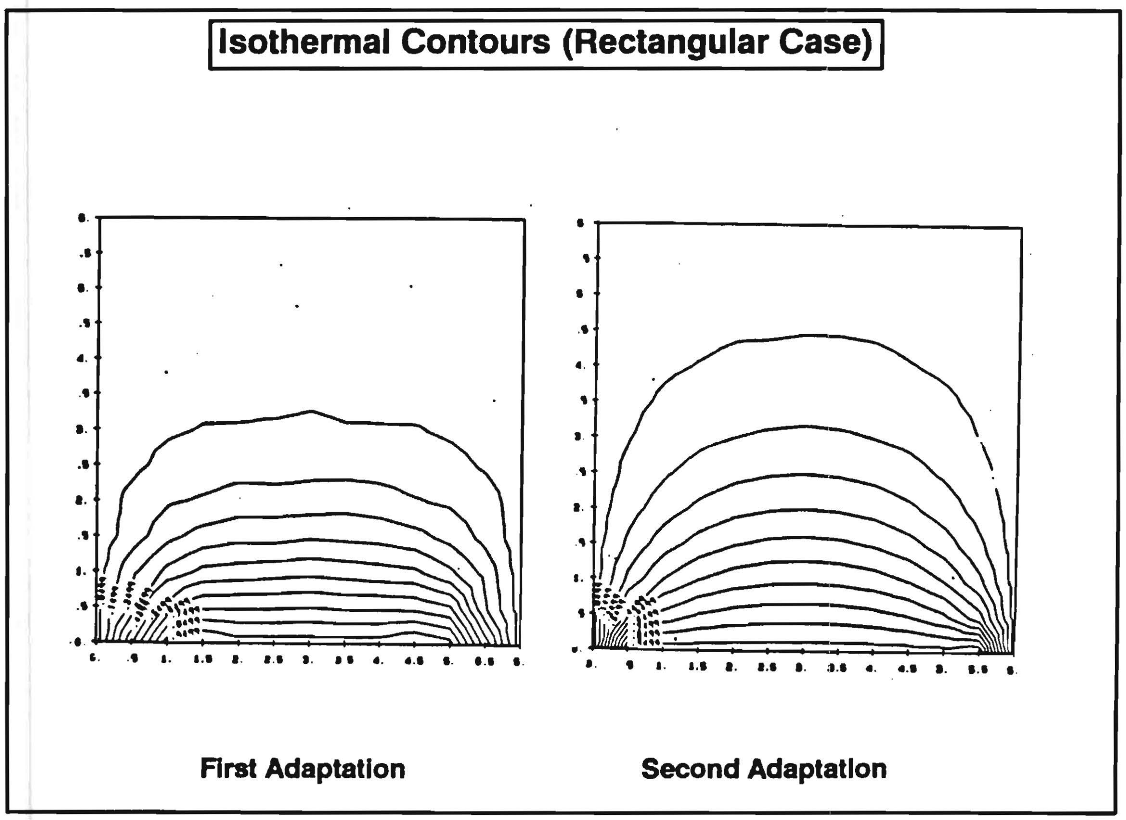


Figure 2. Isothermal Contours from Resulting Grid Refinements

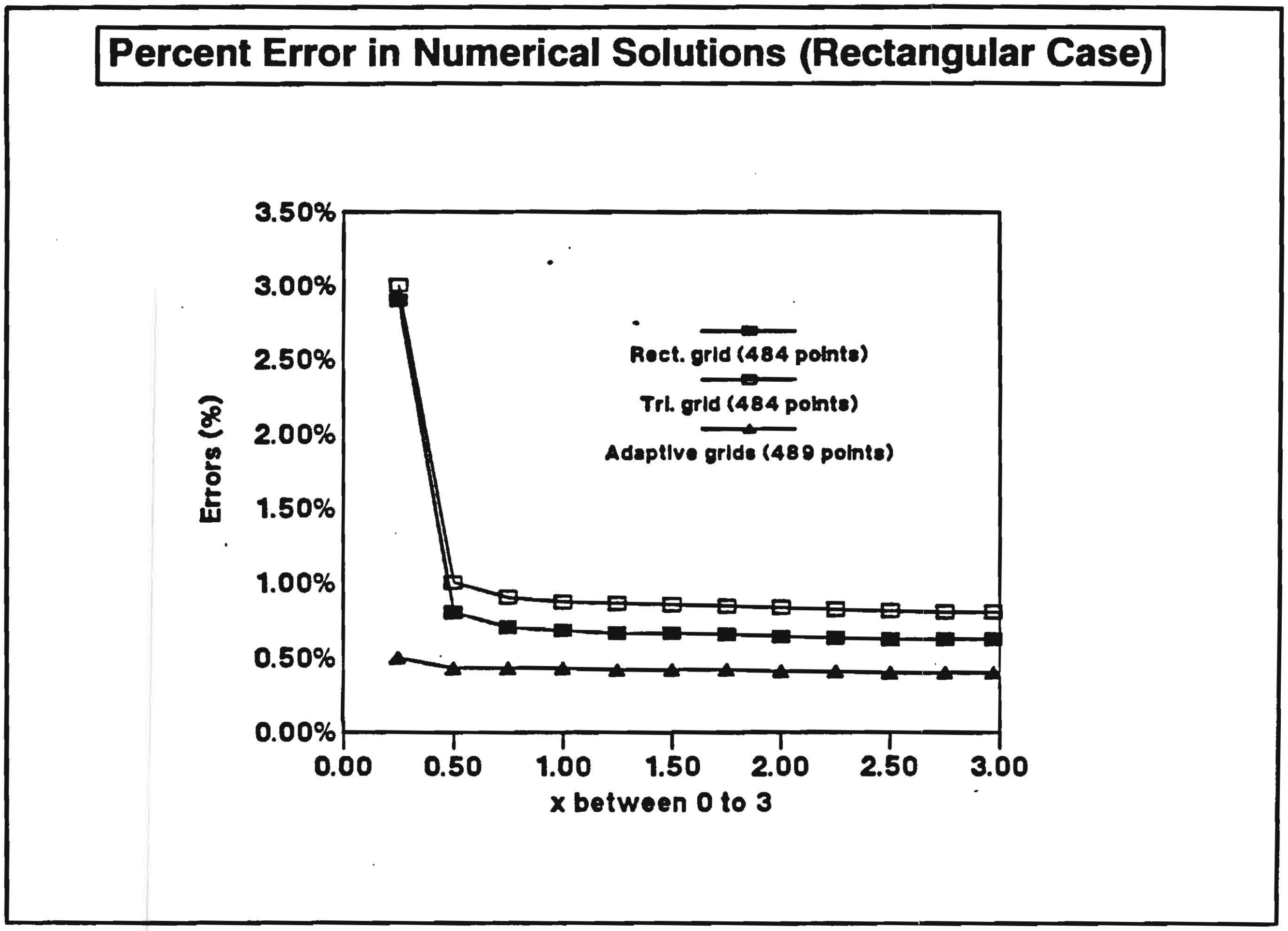

Percent Error in Numerical Solutions (Rectangular Case)
3.50%
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
Errors (%)
Rect. grid (484 points)
Tri. grid (484 points)
Adaptive grids (489 points)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
x between 0 to 3

Figure 3.

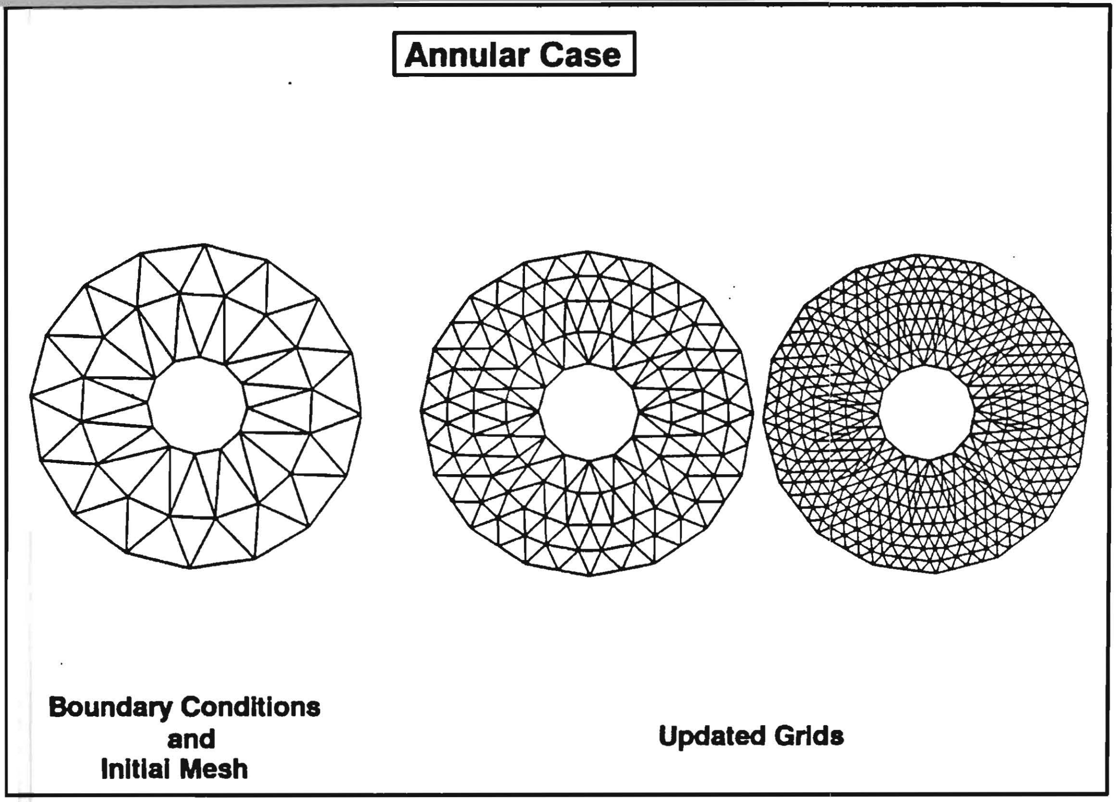


Figure 4a. Grid Refinements Using the Smoothing Algorithm
Annular Geometry

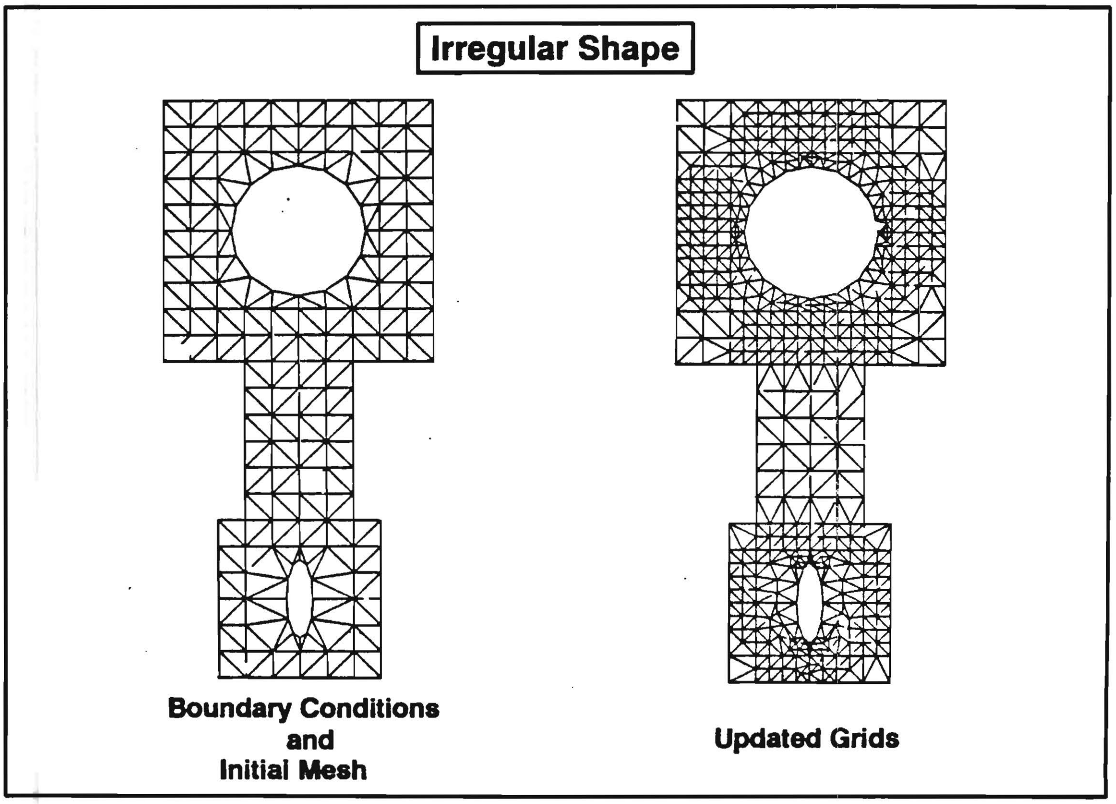


Figure 4b. Grid Refinements Using the Smmothing ALgorithm
Irregular Geometry

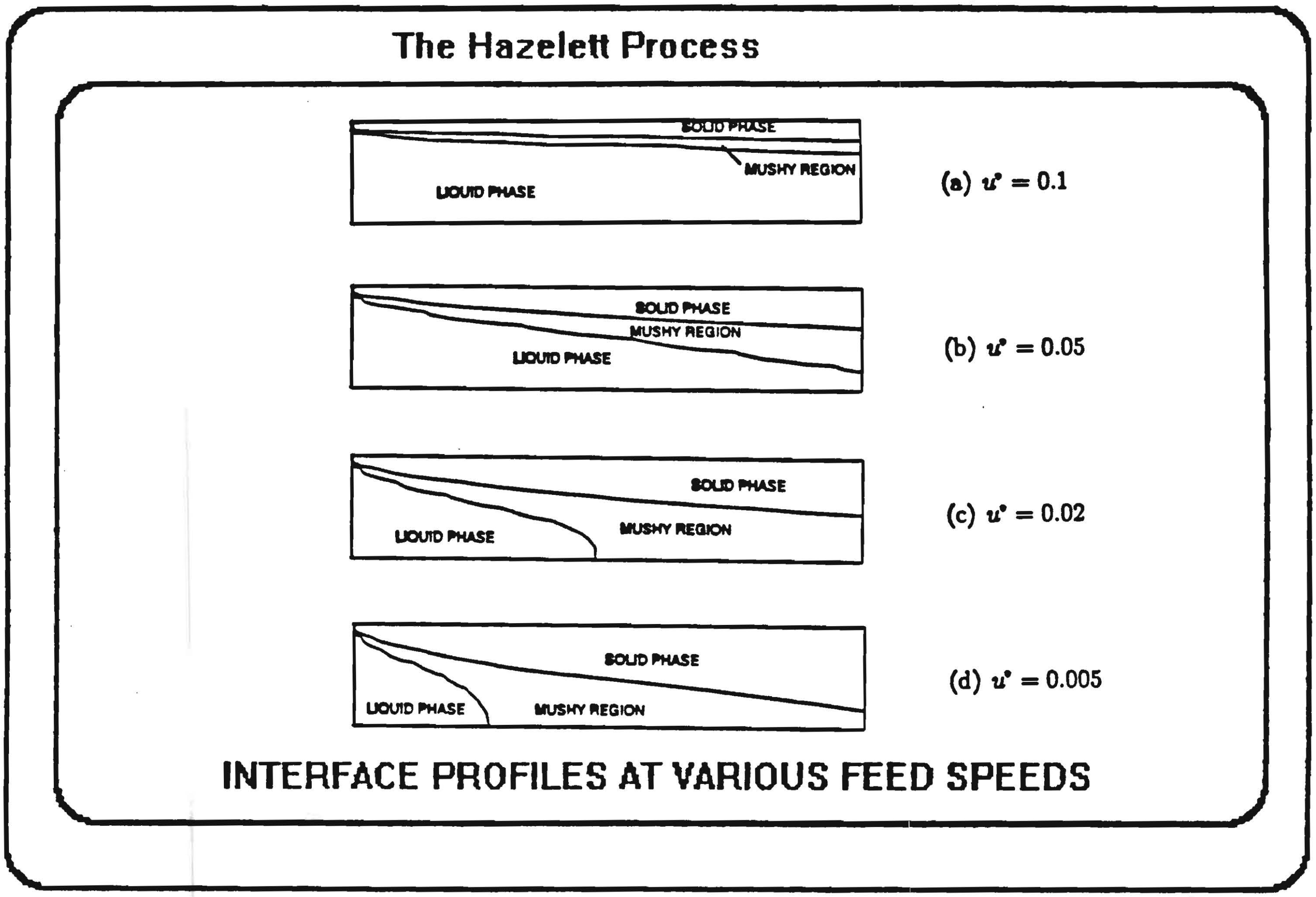


Figure 5. Interface Boundaries for the Hazellet Process

cover page

Title: Numerical Modeling of Transient Alloy Solidification in Complex Geometries

Authors: Jong-Hyun Kim
Carolyn Meyers
Prateen V. Desai

ABSTRACT

Most numerical techniques for the solution of phase-change are restricted due to the existence of moving boundaries and to the changes in thermal properties between the phases. In binary alloy solidification, three distinct phases, solid, liquid and mushy, make solutions more difficult to obtain.

In this paper, computational strategies are developed to simulate the physical phenomenon of transient, two-dimensional phase change processes. An irregular triangular mesh generation algorithm together with a specific heat method is developed to handle this complex solidification domain.

Two cases are selected to demonstrate the usefulness of this algorithm. First, solidification in a rectangular cavity is solved to validate the numerical accuracy of proposed algorithm. Second, wheel casting problems are simulated to understand the segregation behaviors during solidification process. This algorithm can be applied to many problems involving 2-dimensional complex shapes.

cover page

Title: **Adaptive Irregular Triangular Grid Generation for Transient Diffusion Problems**

Authors: Jong-Hyun Kim
In-Cheol Lim
Prateen V. Desai
Carolyn W. Meyers

ABSTRACT

The increasing interest in adaptive triangular grid generation is largely due to the computational difficulties associated with enmeshment of problems with complicated geometries. For accurate solutions of these types of problems, definition of boundary points and connectivity informations necessitate a significant amount of preliminary analysis.

To overcome the difficulties associated with conventional as well as irregular grids, a new method for generating triangular irregular grids for time dependent two dimensional heat conduction problems has been developed. This irregular triangular grid generation scheme is based on the Dirichlet tessellation. Connectivity information of each grid is obtained automatically during grid generation.

Three different cases have been selected to demonstrate the usefulness of this adaptive grid algorithm. For the problems of interest, this adaptive algorithm yields better accuracy near the regions of high temperature and irregular boundaries.

Entrapment in Hybrid Composites During Solidification Processing

It is the intent of this proposed research to explore the solidification process of hybrid composites in terms of microstructure/defect evolution and subsequent mechanical property levels. The matrix will be composed of a binary alloy and the reinforcement will consist of a combination of short fibers and particulates. The solute distribution in the cast composite must be ascertained and the solute segregation effect induced by the presence of reinforcement will be accounted for. The change in freezing time, solidification mode and defect evolution associated with variations in the frequency of the solidification front will be studied .

To meet this objective the focus will be on developing a comprehensive model of the capture/rejection phenomenon that occurs during the solidification processing of composites. It has been shown that when a liquid containing a dispersion of particle is solidified the solidification front can exert a repulsive force on the particle and push them along with it, thereby increasing the particle concentration in the last solidifying liquid.(See Figure 1) It has been validated that this phenomenon of particle pushing occurs only below a certain velocity of the advancing solidification front known as the critical velocity.

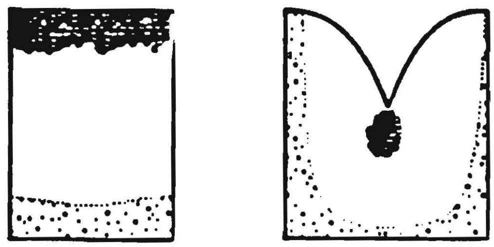
The evaluation of this critical velocity is key to determining the final distribution of reinforcement. Short range interactions between the particle and the interface have been emphasized in previous studies, and these interactions would be important for the solidification of pure materials. The trapping or engulfing of particles by the interface has been thought to depend on the balance of forces between the repulsion at the interface and difficulty in pushing the particle (including displacing the liquid in front ot the particle) through the medium in front of the interface. Furthermore, experimental studies have been carried out in transparent materials such as salol which have high entropy of fusion so that they grow with a faceted interface even when small impurities are present. The kinetic effects present in these systems tend to stabilize the planar interface with respect to local perturbations in the shape of the interface. Most metals, on the other hand, have nearly isotropic interface properties which allow the solid-liquid interface to deform its shape readily to conform to the shape dictated by the local solute gradient at the interface.

Materials for particulate composites consists of alloys in which solute diffusion plays a dominant role in establishing the morphology of the interface. These solute fields are long range in nature so it is anticipated that the solute field interaction would be significantly more important than the short-range interact forces that are considered in the earlier models for pure metals. The alloys used for composite materials are generally concentrated alloys so that under most practical growth conditions the microstructure will be either cellular, dendritic or eutectic. The interactions between particles and the non-planar interface will be significantly different from those of the planar interface. In order to examine how the particle alters the morphology of the interface, and the mechanism by which particles are trapped or pushed at the interface, experiments will be carried out in a transparent system where the interface configurations can be examined in situ and the particle interaction with cellular and dendritiec interfaces can be observed precisely. The microstuructural changes observed in the solidification analog experimental system will be analyzed and incorporated appropriately into the theoretical models.

The solidification microstructure that develops when an alloy is directional solidified in the presence of inert particles not only depends on the processing parameters such as the growth rate and the temperature gradient, but is also significantly influenced by the size and the density of the particles. The influence of particles on the solidification microstructure will examined in three parts: (1) the long range interaction between the particle and the interface, (2) the changes in morphologies due to the presence of particles and (3) the effect of particles on the stability of the interface. The effect of the buoyancy force on the redistribution of particles will be included in the model.

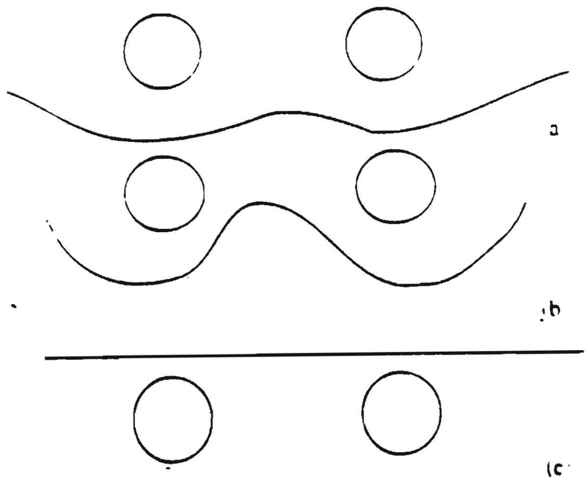
In binary alloys, the interaction between the interface and the particle begins when the particle are at comparatively large distances away from the interface. This long-range interaction becomes dominant since the presence of particles perturbs the diffusion field in the liquid ahead of the interface. This perturbed diffusion field alters the concentration gradients at different segments of the interface so that the shape of the interface changes with time. These interaction distances are large compared to the short-range forces such as the repulsive forces that become important when the interface is close to the particle, that the solute effect will may become dominant during the solidification of alloy in the presence of particles.

An integral component of the model development will be the determination of the interface profile during the solidification process(See Figure 2). Numerical simulations based on theory presented in the literature coupled with empirical data where appropriate will be incorporated into a computer code which will track the position and velocity of the solidification front as well as the position of each particle as a function of time. The net redistribution of particles due to the combined effect of solute diffusion, buoyancy force, and pushing of the particle by the moving solidification front will be determined.



A case of initial engulfment and later pushing in the same casting

Figure 1



A schematic illustration of interface perturbation near a particle and the origin of bands around a trapped particle. a–c: Planar interface approaches and passes the particles

Figure 2

E-25-M57

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

APPENDIX IV

2

For Consideration by NSF Organization Unit (Indicate the most specific unit known, i.e. program, division, etc.)	For NSF Use Only
	NSF Proposal Number
Program Announcement/Solicitation No./Closing Date: FAW - Renewal	

Date Received	Number of Copies	Division Assigned	Fund Code	File Location

Employer Identification Number (EIN) or Taxpayer Identification Number (TIN)	Show Previous Award No. If This is:	Is This Proposal Being Submitted to Another Federal Agency?
58-0603146	XX A Renewal or ☐ An Accomplishment-Based Renewal	YES____ NO XX If YES, List Acronym(s)

Name of Organization to Which Award Should be Made:	Address of Organization, Including Zip Code
Georgia Tech Research Corporation	Georgia Institute of Technology Atlanta, Georgia 30332-0420
Institutional Code (If known): 0015693000	

Is Submitting Organization: ☐ For-Profit Organization; ☐ Small Business; ☐ Minority Business; ☐ Woman-Owned Business

Branch/Campus/Other Component (Where work is performed, if different)	Institutional Code (If known)
Woodruff School of Mechanical Engineering	

Title of Proposed Project

Requested Amount	Proposed Duration (1-60 months)	Requested Starting Date
$ 50,000	12 months	8/1/93

Check Appropriate Box(es) If This Proposal Includes Any of the Items Listed Below:

☐ Vertebrate Animals
☐ Human Subjects
☐ Historical Places
☐ Research Involving Genetically Engineered Organisms
☐ National Environmental Policy Act
☐ Proprietary and Privileged Information
☐ Disclosure of Lobbying Activities
☐ Facilitation for Scientists/Engineers with Disabilities
☐ Research Opportunity Award
☐ International Cooperative Activity:

Country/Countries

PI/PD Department	PI/PD Postal Address
Geo. W. Woodruff School of ME	Georgia Institute of Technology Atlanta, GA 30332-0405
PI/PD Fax Number: 404-894-8336	

Names (Typed)	Social Security No.*	High Degree, Yr	Telephone Number	Electronic Mail Address
PI/PD Name: Carolyn W. Meyers	228-64-6323	Ph.D., '84	404-894-3264	carolyn.meyers@me.gatech.edu
Co-PI/PD				
Co-PI/PD				
Co-PI/PD				
Co-PI/PD				

NOTE: The FULLY SIGNED Certification Page must be submitted immediately following this Cover Sheet.

*Submission of social security numbers is voluntary and will not affect the organization's eligibility for an award. However, they are an integral part of the NSF information system and assist in processing the proposal. SSN solicited under NSF Act of 1950, as amended.

CERTIFICATION PAGE

Certification for Principal Investigators and Co-Principal Investigators:

certify that to the best of my knowledge that:

1) the statements herein excluding scientific hypotheses and scientific opinions are true and complete, and

2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision.

understand that the willful provision of false information or concealing a material fact in this report or any other communication submitted to NSF is a criminal offense (U.S.Code, Title 18, Section 1001.)

Name (Typed)	Signature	Date
PI/PD		7/23/93
Co-PI/PD		
Co-PI/PD		
Co-PI/PD		
Co-PI/PD		

Certification for Authorized Institutional Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is providing the certifications regarding Federal debt status, debarment and suspension, drug-free workplace, and lobbying activities, as set forth in GRESE, NSF 92-89.

Debt and Debarment Certifications (If answer "yes" to either, please provide explanation.)

Is the organization delinquent on any Federal debt? Yes ____ No XX

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ____ No XX

CERTIFICATION REGARDING LOBBYING

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Statement of Loan Guarantees and Loan Insurance

The undersigned states, to the best of his or her knowledge and belief, that:

If any funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this commitment providing for the United States to insure or guarantee a loan, the undersigned shall complete and submit Standard Form-LLL, "Disclosure From to Report Lobbying," in accordance with its instructions.

Submission of this statement is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required statement shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED INSTITUTIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME/TITLE (TYPED) David B. Bridges / Contracting Officer		7/29/93

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
(404) 894-4817	David.Bridges@OCA.GATECH.EDU	(404) 894-6956

APPENDIX V

EE INSTRUCTIONS ON REVERSE
EFORE COMPLETING

SUMMARY PROPOSAL BUDGET

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (MONTHS)	
	Proposed	Granted
AWARD NO.		

RGANIZATION
Georgia Institute of Technology

RINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Carolyn W. Meyers

. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.6. show number in brackets)	NSF Funded Person-mos. CAL.	ACAD	SUMR	Funds Requested By Proposer	Funds Granted By NSF (If Different)
1. Carolyn W. Meyers			2	$ 14,000	$
2.					
3.					
4.					
5. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
6. (1) TOTAL SENIOR PERSONNEL (1-5)				14,000	
. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1) POST DOCTORAL ASSOCIATES ½ of 1 quarter				4,000	
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS - Ph.D. level				14,000	
4. (1) UNDERGRADUATE STUDENTS				4,500	
5. ( ) SECRETARIAL CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				36,500	
. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) (25.1%)				4,518	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				41,018	
. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000:)					
TOTAL PERMANENT EQUIPMENT					
. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				1,182	
2. FOREIGN					
. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $					
2. TRAVEL					
3. SUBSISTENCE					
4. OTHER					
( ) TOTAL PARTICIPANT COSTS					
. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				3,254	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				3,254	
H. TOTAL DIRECT COSTS (A THROUGH G)				45,454	
. INDIRECT COSTS (SPECIFY RATE AND BASE) (10%)					
TOTAL INDIRECT COSTS				4,546	
. TOTAL DIRECT AND INDIRECT COSTS (H + I)				50,000	
. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPM 252 AND 253)					
. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 50,000	$

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Carolyn W. Meyers	7/23/93	INDIRECT COST RATE VERIFICATION		
NST. REP. TYPED NAME & SIGNATURE*	DATE 7/25/93	Date Checked	Date of Rate Sheet	Initials-DGC

NSF Form 1030 (8/90) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233)

To NSF Program: Faculty Awards for Women

APPENDIX VIII

Annual NSF Grant Progress Report

PI Name: Carolyn W. Meyers

NSF Award Number: EID-9023561

PI Institution: Georgia Institute of Technology

PI Address: George W. Woodruff School of Mechanical Engineering Atlanta, GA 30332-0405

Date: July 23, 1993

I certify that to the best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinions) are true and complete, and (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision. I understand that the willful provision of false information or concealing a material fact in this report or any other communication submitted to NSF is a criminal offense (U.S.Code, Title 18, Section 1001.)

Signature: ______________________________

Please include the following information:
1. A brief summary of overall progress, including results obtained to date, their relationship to the general goals of the award and their significance to science;
2. an indication of any current problems or favorable or unusual developments;
3. a brief summary of work to be performed during the next year of support if changed from the original proposal; and
4. any other information pertinent to the type of project supported by NSF or as specified by the terms and conditions of the grant.

If applicable, please attach a copy of any updated human subject or animal subject certification.
[Attach additonal sheets as necessary.]

FAW ANNUAL REPORT

RESEARCH SUMMARY FOR
CARMEN SIDBURY AND CALVIN MACKIE

The solidification microstructure that develops when an alloy is directionally solidified in the presence of inert particles strongly depends on the processing parameters. Among these processing parameters are the growth rate of the solidification front, the temperature gradient during solidification, and the size and distribution of the inert particles. While the significance of the former two parameters has been studied, the influences exerted by the latter parameters are obscure. Specifically, solute diffusion effects, buoyancy force influences and particle interactions with each other and with the advancing solidification front are not well understood. **Quantifying the effects of these factors on the capture/rejection phenomenon of the inert particulate reinforcement at the solidification front in metal matrix composites are the objectives of this research.**

Four theories of capture/rejection phenomena are prominent in the literature. The kinetic approach of particle pushing, after Uhlmann, Chalmers and Jackson (1), proposes a critical velocity above which particles are entrapped by the advancing front to be:

$$V_c = 0.5(n+1)LA_0V_0\frac{D}{KTR^2}$$

V = theoretical critical velocity
L = latent heat of fusion per unit volume
A = atomic spacing
V = atomic volume
D = diffusion coefficient of liquid
KT = Boltzman factor
R = particle radius
n = constant approx. equal to 5.0

The Chernov, Temkin, and Melnikova approach (2) considers the repulsion of the particles by molecular forces if there exists a positive disjoining pressure in the gap between the particle and the growing solidification front. This approach is represented by:

$$\frac{B_n}{h^n} > 0$$

B_n = constant determined by the relationship between the dielectric constants of the crystal, the liquid, and the particle.
h = film thickness
n = power index; takes the value n=3 and 4 for different media (metal and dielectric)
B_n/h^n = is defined as the disjoining pressure

An empirical relation based on thermal conductivities is the basis for the Zubkov model (3). The rate of growth of the solidification front increases and particle capture occurs when the thermal conductivity of the particle is less than that of the growing interface that is:

$$\frac{K_p}{K_l} < 1$$

(where K_p and K_l represent the thermal conductivies of particles and liquids respectively) the interface growth rate increases.

Lastly, the Bolling and Cisse (4) approach concentrates on the deformation of the solidifying interface and the viscous drag on the particle as the interface advances. The critical velocity for entrapment is expressed by:

$$V_c = \left(\left(\frac{4\psi\ (\alpha,\beta\ )}{9\pi\ \eta^2 R^3} \right) KT\gamma\ a_0 \right)^{1/2}$$

V_c = critical velocity
ψ = $\alpha\,(1 - \alpha)^3 / (1 - 3\alpha)$
α = interface shape factor and a function of β
β = $\ln \alpha + (1 - \alpha) / (1 - 3\alpha)$; β is same characteristics of melt and particle properties and is assumed to be unity
KT = Boltzman factor
η = viscosity
R = particle radius
γ = specific solid-liquid surface free energy
a_0 = atomic spacing

In summary, none of these theories accurately represents the capture/rejection event during the solidification of metal matrix composites. The Uhlmann-Chalmers-Jackson theory deos not agree with experimental observations; the Chernov-Temkin-Melnikova theory.only considered the short range forces which become effective only when the interface is within a few atomic distances from the particle, however for binary alloys long range interactions become dominant. The Zubkov model uses a temperature independent thermal conductivity thereby ignoring the fact that the thermal conductivities of most metals vary with temperature. And the Bolling and Cisse model assumes the interface shape to be invariant with time. There does, however, appear to be general agreement that a critical velocity for entrapment does exist. This critical velocity is dependent on the interface shape which in turn is affected by the temperature gradient and the interface growth rate as shown in Figure 1.

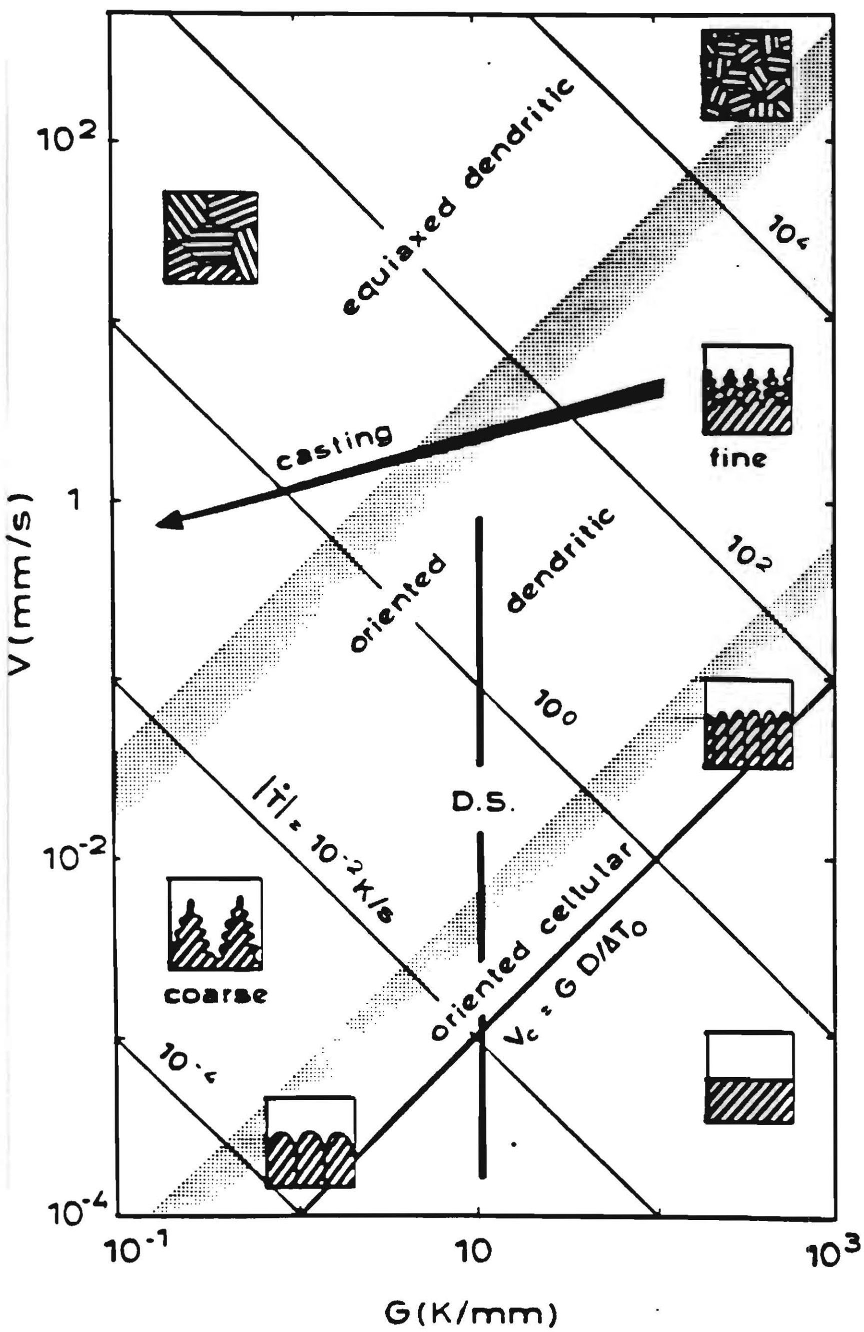


Figure 1

An inherent limitation of studying the solidification process in metals and metal-based composites is that the morphology cannot be observed in situ due to their opaque property. Thus, the structure must be frozen in, usually by quenching, and then excised to be examined. There are, however, transparent organic compounds having low melting points and entropies of fusion similar to those of metals and metallic materials which represent resonable solidification analog systems. To study the capture/rejection phenomena in the solidification processing of metal matrix composites, a succinonitrile based system will be used.

At present, the major components of the directional solidification experimental system have been aquired. This system , shown in Figure 2, consists of three functional parts: sample cells with heating and cooling chambers, drive and controls sytem, and monitoring devices for paremeter measurements. The quartz sample tube is fixed to a frame and remains stationary during the process. The furnace and cooling chamber surrounding the sample tube moves upward at a controlled velocity. The gradient can be varied by either changing the location of the furnace and the cooling chamber, regulating the temperature of the furnace, or regulating the temperature of the liquid circulating through the cooling chamber. The translation system consists of a drive plate housing the imaging system, the cooling chamber and the furnace. The translation stage has the capability of rates from 1 to 100 microns/second.

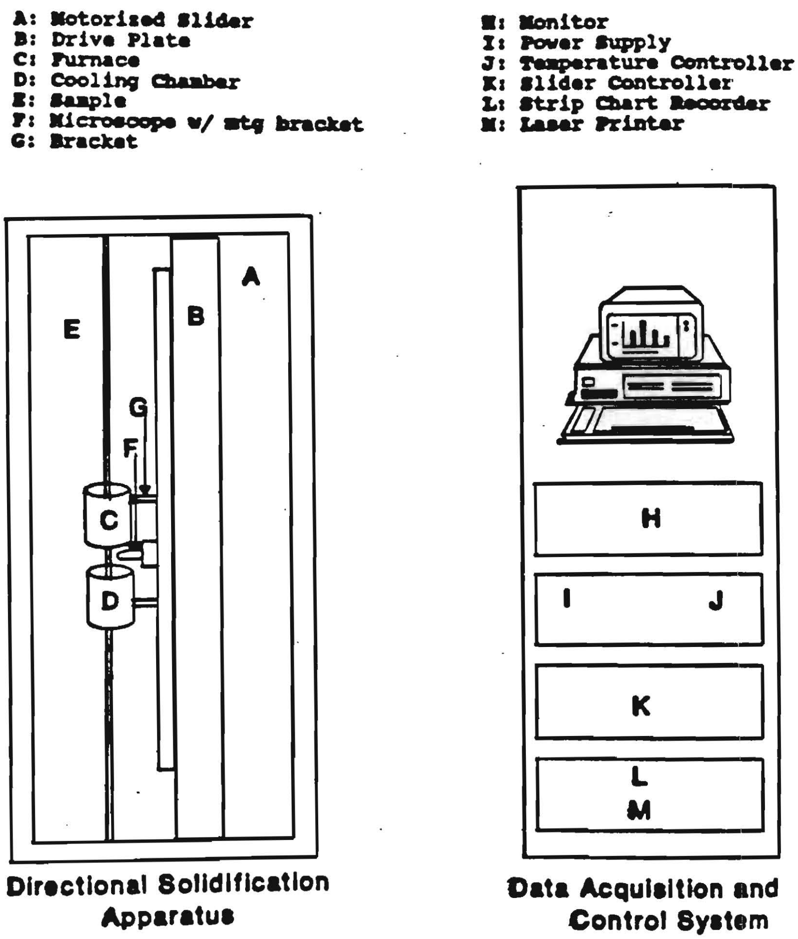


Figure 2: Directional Solidification Experimental Set-up

The heart of the monitoring system is the microscope centered over the gap between the hot and cold chambers. Data from the continuously focused microscope is recorded using a video camera allowing the observations of particles as small as 2.8 microns. Each component has been tested and preliminary tests are to be completed by the end of summer quarter 1993.

Plans for 1993-94

Roughly half of the year will be devoted to the collection of experimental data. This data will then be analyzed and with formed the basis for the development of a more realistic and comprehensive model of the solidification processing of particulate reinforced metal matrix composites. It is intended that the research on this aspect of the processing of metal matrix composites will be completed by Carmen Sidbury in August 1994.

The aim of the investigation being conducted by Calvin Mackie is to study the critical behavior of a solidifying system at the onset of thermosolutal convection in the liquid region. This investigation is very significant because a better unerstanding of the dynamics between convection and solidification will ultimately aid in the growth of crystals from melt or other solidifying aqueous solutions in the material industry.

In particular, linear and weakly nonlinear stability analyses were performed to calculate critical Rayleigh and wave numbers at the onset of thermal convection for a solidifying single-component Boussinesq fluid for a variety of boundary conditions. The investigation is performed by developing a sixth-order single variable perturbation differential equation for eigensystem. The analysis yielded the following conclusions:

- Analytical analysis reveals explicitly the coupling between the onset of convection and the deflection of the interface.

- The critical Rayleigh number for the onset of instability depends not only upon the state of the liquid, but also on the boundary conditions at the solid-liquid interface.

- The dimensionless thickness, A, of the solidified layer plays a relevant role in the analysis. Increasing A has a stabilizing effect on the onset of convection.

- The critical wave number decreased as the Biot number was decreased.

- As the Biot number is increased, the critical Rayleigh number decreases. Beyond a Biot number of 10, the solution approaches the isothermal wall case, corresponding to an infinite Biot number.

Plans for 1993-94

Presently, the analysis is being extended to investigate the influence of nonmelting particulates on the thermoconvective stability of a solidifying porous medium, consisting of spherical particles within a melt, to represent a solidifying metal matrix composite. The critical conditions for the onset of the convection will be determined by performing a stability analysis on the saturated region. I am assuming the porous medium is isotropic and homogeneous and the solid, liquid, and matrix are all in local thermal equilibrium. Comparison of the Brinkman-extended Dacry model to the Darcy model for a porous medium must be undertaken. Utilizing the Brinkman model will allow comparison between the homogeneous liquid model and the matrix model. However, the Brinkman model increases the degree of the governing differential by two thus producing a more difficult analysis. The overall objective is to fully understand the role of nonlinear convection on solidifying systems; over the next year, a full nonlinear stability analysis will be performed using the critical conditions as initial conditions for the instabilities.

Additional Comments:

A female undergraduate student was also partly supported by this grant. A sophomore in the School of Mechanical Engineering, Stephanie Logan assists the graduate students in the lab. As a result of her efforts, Stephanie won 2nd Place in the Student Poster Competition at the American Foundrymen's Society's Casting Congress in April 1993. It is the intent of the PI to continue supporting Stephanie Logan to further expose her to materials research and to encourage her to consider graduate school in the area.

Papers:

"Stereological Analysis of the Size-Shape Distribution of Second-Phase Particles in HIPped A356 Castings", revised for publication in **Materials Characterization** (1993) with J.S. Chou.

"Structure/Mechanical Property Relationships in HIPped Cast Aluminum-Silicon Alloys", **Proceedings, US-Taiwan Joint Symposium on Advanced Manufacturing Processes**, Atlanta, Georgia (Feb.10-12, 1993) 115-130. With J.S. Chou.

"Statistical Analysis for the Effects of Composition on Braking Parameters", submitted to **Wear** (1992) (in review). With Ward O. Winer and Dong-Yoon Chung.

"On Simulating Binary Alloy Solidification in Complicated Geometries", **Proceedings, First International Conference on Transport Phenomena in Processing**, Selchuk Gucerl, editor, PA: Technomic Publishing Co. (1993) 328-338. With J.H. Kim and P.V. Desai.

"Adaptive Irregular Triangular Grid Generation for Transient Diffusion Problems", **Proceedings, First International Conference on Transport Phenomena in Processing**, Selchuk Guceri, editor, PA: Technomic Publishing Co. (1993) 1527-1536. With J.H. Kim and P.V. Desai.

"Numerical Modeling of Transient Alloy Solidification in Complex Geometries", **Proceedings, First International Conference on Transport Phenomena in Processing**, Selchuk Guceri, editor, PA: Technomic Publishing Co. (1993) 318-327. With J.H. Kim and P.V. Desai.

"Simulation of Mold Filling Using the Modified SOLA-VOF Method", **Proceedings, First International Conference on Transport Phenomena in Processing**, Selchuk Guceri, editor, PA: Technomic Publishing Co. (1993) 1150-1158. With J.H. Kim and I.C. Lim.

Presentations:

"The Role of Women and Minorities in Changing the Culture of Engineering Academia", Frontiers in Education, November 1992, Nashville, Tn.

"Linear Stability of a Partially Solidified Melt", with C. Mackie and P.V. Desai, American Physical Society 45th Annual Meeting, Division of Fluid Dynamics, November 1992, Tallahassee, FL.

"Circles, Squares, Polygons and You", Keynote Address, Board on Minorities and Women, Winter Annual Meeting ASME, November 1992, Anaheim, CA.

"The Role of Women and Minorities in Changing the Culture of Engineering Academia", Frontiers in Education, November 1992, Nashville, Tn.

"Single Varible Perturbation Analysis of a Solidified Melt", with C. Mackie and P.V. Desai, The Materials, Metals, and Minerals Society 1993 Annual Meeting, February 22-25, 1993, Denver, CO.

"The Role of Faculty in Women in Engineering Programs", WEPAN, May 1993, Washington, D.C.

"Combining a Career with Family", ASEE Annual Meeting, June 1993, Champaign-Urbana, Il.

OTHER RELATED ACTIVITIES

1. Director, Center for Professional Success, SUCCEED Coalition (half time appointment).

2. Election to the grade of Fellow in the American Society of Mechanical Engineers, Spring 1993.

3. Election to the Board of Directors of the Women's Program Advocates Network (WEPAN), Spring 1993.

4. Completed term on the Advisory Board of the Engineering Directorate of the National Science Foundation, Spring 1993.

5. Organized and chaired the Women in Mechanical Engineering (WOMEN) in the George W. Woodruff School of Mechanical Engineering at Georgia Tech, 1992-93.

6. Appointed Vice-President for Minorities and Women, ASME Region XI, fall 1992.

7. Session Chair, Aluminum Division, American Foundrymen's Society, Annual Casting Congress, April 1993.

8. Review panels for the NSF: Young Scholars Program, MRCE, Mechanics and Materials.

9. Review panel for Department of Defense Graduate Fellowship and National Defense Education Graduate Program.

TEACHING

Due to my involvement in the start up of the SUCCEED Coalition, I did not teach any courses during this past academic year. Since my involvement with SUCCEED will be scaling down at the end of summer quarter 1993, I will be teaching a solidification processing course in the fall, ME 4205, and am developing two new senior level technical electives-Smart Materials and Advanced Processing of Materials, both of which should be implemented by the spring of 1994.

E-25-M69
#3
~~E-25-X38~~
#3

FACULTY AWARD FOR WOMEN SCIENTISTS AND ENGINEERS

ANNUAL PROGRESS REPORT

Period of Performance: July 1, 1993-June 30, 1994

**Submitted
to the
National Science Foundation
Award Number EID 9023561**

Period of Performance: July 1, 1993-June 30, 1994

Program Officer: Dr. Sonia Ortega

**Submitted
by**

**Carolyn W. Meyers, Ph.D.
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, Ga. 30332-0405**

August 15, 1994

and viscous forces and their evolution, coupled with the morphological changes at the interface, must thus be examined to allow the development of a comprehensive model of the force field leading to the distribution of the reinforcement after solidification has occurred. *This research proposes to use experimentally obtained data from a metal analog system as the basis for such a model.*

B. *Ongoing Research*

Consideration of the many parameters affecting physical phenomena in the solidification process dictates that informed choices of those having the most significance on reinforcement distribution must be made. Preliminary work to date indicates the following process variables are significant in the behavior of the reinforcement at the melt interface:

-radius of the reinforcement,
-viscosity of the melt,
-surface energy at the interfaces between the reinforcement and the liquid and solid phases,
-reinforcement shape,
-reinforcement distribution,
-densities of the constituents,
-thermal properties of the constituents, and
-percent by volume of reinforcement.

At the growing interface during the solidification process, solute of differing density from that of the bulk liquid is often rejected. Under a gravitational field, this rejection results in solutal convection, noticeable when the density of the solute is less than that of the melt. Thermal and solutal density gradients in a system then combine to result in thermosolutal convection. This convection induced distortion of the solid-liquid interface has been observed using a metal analog system representing the pure and slightly alloyed compositions (6-9).

The thermal and solutal Rayleigh numbers , R_t and R_s, respectively, may be used to determine the onset of incipient convection. The Rayleigh number is a dimensionless parameter defined as the ratio of the buoyancy forces to the viscous forces present in the system. The Rayleigh number thus marks the transition from conduction dominated heat transfer to multi-mode heat transfer (including conduction and convection). The thermal and solutal Rayleigh numbers are defined by:

$$R_t = [g\, \beta_T\, G_L\, (D/V)^4\,] \,/\, (\nu\, \kappa) \quad \text{and} \tag{1}$$

$$R_s = [\, g\, \beta_c\, (C_m - C_o)\, (D/V)^3\,] \,/\, (\nu\, D) \tag{2}$$

in which

- β_t, β_c = volumetric coefficients of thermal and solutal expansion, respectively,
- G_L = thermal gradient in the liquid,
- D = diffusion coefficient,
- V = interface velocity,
- ν = kinematic viscosity,
- C_m = monotectic composition,
- C_o = alloy composition, and
- κ = thermal diffusivity.

The critical Rayleigh number which corresponds to the onset of incipient convection in a system may also be determined experimentally or numerically. In earlier experiments conducted using succinonitrile, a critical Rayleigh number was determined to be 60,000 (10). This number will be used initially in calculating the experimental conditions which guarantee convective-conductive mode of heat transfer. It is anticipated that the critical Rayleigh number for the particulate reinforced system under study will be larger than this value. Commercial software in fluid dynamics, FIDAP, will be used to assess convection levels present in the melt.

Preliminary calculations relating the solidification rate with the volume percent reinforcement were executed on the basis of the reported Rayleigh number, i.e., 60,000. Properties of the constituents employed are listed in Table 1 and are taken from similar examinations as reported in the literature (11).

Density of liquid	ρ	988 kg/m^3
Thermal expansivity of solid	α_s	$5.6 \times 10^{-4}/K$
Thermal expansivity of liquid	α_l	$8.1 \times 10^{-4}/K$
Shear Viscosity	η	2.6×10^{-3}Pa-s
Kinematic viscosity	ν	$2.6 \times 10^{-6} m^2/s$
Latent heat of fusion	L	4.70×10^4j/kg
Thermal conductivity of solid	k_s	0.225 J/mKs
Thermal conductivity of liquid	k_l	0.223 J/mKs
Thermal diffusivity of solid	κ_s	$1.16 \times 10^{-7} m^2/s$
Thermal diffusivity of liquid	κ_l	$1.12 \times 10^{-7} m^2/s$
Distribution coefficient	k	0.044
Liquidus slope for ethanol in SCN	m_l	3.6K/wt pct
Solidus slope for ethanol in SCN	m_s	81K/wt pct
Diffusivity of ethanol in SCN	D	$10^{-9} m^2/s$

Table 1. Constituent Properties for Trial Runs

The results of the simulation are expressed in terms of a stability limit diagram, Figure 1, which shows the boundaries of convective and interfacial stability. For this study, the interfacial stability criterion of Mullins and Sekerka as stated below is used:

$$[G_L/V] > [m_L(C_m - C_o)/D] \qquad (3).$$

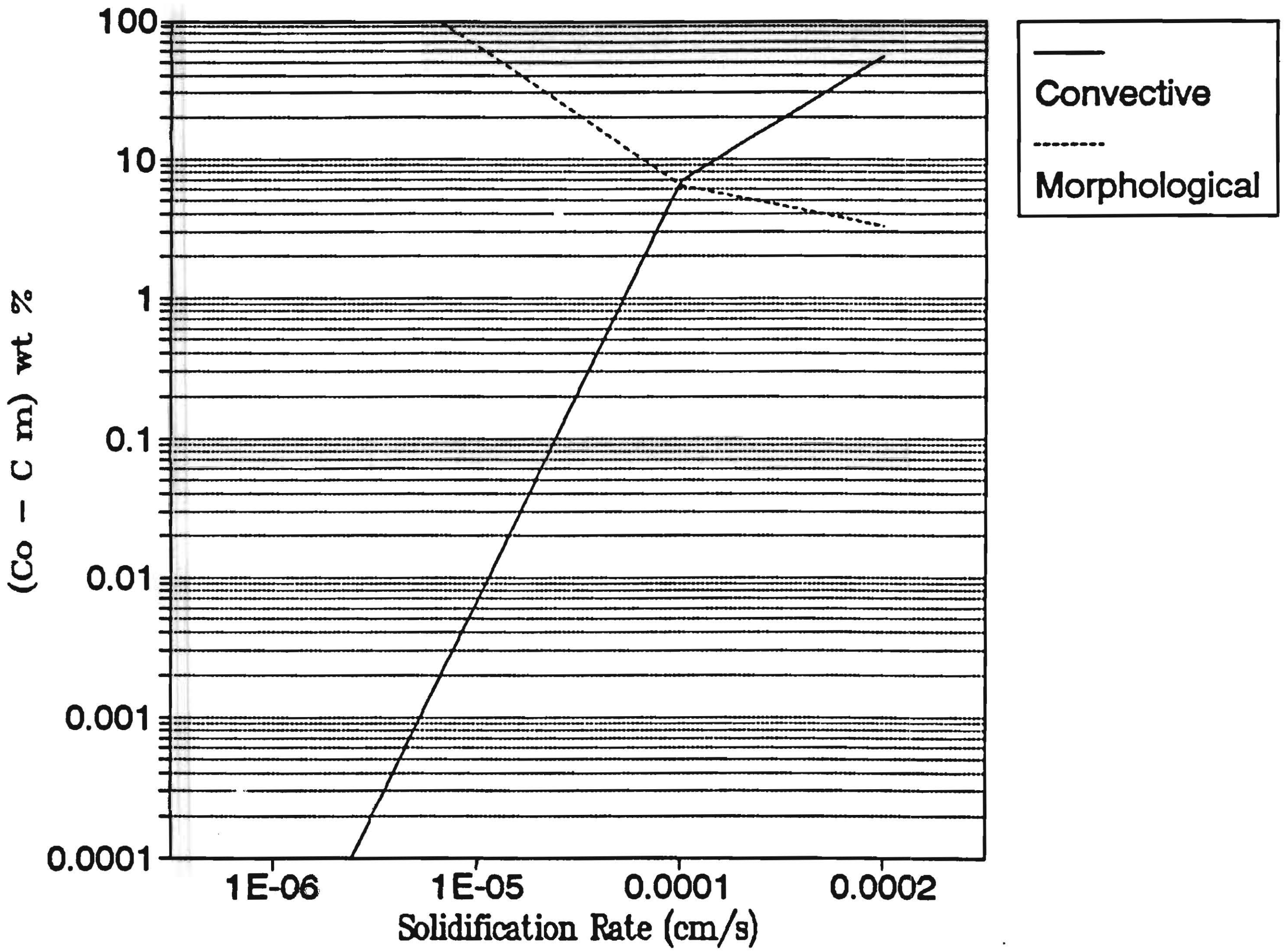


Figure 1. Stability Limit Diagram using Data in Table 1.

C. *Ongoing Research - Experimental Plan:*

Experimental studies on the solidification processing of particulate reinforced metal matrix composites have used thin samples to minimize convection effects and to isolate interfacial interactions (12). However, in the actual production of metal matrix composites, thermosolutal convection in the interdendritic regions induces reinforcement motion in the liquid and subsequently leads to segregation of the reinforcement. The directional solidification apparatus used in this research allows the examination of the influence of convection on the segregation of the reinforcement.

Real time visualization of the solidification front is accomplished through the use of a specialized furnace assembly and a transparent metal analog system. Optical imaging including transmitted light capabilities allows the direct observation of the solidification front during the solidification process. This system is modeled after the temperature gradient stage used by Hunt et.al. (13) and Eshelman and Mason (14). However, for this research the stage is mounted in the vertical orientation.

Cylindrical samples are typically used in directional solidification studies. Due to the optical requirements of this experimental program, the sample geometry consists instead of a relatively thin rectangular cells. All pre simulation operations are performed in a dry nitrogen/argon filled glove box in consideration of the solubility of the constituents with oxygen and water.

Since acetone and ethanol are soluble in succinonitrile, these will be used as alloy constituents. Property data are available on both. The sample cells are attached to the translation stage and move vertically in either direction at a controlled velocity, while the furnace and cooling chambers remain fixed during solidification. The gradient is varied by changing either the location of the furnace and the cooling chamber or the temperature of the furnace or the temperature of the liquid circulating through the cooling chamber. Solidification is then viewed through a microscope centered over the gap between the hot and cool chambers. With a video cassette recorder integrated with the camera and monitor, the processes in each simulation are recorded.

The output from the video system is analyzed using a commercial software image analysis package. The sequence of steps in the experimental program which are used to characterize the redistribution of the reinforcement during the solidification process is shown in Figure 2. The experimental set-up is shown in Figure 3.

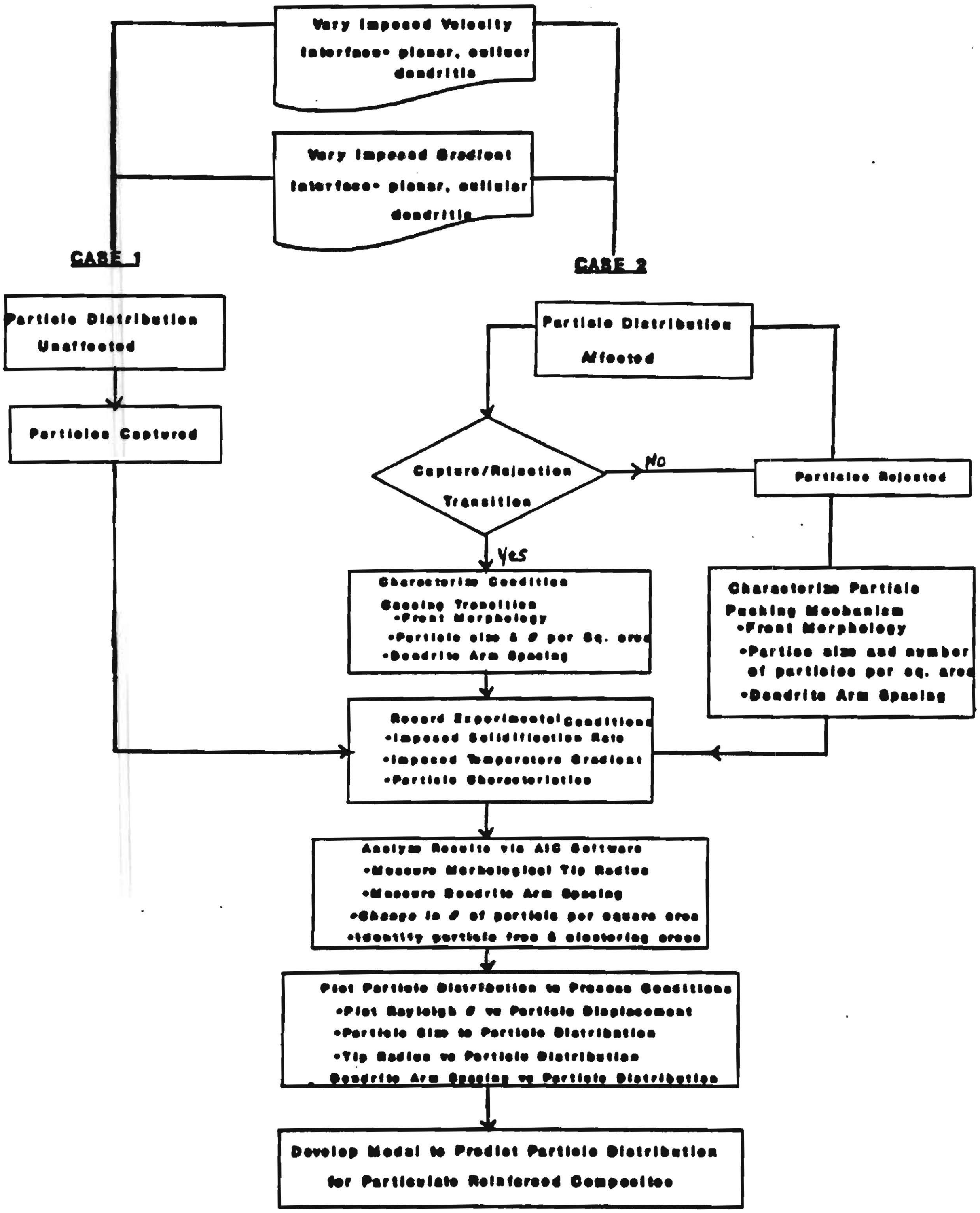


Figure 2. Research Procedure

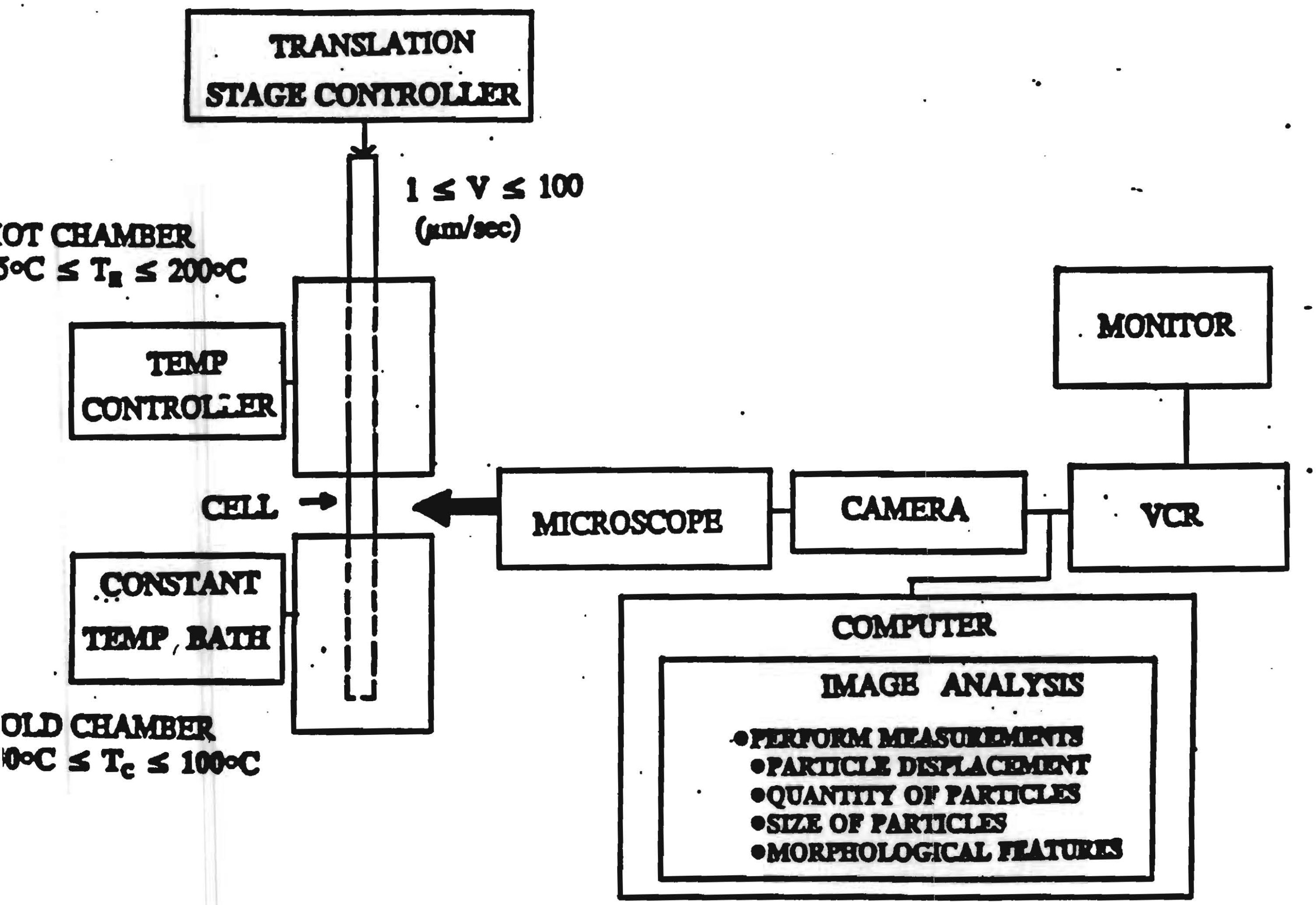


Figure 3. Experimental Set-Up

D. *Plans for 1994-95*

The bulk of this academic year will be spent running trials with different variables and analyzing the subsequent data. These additional trials will address the low density of particles that are encountered by the interface. One problem observed during the trial runs is that many of the particles seem to settle out, leaving few particles in the melt at the onset of directional solidification. This occurrence has been reported in the literature, which indicates that the holding time required to obtain a planar interface is quite large when compared to the holding time in the melt in a typical casting operation.

Results from trial runs using as-received succinonitrile and low volume fractions of stainless steel particles are shown in Figures 4-7.

To facilitate the computer simulation of the fluid dynamics during solidification, a new, higher power personal computer has been purchased . Use of this computer will allow the fluid flow simulation software, FIDAP 6.0, to be run to provide benchmark data for the case of natural convection.

Lastly, the graduate student will be presenting preliminary results of her research at the fall meeting of the American Physical Society (APS) and at the NSF Conference on Diversity. She intends to defend her research in the Spring of 1995.

G = 150^{o}C/in
V = 1 μm/sec

Figure 4. Planar Interface Approaching Particles

Figure 5. Planar Interface Capturing Particles

V = 8 μm/sec

Figure 6. Dendritic Interface Approaching Particle

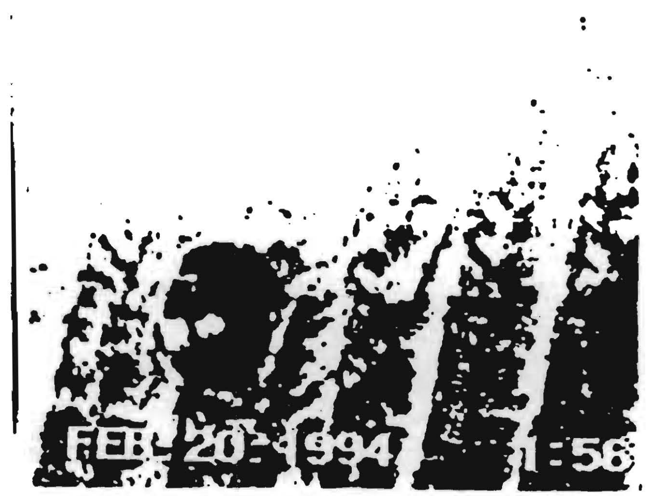


Figure 7. Dendritic Interface Engulfing Particle

Carolyn W. Meyers, Ph.D.
Award Number EID 9023651

Additional Comments:

During the past award year, a undergraduate research assistant, Stephanie Logan, was also supported by the FAW. Stephanie is a rising senior in the Woodruff School of Mechanical Engineering and plans to continue working in the lab during the next academic year. Another undergraduate student, Al Etheridge, is also partly supported by the award.

Additionally, the PI taught two courses, Mechanical Behavior of Materials and Materials Processing, in the George W. Woodruff School of Mechanical Engineering.

References

1. I. Jin and D.J. Lloyd, "Solidification of SiC Particulate Reinforced Al-Si Alloy Composites", ASM Intl. Conf. on Fabrication of Particulate Reinforced Metal Composites, Canada, 1990, 47.

2. J. Cornie, H.K. Moon, and M.C. Flemings, "A Review of Semi-Solid Slurry Processing of Al Matrix Composites", ibid.

3. D.J. Lloyd and B. Chamberlain, " Properties of Shape Cast Al-SiC Metal Matrix Composites, ASM Intl. Conf. Proc.: Cast Reinforced Metal Composites, Edited by S.G. Fishman and A. K. Dinghra, Ohio, 1988, 263.

4. D.R. Uhlman, B. Chalmers, and K.A. Jackson, J. of Appl. Physics, 35 (1964), 2986.

5. G.F. Bolling and J. Cisse, " A Theory for the Interaction of Particles with a Solidifying Front", J. of Crystal Growth, 10 (1971), 56.

6. A.M. Zubkov, V.G. Labanov, and V.V. Nikonova, Soviet Physics Crytallography, 1973, 18.

7. P.K. Rohatgi, F.M. Yarandi and Y. Liu, "Influence of Solidification Conditions on Segregation of Aluminum-Silicon Carbide Particle Composites", ASM Intl. Conf. on Fabrication of Particulate Reinforced Metal Composites, Canada, 1990, 249.

8. D. Stephanescu, S.A. Kacar, and A. Moitra, "The Influence of Buoyant Forces and Volume Fraction of Particles on the Particle Pushing/Entrapment Transition during Directional Solidification of Al/SiC and Al/Graphite Composites", Met. Trans., 21A (1990), 231.

9. R.J. Schaefer and S.R. Coriell, "Convection Induced Distortion of a Solid-Liquid Interface", Met. Trans, 15A (1984), 2109.

10. C.B. Moss and J. Barry Andrews, "The Effect of Convection in Immiscible Systems During Directional Solidification, in process.

11. A. Papapetrou, Zeit. f. Krist., 1935, 92A, 89.

12. J.A. Sekhar and R. Trivedi, "Solidification Microstructure Evolution in the Presence of Inert Particles", Mat. Sci. & Eng., A147 (1991), 9.

13. J.D. Hunt, K.A. Jackson, and H. Brown, Rev. Sci. Instrum., 37 (1966), 805.

APPENDIX V

SUMMARY PROPOSAL BUDGET

ORGANIZATION	FOR NSF USE ONLY			
	PROPOSAL NO.	DURATION (MONTHS)		
		Proposed	Granted	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	AWARD NO.			

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title: A.6. show number in brackets)	NSF FUNDED PERSON.MOS. CAL	ACAD	SUMR	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
1. Carolyn W. Meyers, Ph.D. - Associate Professor, Mechanical Engineering	2.0	1.0	1.0	$16,334	$
2.					
3.					
4.					
5. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
6. ( ) TOTAL SENIOR PERSONNEL (1-5)				16,334	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				15,000	
4. (1) UNDERGRADUATE STUDENTS				2,000	
5. ( ) SECRETARIAL-CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				33,334	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				8,234	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				41,568	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,000	
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $____ 2. TRAVEL ____ 3. SUBSISTENCE ____ 4. OTHER ____					
TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,455	
2. PUBLICATION COSTS/PAGE CHARGES				432	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				1,887	
H. TOTAL DIRECT COSTS (A THROUGH G)				45,455	
I. INDIRECT COSTS (SPECIFY) 10% TOTAL INDIRECT COSTS				4,545	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				50,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS GPM 252 AND 253)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$0,000	$

PI/PD TYPED NAME & SIGNATURE* Carolyn W. Meyers, Ph.D. Carolyn W. Meyers	DATE 8/15/94	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
INST. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date of Rate Sheet	Initials - DGC Program

NSF FORM 1030 (F-83) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233)

INSTRUCTIONS FOR USE OF SUMMARY PROPOSAL BUDGET (NSF FORM 1030)

1. **General**

a. Each grant proposal, including requests for supplemental or incremental funding, must contain a Summary Proposal Budget in this format unless a pertinent program guideline specifically provides otherwise.

b. Copies of NSF form 1030 and instructions should be reproduced locally as NSF will not supply the form.

c. A separate form should be completed for each year of support requested. An additional form showing the cumulative budget for the full term requested should be completed for proposals requesting more than one year's support. Identify each year's request (e.g. "First year ____" or

APPENDIX VI

Current and Pending Support for Research and Education in Science and Engineering

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of the proposal.

1. Name of Principal Investigator	Source of Support	Project Title	Award Amount (or Annual Rate)	Period Covered by Award	Person-Months or % or Effort Committed to the Project			Location or Research
					ACAD.	SUMM.	CAL YR.	
A. Current Support List-If none, report none Carolyn W. Meyers, Ph.D.	NSF	Faculty Award for Women	$50,000	7/1/93-6/30/94	2	1.5	3.5	Georgia Tech
B. Proposal Pending 1. List this proposal	NSF	Faculty Award for Women	$50,000	7/1/94-6/30/95	2	1.5	3.5	Georgia Tech
2. Other pending proposals, including renewal applications. If non, report none.	AFS	Crack Propagation in Light Alloys	$183,000	1/1/95-12/30/96	2	1.5	3.5	Georgia Tech
3. Proposals planned to be submitted in near future. If none, report none.								
II. Name of co-principal investigator and/or faculty associate A. ________ B. ________								
III. Transfer of Support If this project has previously been funded by another agency, please list and furnish information for immediately proceeding funding period.								
IV. Other agencies to which this proposal has been/will be submitted	none							

USE ADDITIONAL SHEETS AS NECESSARY

NSF FORM 1239 (1-87)

E-25-M39
#4

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

R CONSIDERATION BY NSF ORGANIZATION UNIT(S) (icate the most specific unit known, i.e., program, division, etc.)	FOR NSF USE ONLY — NSF PROPOSAL NUMBER
GRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/If not in response to a program announcement/solicitation enter GPG, NSF 95-27	

TE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	FILE LOCATION

PLOYER IDENTIFICATION NUMBER (EIN) OR XPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY?
	[X] A RENEWAL OR EID-9023561 [ ] AN ACCOMPLISHMENT-BASED RENEWAL	YES [ ] NO [X] IF YES, LIST ACRONYM(S)

ME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING ZIP CODE
Georgia Tech Research Corporation	Georgia Institute of Technology Atlanta, GA 30332-0420
ARDEE ORGANIZATION CODE (IF KNOWN)	

ME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE	ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING ZIP CODE
RFORMING ORGANIZATION CODE (IF KNOWN)	

AWARDEE ORGANIZATION (Check All That Apply) (e GPG II.D.1 For Definitions)
[ ] FOR-PROFIT ORGANIZATION [ ] SMALL BUSINESS [ ] MINORITY BUSINESS [ ] WOMAN-OWNED BUSINESS

LE OF PROPOSED PROJECT
Faculty Award for Women Scientists and Engineers

QUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE
50,000	12 months	7/1/95

ECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- BEGINNING INVESTIGATOR (GPG I.A.3)
- DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.D.1)
- PROPRIETARY & PRIVILEGED INFORMATION (GPG II.D.10)
- NATIONAL ENVIRONMENTAL POLICY ACT (GPG II.D.10)
- HISTORIC PLACES (GPG II.D 10)
- SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.12)
- GROUP PROPOSAL (GPG II.D 12)
- [ ] VERTEBRATE ANIMALS (GPG II.D.12) IACUC App. Date ______
- [ ] HUMAN SUBJECTS (GPG II.D.12) Exemption Subsection_____or IRB App. Date ______
- [ ] INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES ______
- [ ] FACILITATION FOR SCIENTISTS/ENGINEERS WITH DISABILITIES (GPG V.G.)
- [ ] RESEARCH OPPORTUNITY AWARD (GPG V.H)

PD DEPARTMENT	PI/PD POSTAL ADDRESS
rolyn W. Meyers, Ph.D. chanical Engineering	Georgia Institute of Technology School of Mechanical Engineering Atlanta, GA 30332-0405
PD FAX NUMBER 4-853-0168	

MES (TYPED)	Social Security No.*	High Degree, Yr	Telephone Number	Electronic Mail Address
PD NAME rolyn W. Meyers, Ph.D.	228-64-6323	Ph.D.,1984	404-894-1322	carolyn.meyers@me.gatech.edu
PI/PD				
PI/PD				
PI/PD				
PI/PD				

IOTE: THE FULLY SIGNED CERTIFICATION PAGE MUST BE SUBMITTED IMMEDIATELY FOLLOWING THIS COVER SHEET

BMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION'S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE NTEGRAL PART OF THE NSF INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED.

CERTIFICATION PAGE

ertification for Principal Investigators and Co-Principal Investigators

ertify to the best of my knowledge that:

) the statements herein (excluding scientific hypotheses and scientific opinions) are true and complete, and

) the text and graphics herein as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the gnatories or individuals working under their supervision. I agree to accept responsibility for the scientific conduct of the project and to provide the quired progress reports if an award is made as a result of this application.

understand that the willful provision of false information or concealing a material fact in this proposal or any other communication submitted to NSF is a iminal offense (U.S.Code, Title 18, Section 1001).

ame (Typed)	Signature	Date
I/PD arolyn W. Meyers, Ph.D., echanical Engineering		11/1/95
o-PI/PD		
o-PI/PD		
o-PI/PD		
o-PI/PD		

ertification for Authorized Organizational Representative or Individual Applicant

y signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made erein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if award is made as a result of this application. Further, the applicant is hereby providing certifications regarding Federal debt status, debarment and uspension, drugfree workplace, and lobbying activities (see below), as set forth in the *Grant Proposal Guide (GPG),* NSF 95-27. Willful provision of lse information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, ection 1001).

addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has nplemented a written and enforced conflict of interest policy that is consistent with the provisions of *Grant Policy Manual* Section 510; that to the best of s/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have een satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's onflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

ebt and Debarment Certifications (If answer "yes" to either, please provide explanation.)

the organization delinquent on any Federal debt? Yes ☐ No ☐

the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, voluntarily excluded from covered transactions by any Federal Department or agency? Yes ☐ No ☐

ertification Regarding Lobbying

is certification is required for an award of a Federal contract, grant or cooperative agreement exceeding $100,000 and for an award of a Federal loan or commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

ertification for Contracts, Grants, Loans and Cooperative Agreements

e undersigned certifies, to the best of his or her knowledge and belief, that:

No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to luence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in nnection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative reement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or ployee of any agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with this deral contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying tivities," in accordance with its instructions.

The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including contracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

s certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this tification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the uired certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

THORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
ME/TITLE (TYPED)		

EPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

ANNUAL NSF GRANT PROGRESS REPORT

NSF Program: Faculty Award for Women **NSF Award Number:** EID 9023561

PI Name: Carolyn W. Meyers, Ph.D. **Period Covered By This Report:** 7/1/94-6/30/95

PI Institution: Georgia Institute of Technology **Date:** November 1, 1995

PI Address: George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0405

[X] **Check If Continued Funding Is Requested**

Please include the following information:

1. Brief summary of progress to date and work to be performed during the succeeding period;
2. Statement of funds estimated to remain unobligated —if more than 20%— at the end of the period for which NSF currently is providing support (not required for participants in the Federal Demonstration Project);
3. Proposed budget for the ensuing year in the NSF format, only if the original award letter did not indicate specific incremental amounts or if adjustments to a planned increment exceeding the greater of 10% or $10,000 are being requested;
4. Current information about other research support of senior personnel, if changed from the previous submission;
5. Any other significant information pertinent to the type of project supported by NSF or as specified by the terms and conditions of the grant;
6. A statement describing any contribution of the project to the area of education and human-resource development, if changed from any previous submission; and
7. Updated information on animal care and use, Institutional Biohazard Committee and Human Subject Certification, if changed substantially from those originally proposed and approved.

(addressed in text)

I certify that to the best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinions) are true and complete, and (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision. I understand that the willful provision of false information or concealing a material fact in this report or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1001.)

P.I. Signature: ______________________

NSF Form 1328 (1/94)

NATIONAL SCIENCE FOUNDATION

PROJECT SUMMARY

FOR NSF USE ONLY			
DIRECTORATE/DIVISION	PROGRAM OR SECTION	PROPOSAL NO.	F.Y.
EHR	HRD	EID9023561	95

NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

Georgia Institute of Technology, School of Mechanical Engineering

ADDRESS (INCLUDE DEPARTMENT)

Georgia Institute of Technology, School of Mechanical Engineering, Atlanta, Georgia 30332-0405

PRINCIPAL INVESTIGATOR(S)

Carolyn W. Meyers, Ph.D.

TITLE OF PROJECT

Faculty Award for Women Scientists and Engineers

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The objective(s) of this project is (are):

At this point in the award period, the last year, the objectives of the project are as follows:

-To continue the support of Ty Duval and Calvin Mackie, both doctoral students, in the completion of their research;
-To initiate the continuation of research on the solidification of cast metal matrix composites using the previously designed directional solidification apparatus and to support[at least one student at the North Carolina A&T State University; the objective is to predict and therefore control the distribution of the reinforcing constituent;
-To complete three papers in process from the research already conducted by Carmen Sidbury and to submit these to refereed journals; and
-To draft three additional papers from the research on convective stability in porous media.

Mr. Duval's research should prove to be critical to the successful treatment of knee joint injuries, which are quite common. Mr. Mackie's and Miss Sidbury's research should facilitate the near net shape cost effective manufacture of parts and products from cast metal matrix composites

INSTRUCTIONS

The project summary (abstract) should include a statement of the research objectives, scientific methods to be employed, and the significance of the proposed research.

FACULTY AWARD FOR WOMEN SCIENTISTS AND ENGINEERS

ANNUAL PROGRESS REPORT

Period of Performance: July 1, 1994 - June 30, 1995

Submitted
to the
National Science Foundation
Award Number EID 9023561
Program Officer: Dr. Sonia Ortega

by

Carolyn W. Meyers, Ph.D.
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0405

November 1, 1996

Carolyn W. Meyers, Ph.D.
Award Number EID 9023561

Summary of Technical Progress

A. Overview of Ongoing Research

The research primarily supported by this award and detailed in the previous progress report has resulted in the successful defense of the dissertation, *Effect of Processing Conditions on Cast Particulate Reinforced Composite Materials* by Carmen K. Sidbury on August 28, 1994 (Attachment A). Miss Sidbury is an African American female. She will be formally awarded the doctorate degree at Georgia Tech's Fall 1995 commencement in December 1995. Miss Sidbury is currently employed as a Member of the Technical Staff at the AT&T Laboratories in Norcross, Ga.

Mr. Calvin Mackie, also supported by this award, is scheduled to defend his dissertation on the *Convective Stability of a Solidification Interface in a Porous Layer* in December 1995. Mr. Mackie, an African-American male, along with Miss Sidbury, both presented papers at the annual meeting of the American Physical Society in November 1994 in Atlanta, Ga. The titles of these papers are, respectively,:

Convective Stability of a Solidification Interface in a Porous Layer
and
Experimental Observations of the Interaction of Inert Particles at a Solid/Liquid Interface.

Additionally, both students had papers accepted for publication in the Proceedings of the Modeling of Casting, Welding and Advanced Solidification Processes VII conference held in London, England in September 1995 (letter of acceptance for one included in Attachment B. Lastly, three papers are in preparation detailing the results and implications of Miss Sidbury's thesis. All papers will be included in the Final Report for this award, to be done in 1996.

Another student, Ty A. Duval, is supplementary supported by this award. Mr. Duval, a NSF Graduate Fellowship awardee and a Hispanic American, is working on *Modeling the Damage Accumulation in the Cartilages of the Human Knee Joint.* Mr. Duval passed the qualification examinations in May 1995 and is preparing the proposal for his research. This research is conducted jointly with Dr. Thomas Branch, Emory University School of Medicine. A copy of this proposal will be forwarded when completed.

Carolyn W. Meyers
Award Number EID 9023561

B. Plans for Academic Year 1995 - 1996

The PI will be moving to the North Carolina A&T State University's College of Engineering as Dean and Professor of Mechanical Engineering in January 1996. The PI plans to continue to support Mr. Duval and Mr. Mackie and act as their co-advisor for the thesis research at Georgia Tech. Additionally, the PI intends to continue the research on the solidification and microstructure evolution of cast metal matrix composites at NC A&T. As the budget reflects, one new student will be supported with stipends and equipment.

C. Other Activities

The PI presented talks at the following meetings: WEPAN '95, Norfolk State University (research seminar), GT Society of Black Engineers, ASEE, 1994 NSF Diversity Conference and ASME. She was also appointed to the NSF EHR Advisory Committee, Advisory Board to MIT's Women in the Professoriate Committee, chaired the NSF Workshop on Restructuring Undergraduate Education, editorial board of the Journal of Engineering Education, and recently elected Vice President for Women and Minorities of the ASME.

Georgia Tech

THE GEORGE W. WOODRUFF SCHOOL OF
MECHANICAL ENGINEERING

Georgia Institute of Technology
Atlanta, Georgia 30332-0405

Subject: Ph.D. Thesis Defense

By: Carmen K. Sidbury

Time: Monday, August 28, 1995 @ 12:00 PM

Place: Coon Bldg. Room 217

Title: Effect of Processing Conditions on Cast Particulate Reinforced Composite Materials

Committee: Dr. Carolyn Meyers, ME, Co-Advisor

Dr. Prateen Desai, ME, Co-Advisor

Dr. Steven Danyluk, ME

Dr. Rosario Gerhardt, MSC

Dr. Russell Heikes, ISYE

SUMMARY

Modern fiber-reinforced or particle filled metal matrix composites(MMCs) produced by foundry techniques find a wide variety of applications because of the low cost of their fabrication and the tailorability of achievable engineering properties. One limitation to the extensive usage has been the cost efficient fabrication of sound parts from PMMCs. The spatial distribution of the particulate reinforcement influences the soundness and the reliability of cast PMMCs via an interaction between the reinforcement and the growing solidification interface.

In this research particle behavior at a solid-liquid interface is related to various system parameters which impact the microstructure that develops during the solidification of the PMMC analog. Directional solidification studies in the presence of inert particles have been carried out in the SCN-Water system whose transparent nature allows the examination of the dynamic changes in microstructure that occur near the region of the particle and the solid-liquid interface. It is shown that, in binary alloys, the effect of particles on the solute field is dominant. The presence of particles alters the solute gradient at the interface which can give rise to significant changes in the features of the developing microstructure.

An additional component of this research entailed the development of a numerical model to determine the level of convection present in the experimental systems. The results indicate that maximum velocity vectors occur in the region near the solid-liquid interface and therefore are expected to play a role in any interactions that occur in this region. Information obtained from research in this area is expected to increase the feasibility of designing a critical size and distribution of particles. This is accomplished through characterization of processing conditions such as growth rate, composition and temperature gradient to obtain an optimum microstructure which will produce a composite material with superior properties.

Attachment B

Centre for Numerical Modelling and Process Analysis

CO-DIRECTORS: Prof Mark Cross DSc C Math FIMA
Prof Edwin R Galea PhD
Prof Brian Knight PhD
Koulis Pericleous PhD
Mayur K Patel PhD

the UNIVERSITY of GREENWICH

School Office : 081 316 8700
FAX : 081 316 8665
Direct Line : 081 316 8702

Our Ref : SX/MC/FB

Date 10 October 1994

Professor C.W. Meyers
Georgia Institute of Technology
G.W. Woodruff School of
Mechanical Engineering
SSTC #1
Atlanta, GA 30332-0405, USA

Dear Professor Meyers,

Modelling of Casting, Welding and Advanced Solidification Processes VII

I am writing with respect to the paper you have submitted to the above conference entitled "Convective Stability of a Solidification Interface in a Porous Layer". I am sure you will be interested to know that we have had over 160 papers submitted for this meeting, from which only about 60 can be presented orally. Given the very high quality of the vast majority of the papers and our desire to give an adequate geographical coverage of the worldwide community, your paper has been initially accepted for a poster presentation and inclusion in the proceedings.

You will shortly be receiving the publication information and camera ready pack from TMS, the publishers of the proceedings. We invite you to prepare a 8-page paper which describes the work submitted in your abstract. You will need to submit this paper to my office by 31 January 1995 when it will be reviewed again. On the basis of this review we will finally select the papers for either oral or poster presentation.

The standard of the papers submitted has been extremely high and we have been able to reject relatively few on the basis of quality. As such, the poster sessions in this meeting will have a much higher profile than at other meetings, containing many papers that would certainly be worthy of oral presentation if space were available.

I look forward to receiving your paper.

Yours sincerely,

Prof. M. Cross (Conference Chairman)

School of Mathematics, Statistics and Scientific Computing

Woolwich Campus
Wellington Street, Woolwich
London SE18 6PF
Telephone: 081-316 8000