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ABSTRACT

A project was conducted at Delaware County Community College, Media, Pennsylvania, to train two instructional staff members in the area of composite materials technology. A 1-year training program was set up for the two technical instructional specialists at the Boeing Helicopter Training Center, Eddystone, Pennsylvania. The program consisted of 580 hours of comprehensive classroom and laboratory training dealing with the selection, fabrication, testing, and use of graphite composite materials. Emphasis was on the Boeing/Bell V-22 aircraft. During the training, the specialists recorded, collected, and collated information on general composites, as well as a variety of materials related to the teaching methodology to be used. The instructional specialists also participated in visits and discussions with a variety of manufacturers of plastic and composite items. After the training, the specialists developed core courses in composite materials technology and structured a complete curriculum around those courses. The curriculum allows for a 2-year associate degree program, a 1-year certificate of proficiency program, and a certificate of competency program to be conducted in conjunction with company training programs. Ten attachments include the resumes of the two instructors, and listings of course outlines, professional organizations, and books acquired. (KC)

PA88PD05 018247

FINAL REPORT

COMPOSITE TECHNOLOGY
PERSONNEL DEVELOPMENT
(CONTRACT # 86-8006)

RACHEL MASSUDA
EDWIN FINK

DELAWARE COUNTY COMMUNITY COLLEGE

MEDIA, PENNSYLVANIA 19063

JUNE 30TH, 1988

PENNSYLVANIA DEPARTMENT OF EDUCATION

BUREAU OF VOCATIONAL AND ADULT EDUCATION

CURRICULUM AND PERSONNEL DEVELOPMENT SECTION

Acknowledgment

We acknowledge the contribution made by the Boeing Company and their technical training staff.

We would also like to thank members of our Advisory Committee for all the helpful advice and comments in planning the curriculum.

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II. Final Report Summary

A. Abstract

This final report is submitted by Delaware County Community College of Media, PA 19063, for the Composite Technology Personnel Development Contract #86-8006, funded for fiscal year 1987-1988.

The purpose of this document is to report on the progress made in personnel development of two instructional staff members in the area of composite materials technology.

The planned objective was to provide one year training in the area of composites for two Technical Instructional Specialists at Boeing Helicopter Training Center, Eddystone, PA, and to use the training to implement a multilevel instructional program in the field of composite materials technology.

The objectives achieved were the training at Boeing of the two instructional specialists, the application of the training to develop core courses in composite materials technology and, to structure a complete curriculum around those courses.

B. Financial Summary

	Approved Budget	Actual Expenditures
Non-instructional Salaries:		
* 1 full-year Engineering Instructional Specialist - unknown	$ 40,000	$ 21,600.00
* 1 half-year Engineering Instructional Specialist - unknown	20,000	21,600.00
* Technical Support Personnel	---	297.00
* Technical Support Personnel	---	800.00
	60,000	44,297.00
Non-instructional Benefits:		
Full-year Specialist @ 27%	10,800	5,832.00
Half-year Specialist @ 27%	5,400	5,832.00
Technical Support Personnel @ 27%	---	80.19
Technical Support Personnel @ 27%	---	216.00
	16,200	11,960.19
Other:		
Travel - advisory meetings, other industries/ schools, and conferences 4,762 miles @ .21/mile	1,000	964.66
	1,000	964.66
TOTAL	77,200	57,221.85

* NOTE: Because the two Engineering Instructional Specialists were not hired until October 1987, both positions became full-time. The annual rate for each was $35,000 rather than $40,000. In addition, two technical support personnel were utilized periodically to assist with grant start-up activities.

III. Project Approach/Methodology

With the development of the V-22 aircraft for the United States armed forces and predicting large orders by both the military and civilian sectors, Boeing Helicopter expects to hire a large number of employees who are versed in the "state of the art" skills of working with advanced composite materials. With the exception of the Boeing Training Center there are no other educational facilities in this area to train technicians and journey workers in composite materials technologies. Therefore an agreement was made between DCCC and Boeing for an "Industry to Education Technology Transfer Program". This effort would consist of a one year residence at the Boeing Helicopter Training Center of two instructional specialists. The training would then be adapted into the development of a curriculum.

Two individuals of considerable technical expertise were employed to partake in this training. Dr. R. Massuda and Mr. E. Fink (resumes shown in Attachment 1) were employed by Delaware County Community College on November 1, 1987. Due to scheduling conflicts, both instructional specialists were trained concurrently at Boeing instead of the sequence described in the initial proposal. Boeing training started on November 15, 1987 and was completed on May 12, 1988. The training consisted of 580 hours of comprehensive classroom and laboratory training dealing with the selection, fabrication, testing and use of graphite composite materials. Emphasis was specifically structured toward the Boeing/Bell V-22 aircraft. Attachment 2 is a listing of Boeing courses completed. During the instructional process, the

specialists recorded, collected, and collated information and notes on general composites information, process, and testing, as well as a variety of materials related to the teaching methodology to be used. The data was collected for use during the intensive curriculum development of Phase II in 1988-1989.

The instructional specialists also participated in visitations and discussions with a variety of manufacturers of plastic and composite items, from fiberglass yacht hulls to injected, extruded, and blow-molded items. The intent of these visitations was to involve manufacturers in the advisory, employment, and possible equipment/material donation process.

The Boeing training led to a preliminary draft of a curriculum that could be used to provide trained workers and technicians. Curriculum concept evolved around a dual instructional program.

The instructional specialists have participated in the formation of an Advisory Committee consisting of eight industrial/educational members with outstanding expertise in the field of composite technologies. Attachment 3 is a listing of members of the Advisory Committee.

IV. Project Summary

The intent of the project was to provide multilevel "state of the art" composite education to two DCCC instructors. The ultimate objective was to have an educational program structured to include an associate degree program and two certificate programs. These programs will be geared to give additional training to the high school graduate or equivalent from both the

general and the vocational technical tracks, as stated in the Perkins Act,"to improve the academic foundation of vocational students and to aid in the application of new technologies."

The courses will be well articulated to allow the graduates to transfer credit towards engineering baccalaureate education in materials science, plastics technology or a related discipline.

The Associate Degree Program

The two- year program in composite materials technology as described in Attachment 4 consists of 63 credits, including six core courses. In addition, other courses will be developed during 1988-89 to integrate their aspects to the technology. Description of the course objectives and outlines are included in Attachment 5. Upon completion of the program, the graduate will be qualified for employment as a technician in many of the area industries.

The Certificate of Proficiency Program

The one-year program as described in Attachment 6 consists of 32 credits including core composite courses. This program has been designed to allow a candidate to advance and obtain an associate degree with the completion of additional courses or secure employment as a journey worker.

The Certificate of Competency Program

This program will be conducted in conjunction with interested companies to train their current or future employees. The training provided will be specific to the objectives of the participating company. Examples of courses to be offered are com-

posite materials, layup, assembly, filament winding, and injection molding. These intensive courses will be designed based on a 40-hour week.

A major portion of the instructional methods will consist of the practical hands-on application of learning. Delaware County Community College has pursued this objective by obtaining a laboratory/classroom facility located at the Marple Vo-Tech School. Basic laboratory equipment has been chosen and purchased. Additional equipment requirements have been developed and submitted with the Phase II Proposal. Attachment 7 is a list of all the laboratory equipment required for this project.

A bibliography related to composites has been compiled and a number of books covering topics of interest have been acquired. Some of these are being evaluated for use as textbooks. Attachment 8 lists all acquisitions (books and journal subscriptions). A collection of other references including journal article reprints have also been obtained. These are listed in Attachment 9. All activities were augmented to keep current in the latest technical developments by memberships in the professional societies listed in Attachment 10.

Delaware County Community College has implemented a multi-year project to develop a program in composites technology. This three- year program was designed in three phases. This report details the progress made in Phase I, the objective of which was to train instructional specialists in composite technology. The other two phases of the program will develop and implement curricular courses based on the training received.

ATTACHMENTS

Number	
1	Resumes
2	Boeing Courses
3	Advisory Committee
4	Associate Degree
5	Course Outlines
6	Certificate of Proficiency
7	Lab Equipment
8	Books Acquired
9	Journal Articles
10	Professional Organizations

Attachment 1

RESUME

Rachel Massuda
532 Long Meadow Lane
Eagleville, PA 19403
Telephone: (215) 539-4453

Employment Experience:

10-1985 to 7-1986; Senior Chemist, Mass Lamination, Inc., Hatfield, PA 19440. Supervise the quality control during manufacturing of prepregs and laminates for printed circuit boards, set up laboratory for testing in conformance to Military Specifications.

11-1983 to 1-1985; Senior Project Engineer, temporary position, Materials and Processing Technology Department, Zenith Electronics Corporation, Glenview, IL 60025. Responsible for technical aspects of production scale-up of multicomponent silicone parts, characterization of raw materials and finished parts, establishing test methods, setting-up specifications. Involved in the passivation and encapsulation of semiconductors.

2-1978 to 6-1982; Senior Research Chemist, Materials Science Department, UOP Corporate Research, Des Plaines, IL 60016. In charge of research and development projects in the area of solar energy: photoelectrolysis, semiconductor-liquid junction solar cells, selective solar absorbers. Conducted research in polymer characterization techniques in composite materials and laminates for printed circuit boards. Developed tests for on-line process monitoring and control. Involved in emission spectroscopy during plasma processing of materials. Supervised work of two professionals.

7-1977 to 11-1977; Spectroscopist, temporary position, Nicolet Instrument Corporation, Madison WI. Applications of Fourier Transform Infrared Spectroscopy in solving analytical problems.

10-1975 to 4-1977; Postdoctoral fellow, Department of Chemistry, University of Montreal, Montreal, Canada. Conducted research in hydrogen bonding by low temperature infrared spectroscopy, in a study of the interaction between inhalation anesthetics and functional groups in molecules: amines, amides, and alcohols.

1974 to 1975; part time teaching at the secondary school level, and private tutoring.

1969 to 1973; Graduate student, Brandeis University. Waltham, MA. Research in optical spectroscopy of transition metal complexes in the solid state, at liquid helium temperatures; interpretation of the fine structure due to vibronic coupling and the Zeeman effect. Three years teaching assistant in laboratories and recitation classes.

Rachel Massuda
(cont.)

1965 to 1969; Cooperative student, Skinner and Sherman Company (analytical laboratory), Newton, MA. Involved for a total of two years in chemical and physical testing to specifications of miscellaneous materials: leather, rubber, detergent, food, cosmetics, wastes, paper, metal, paint, etc.

Education:

Ph.D. in physical chemistry, 1975, Brandeis University, Waltham, MA, under the supervision of Professor Paul Dorain. Thesis Title: "Vibronic Splitting and the Zeeman Effect in the Optical Spectrum of Iridium (IV), in Cubic Host Crystals at Low Temperatures."

B.A. in chemistry, 1969, Northeastern University, Boston, MA.

Publications:

1) R. Massuda and P.B. Dorain, "Vibronic Splitting of a Γ_8 Electronic States of Ir^{4+} in Single Crystals Cs_2ZrCl_6 at 4.2°K." J. Chem. Phys. 59, 5652 (1974).

2) R. Massuda and C. Sandorfy, "Breaking and Formation of Hydrogen Bonds by Proton Donating Anesthetics." Can. J. Chem. 55, 3211 (1977).

3) G. Trudeau, K.C. Cole, R. Massuda, and C. Sandorfy, "Anesthesia and Hydrogen Bonding. A Semi Quantitative Infrared Study at Room Temperature." Can. J. Chem. 56, 1681 (1978).

Professional Affiliations:

Member American Chemical Society, Local Section American Chemical Society, American Association for the Advancement of Science.

References:

will be sent on request.

EDWIN W. FINK

259 Hilldale Road
Villanova, Pennsylvania 19085
(215) 527-0102

EXPERIENCE SUMMARY

Electrical and control engineering technical associations have been in the areas of Nuclear, Combined Cycle and Cogeneration power systems and Aerospace engineering. Fully experienced in systems integration and test of power block and aerospace power conversion and control systems. Participated and developed procedures and specifications for the start-up, operation and testing of these systems. In depth experience in all phases of data acquisition systems including transducers, signal conditioners, multiplexing, A/D conversion and data storage and transmission. Responsible for the development, support and application of interactive computer graphic systems for electrical and control system design.

EDUCATION

Bachelor's Degree: BSEE Clarkson College 6/48
18 credits toward Master's Degree: MSEE Columbia University

ENGINEERING EXPERIENCE

7/72 - ~~Present~~ 3-85 WESTINGHOUSE ELECTRIC CORPORATION
Combustion Turbine Systems Division, Concordville, Pa.

Senior Engineer - Electrical systems design integration and testing of overall electrical power blocks of combustion turbine, combined cycle and cogeneration power systems. Conceptual design, analysis and development of turbine instrumentation and controls. Development and implementation of preventive maintenance programs, preparation of commissioning start-up and operating instructions and procedures.

8/69 - 7/72 UNITED ENGINEERS AND CONSTRUCTORS
Philadelphia, Pa.

Electrical Engineer - Responsible for engineering and design of electrical systems of a commercial nuclear power plant. Primary responsibilities included electrical distribution systems, motor control centers, standby power systems and process on-line computer systems.

2/67 - 8/69 GENERAL ELECTRIC COMPANY
Space Systems Division, King of Prussia, Pa.

Supervising Engineer - Supervised data systems section. Responsible for the development of coding, test, documentation and validation of meteorological spacecraft data systems. Coordinated the analysis and design of real time software programs. Developed new and improved automatic data processing and analysis techniques.

3/63 - 2/67 FAIRCHILD HILLER CORPORATION
Aerospace Division, Germantown, Md.

Supervisory Engineer - Developed and administered the organization, manpower and facilities of an advanced systems group engaged in the development of rospace power conversion systems. Developed improved solar thermoelectric generators and lightweight power conditioning systems for spacecraft. Directed analysis of mission and vehicle constraints on power system optimization.

/60 - 3/63 GENERAL ELECTRIC COMPANY
Missile & Space Vehicle Department, King of Prussia, Pa.

Systems Engineer - Developed equipment and systems to provide remote load control and indication, signal multiplexing and programmable control for spacecraft power systems. Applied computer technology for the application of logic required for load control and sequencing, self checkout and automatic load shedding.

2/55 - 1/60 WESTINGHOUSE ELECTRIC CORPORATION
Atomic Power Division, Bettis Field, Pittsburgh, Pa.

Lead Engineer - Directed Reactor Nuclear Radiation control systems development. Supervised the design and development of generating system instrumentation and controls. This included Naval (Nautilus class submarines) propulsion power systems and the first commercial nuclear power station to be placed in service. Participated in, and developed procedures and specifications for the start-up, operation and testing of these systems.

3/53 - 2/55 RADIO CORPORATION OF AMERICA
Electronic Tube Division, Harrison, N.J.

Project Engineer - Cognizant engineer for the development of new and improved power conversion systems. Designed and developed solid state and vacuum tube inverters, power rectifiers and frequency converters. Directed analysis on solid state switching systems.

12/49 - 3/53 BG CORPORATION
13 West 52nd St., New York, N.Y.

Development Engineer - Developed thermal instrumentation, high voltage joule discharge electric systems, ignition devices and electro-mechanical switching systems. .

6/48 - 12/49 BENDIX AVIATION CORPORATION
Sidney, N.Y.

Test Engineer - Cognizant engineer for aircraft electric generating and distribution system testing.

12/40 - 6/45 Military Service - U.S. Army Air Force

Attachment 2

BOEING COURSES

Introduction to Personal Computer

Displaywrite

Lotus Freelance Plus

Lotus 1-2-3 Part 1

Blueprint Workshop (parts 1, 3, 4, 5)

Sealing

V-22 Orientation

Previewed Videotapes

Boeing Engineering Standards Training

Basic Composite Familiarization

Graphite Composite Fabrication Phase I

Graphite Composite Fabrication Phase II

Tool Making

Gerber Cutting

Platten Press

Autoclave

Water Jet

PATLM

Nondestructive Testing

Composite Assembly

Orientation on Advanced Development Techniques

Attachment 3

DELAWARE COUNTY COMMUNITY COLLEGE
Media, Pennsylvania 19063

Composites Manufacturing Technology Advisory Committee

Mr. James D. Campbell, III
Manufacturing Technology Manager
E. I. DuPont de Nemours Company
101 Beech Street
Wilmington, DE 19898

Mr. George R. Carlson
Senior Manager of Employee Training
Boeing Helicopter Company
P. O. Box 16858
Philadelphia, PA 19142

Mr. Glenn Ford
Warminster Fiberglass
P. O. Box 188
Southampton, PA 18966

Dr. Roy Henrichsen
Sr. Process Development Engineer
General Electric Astro-Space Division
P. O. Box 8555
Philadelphia, PA 19101

Mr. Joseph P. Hess
Applications Manager
Composite Structures
Bentley-Harris Mfg. Company

Mr. Richard R. Lacovara
Comtech Associates
685 Gerhart Lane
Telford, PA 18969

Mr. Andrew Peoples
Vice President of Sales
Starlite Industries, Inc.
1111 Lancaster Avenue
Rosemont, PA 19010

Dr. Dick Wilkins
Director of Center for Composite Materials
University of Delaware
201 Spencer Laboratory
Newark, DE 19716

Attachment 4

COMPOSITE MATERIALS TECHNOLOGY

Associate Degree Program

PROGRAM DESCRIPTION:

The Associate Degree Program, a two-year technological offering, gives students expertise in composite fabrication and procedures and prepares them for employment as technicians, inspectors, and sales representatives.

The program is structured to include an understanding of the materials and the fabrication, testing, and application of thermosetting and thermoplastic composites.

Upon completion of the degree requirements, students have the option of continuing their educations or applying their technological skills for employment in the composites manufacturing field.

PROGRAM OBJECTIVES:

After graduating, the student should be able to:

----Identify, differentiate, and specify materials and manufacturing techniques used in the fabrication of thermosetting and thermoplastic composites.

----Demonstrate proficiency in using tools and instruments for the fabrication of composite parts.

----Recognize all the regulations and requirements for the safe handling and disposal of composite materials.

----Propose and apply nondestructive testing methods and procedures for the evaluation of composite materials and structures.

DELAWARE COUNTY COMMUNITY COLLEGE
COMPOSITES MANUFACTURING TECHNOLOGY

First Semester	Credits
English Composition I ENG. 100	3
Technical Mathematics I MAT. 110	4
*Materials Science TME. 110	3
*Composite Materials CMT. 100	3
Technical Drawing TDD. 124	3
	16

Second Semester	Credits
English Composition II ENG. 112	3
Numerical Control I TME. 100	3
Computer-Aided Drafting TDD. 225	3
*Reading Composite Drawings CMT. 110	2
*Thermoset Composite Materials Fabrication CMT. 101	4
	15

Third Semester	Credits
*Thermoplastic Composite Materials Fabrication CMT. 102	4
Numerical Control II TME. 101	3
Robotics I TME. 200	3
*Applications of Reinforced Plastics CMT. 120	3
Technical Chemistry CHE. 100	3
	16

Fourth Semester	Credits
Humanities Elective	3
*Composite Materials Testing CMT. 103	4
Technical Physics I PHY. 100	3
Robotics II TME. 201	3
Social Science Elective	3
	16
Total Hours Required:	63

* New courses in composites described in Program Outline (Attach #4)

DELAWARE COUNTY COMMUNITY COLLEGE

PROGRAM OUTLINE AND OBJECTIVES

TME 110

Materials Science

Course Objectives:

A. The student will be able to identify and differentiate between the characteristics of:

1. Metals and nonmetals
2. Organic materials and inorganic materials

by correctly listing the different properties of the above categories.

B. The student will determine structures and properties of materials.

C. The student would select materials by recognizing those properties that make materials most suitable for specific applications.

D. The student will identify the structure of a composite and will correctly propose some applications.

Course Outline:

A. Define and determine structure of materials.

1. Metals and nonmetals

2. Minerals and ceramics

3. Organic materials including polymers

B. Determine properties of materials

1. Metals and nonmetals

2. Minerals and ceramics

Materials Science (continued):

3. Organic materials including polymers

4. Composites

C. Select proper materials according to properties and uses.

CMT 100
Composite Materials

Course Objectives:

A. The student will show his understanding of current composite technology by:

1. identifying matrix components, their properties, and their uses.

2. selecting proper reinforcements and giving examples of different applications.

B. The student would identify and evaluate commercial reinforced uncured materials based on specifications.

C. The student will present a method of combining matrix materials and reinforcements into composite structures by listing the advantages of the assembly.

D. The student will demonstrate his awareness of the principles of safety as applied to the use of composite materials.

Course Outline:

A. Overview

1. Background and historical development
2. Definition of composites

B. Matrix materials

1. Plastics
    a. Thermosetting plastics
    b. Thermoplastics

2. Other matrix materials

Composite Materials (continued):

C. Reinforcements

1. Type

a. Fiberglass
b. Graphite
c. Aramid
d. Other reinforcements

2. Form

a. Fabric and tape
b. Roving and chopped fiber
c. Filaments
d. Whiskers
e. Honeycomb

D. Fillers

E. Surface finish

F. Commercial semiprocessed intermediates

1. Prepreg
2. Molding compound

a. sheet
b. bulk

3. Filament and tape

G. Applications (including structures)

H. Auxiliary considerations

1. Handling and Storage
2. Safety
3. Quality Control

I. Miscellaneous

CMT 101

THERMOSET COMPOSITE MATERIALS FABRICATION

Course Objectives:

A. The student will identify and organize manufacturing procedures and correctly specify the requirements for processing thermoset composites.

B. The student will prove his competence in fabricating reinforced thermoset parts by constructing satisfactory samples using various materials and processes.

C. The student will differentiate between various repair techniques used for thermoset composite assemblies.

D. The student will ascertain his knowledge of tooling fundamentals by fabricating a sample tool.

E. The student will identify and distinguish between acceptable and unacceptable components and procedures by listing possible defects.

F. The student will prove his proficiency in the manipulation of various tools for forming, shaping, cutting and finishing composites.

Course Outline:

A. Tooling fundamentals

B. Materials selection

C. Processing

1. Layup procedures

a. Cutting

b. Manual Layup

c. Curing

2. Spray-up

3. Molding techniques

    a. Injection
    b. Compression
    c. Others

4. Pultrusion

5. Winding and Braiding

D. Machining

1. Assembly

2. Finishing

E. Defect and damage repair

CMT 102
Thermoplastic Composite Materials Fabrication

Course Objectives:

A. The student will identify and organize manufacturing procedures and correctly specify the requirements for processing thermoplastic composites.

B. The student will prove his competence in fabricating reinforced thermoplastic parts by constructing satisfactory samples using various materials and processses.

C. The student will differentiate between various repair techniques used for thermoplastic composite assemblies.

D. The student will ascertain his knowledge of tooling fundamentals by fabricating a sample tool by systematically selecting the correct material and procedure required for using the tool.

E. The student will identify and distinguish between acceptable and unacceptable components and procedures by listing possible defects.

F. The student will prove his proficiency in the manipulation of various tools for forming, shaping, cutting, bonding and finishing composites.

Thermoplastic Composite Materials Fabrication, CMT 102 (Continued)

Course Outline:

A. Tooling fundamentals

B. Materials selection

C. Processing

1. Forming

a. Vacuum
b. Blow
c. Pressure

2. Molding

Injection

3. Casting

D. Machining

1. Assembly

2. Finishing

E. Defect and damage repair

CMT 103
Composite Materials Testing

Course Objectives:

A. The student will distinguish between the techniques of the standard tests (destructive) and non-destructive test procedures.

B. The student will prove his competency by selecting the best techniques for evaluating composite assemblies.

C. The student will correctly interpret test results and apply this information to formulate acceptable quality control standards.

Composite Materials Testing, CMT 103 (Continued)

Course Outline:

A. Understand the principles and procedures of nondestructive testing.

1. Principles of nondestructive testing
2. Ultrasonic tests
3. Radiographic tests
4. Optical inspection
5. Acoustic emission tests
6. Other tests

B. Understand the principles and procedures of destructive testing.

1. Principles of mechanics
2. Tensile tests
3. Shear tests
4. Tear tests
5. Chemical resistance tests
6. Microscopic examination
7. Impact tests

DOCUMENT: TME110 - April 21, 1988. (Separate Disk).

Attachment 6

COMPOSITE MATERIALS FABRICATION

Certificate of Proficiency Program

DESCRIPTION:

The Composite Materials Fabrication Certificate Program is designed to offer instruction in specific skills necessary to use advanced composite materials for the fabrication of parts and structures using current manufacturing procedures. The one-year program is structured to include the processing of reinforced thermoset and thermoplastic materials.

Upon completion of the certificate program, the candidate will be qualified for placement in the reinforced plastics industry or would be able to continue on for an Associate Degree.

PROGRAM OBJECTIVES:

Upon successful completion of the certificate program, the student will:

1. Correctly identify and apply materials to be used in composite fabrication.

2. Demonstrate proficiency in using tools and instruments for the fabrication of composite products by forming, molding, laminating, curing, finishing and repairing.

3. Recognize all the regulations and requirements for the safe handling and disposal of composite materials.

CERTIFICATE OF PROFICIENCY

1st Semester	Credits
Technical Math I MAT. 110	3
Composite Materials CMT. 100	3
Thermoplastic Composite Fabrication CMT. 102	4
Basic Technical Skills TME. 115	3
Technical Drawings CMT. 110	3
	16

2nd Semester	
English Composition I ENG. 100	3
Thermoset Composition Fabrication CMT. 101	4
Composite Materials Testing CMT. 103	4
Reading Composite Drawings CMT. 110	2
Elective	3
	16

Total 32 Credits

Attachment 7

DCCC COMPOSITE LAB

April 29, 1988

THE FOLLOWING ITEMS ARE A LISTING OF MAJOR EQUIPMENT NECESSARY TO OUTFIT A SHOP (LAB) FOR STUDENT PROJECTS IN A GENERIC COMPOSITE COURSE:

A. FY 87-88 equipment which has been funded and is now being purchased:

ITEM I.	Horizontal, Chest Type Industrial Freezer	Compartment Dim. 67"L x 19"W x 30"H (22 cu. ft.) Temp. range +70 Deg. F to -40 Deg.
ITEM II.	Vacuum Pumps and Mounting Carts	Welsh, high vacuum, high capacity, "V" belt, electric motor driven 115VAC with push button switch box on cart.
ITEM III.	Injection Molding Machine	20 Ton, pneumatic, floor model, 2 oz injection shot, full range (4") clamp stroke, takes 8 x 8 DME type mold base.
ITEM IV.	Air Compressor & Air Delivery System	5HP LeRoi Dresser, 20 CFM 100 psi, 80 gal receiver, 220 Vac 3 phase.
ITEM V.	Hot Air Circulating Curing Oven, Floor Standing	Chamber Dim. 60"H x 36"D (45 Cu. Ft.) Temp. to 450 deg. F
ITEM VI.	Binks Paint Arrestor Filter Spray Booth	Working Dim. 84"H x 92"W x 72"D constructed of 18 ga galvanized steel panels with exterior flanges that bolt together.

DCCC COMPOSITE LAB

ITEM VII.	Heated Platten Press	2T WC Hydraulic Press, 30 tons pressure, 600 degrees F. electrically heated, water cooled 15" x 15" platten size 220V standard
ITEM VIII.	Ultrasonic Plastic Welder	P.E. 800 Watt Ultrasonic Plastic Welder 110 volts AC

B. The following major items are required in the fiscal 88-89 vear to further equip the Laboratory for composite fabrication and testing:

ITEM I.

1 Each
Ultrasonic test system
for instructing C-Scan
and thickness measurements
when evaluating thermoplastic
and thermosetting materials and structures

(1 ea.) Ultrasonic Flaw Detector & Thickness Tester

(3 ea.) Zip Ultrasonic Transducers 0.5 mHz 1.0 in element dia.
Product Code D-560-130

(3 ea.) Delay lines, 1.0" dia product code D-071

(3 ea.) BNC-BNC CBL. ASSY
Product Code C-016

ITEM II.

1 Each
Tensile Test System
For use in teaching mechanical
properties of thermoplastic and
thermoset materials and structures

(1 ea.) 5000 lb cap. loadcell,
P/N 70HF5000/70LC5000

(1 ea.) Screw Action Vise Grips
P/N 70HT39

(1 ea.) Screw Action Vise Grips
P/N 70HT40

(1 ea.) Flatbed X-Y recorder
P/N 70710E

ITEM III.

1 SET - Molds and tooling: Assorted molds and tools are required in conjunction with the platten press, injection molding machine and the convection oven to teach students the various methods of fabrication of composite parts by pressing, molding, shaping, winding and laying-up. These are fabricated from metal or plastic that can withstand the high temperature and pressure used in making fiberglass, graphite, and aramid reinforced thermoset and thermoplastic structures. Molds and tools are not standard off-the-shelf items and have to be designed by our staff and contracted to a moldmaker.

Parts and labor

ITEM IV.

1 lot of tooling to be used in instructing students to fabricate and assemble plastic parts, to include:

(1 ea.) Power Saw, 18500 RPM
with vacuum attachment

(2 ea.) Routers with vacuum
attachment

(1 ea.) Zephyr Surface Shaver

(2 sets) of special graphite tools
to consist if drillbits,
reamers and countersinks
(in high speed steel,
PBS Diamond Faced, and Tung-
sten/carbide faced)

(2 sets) Shop tools

ITEM V.

Filament winding and tape winding equipment with CNC interface to be designed and constructed by our staff. Consists of one each:

1. A 3-axis mechanical system with a driven mandrel and support equipment to deliver filaments of fiberglasss, graphite or aramid, or which can be modified for layers of prepreg tape.

2. Dip tank for resin bath.

3. Metering and gauging equipment.

4. Infrared curing lamps.

5. Interface for making the whole procedure automated.

ITEM VI.

1 Each
Sprayup Equipment

Fiberglass and polyester chopper and spray system needed to track the widespread application of making fiberglass structures. System is used in conjunction with the spray booth.

ITEM VII.

1 Each
Ultrasonic knife - 300 W, 40 KH

Ultrasonic knife with replaceable fixed blade coupler. Ten extra blades included - 115V ac with adjustable power. Model #Sh-340, Powersonics, Inc.

ITEM VIII.

1 Each
CAD/CAM SYSTEM

To be used for instruction in design and development techniques of tooling for thermoplastic and thermosetting structures, and to include:

DCCC COMPOSITE LAB

(1 ea.) IBM PS/2 Model 80 System Unit, P/N 8580-071
(1 ea.) Math Co-processor MIII, P/N 8270
(1 ea.) Second 70 meg. fixed disk, P/N 3051
(1 ea.) IBM PS/2 1.44 meg. diskette Drive P/N 3057
(1 ea.) IBM PS/2 color display 8513, P/N 8513-001
(1 ea.) IBMPC DOS 3.3 P/N 628-0060
(1 ea.) IBM Operating System/2 Version 1.1
(1 ea.) HP Laser Printer, HP Model 2686M
(1 ea.) PC Mouse for IBM PS/2 Model 80

C. Additional Materials and Supplies Required for Fiscal Year 1988-1989:

Prepreg Materials (woven and nonwoven cloth and tape)

Fiberglass
Graphite
Kevlar
et. al.

Vacuum Bagging Components

Breather cloth
Bagging film
FEP (perforated and nonperforated)
Release film

Tooling Materials

Graphite } Mat and woven
Fiberglass } reinforcement
Epoxy

Molding Compounds

DOCUMENT: COMPLAB7, 4/29/88, (separate disk).

Attachment 8

BIBLIOGRAPHY OF BOOKS IN FACILITY LIBRARY

Handbook of Composites, George Lubin (Ed). Van Nostrand Reinhold Book Co., New York, NY (1982)

Composites: A Design Guide, Terry Richardson. Industrial Press, N.Y., N.Y. (1987) (Probable textbook for CMT 100)

Fiber Reinforced Composites: Materials Manufacturing and Design, P.K. Mallick. Marcel Dekker, Inc., New York, NY (1988)

Encyclopedia of Composite Materials and Components, M. Grayson, (Ed). John Wiley and Sons, New York, NY (1983)

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Fabrication of Composite Materials Source Book, M.M. Schwartz (Ed) ASM Metals Park, OH (1985)

Carbon Fibers: Technology, Uses and Prospects, The Plastics and Rubber Institute of London, England (Ed), Noyes Publications, Park Ridge, NJ (1986)

Composite materials, Testing and Design, Seventh Conference, J.M. Whitney (Ed). STP 893, ASTM, Philadelphia, PA (1984)

Applications of Composite Materials, M.J. Salkind and G.S. Holister (Eds). STP 524, ASTM, Philadelphia, PA (1973)

Effects of Defects in Composite Materials, ASTM Editorial Staff. STP 836, ASTM, Philadelphia, PA (1984)

Materials Analysis by Ultrasonics: Metals, Ceramics Composites. A. Vary (Ed), Noyes Data Corporation, Park Ridge, NJ (1987)

Tough Composite materials, Recent Developments, NASA Langley Research Center. Noyes Publications, Park Ridge, NJ (1985)

Basic Physics in Diagnostic Ultrasound J.L. Rose and B.B. Goldberg. John Wiley & Sons, New York, NY (1979)

Ultrasonic Nondestructive Testing Laboratory Experiments Manual, J.L. Rose and Y.H. Jeong, Drexel University (1984)

General Dynamics Nondestructive Testing Series of Programmed Instruction Handbooks.

PL4-1	Introduction
PL4-2	Liquid Penetrant
PL4-3	Magnetic Particle
PL4-4	Ultrasonics Vol. 1, II, & III
PL4-5	Eddy Current
PL4-6	Radiographic Testing Vol. I, II, III, IV, V.

General Dynamics Testing Series of Classroom Training Handbooks

CT6-2	Liquid Penetrant
CT6-3	Magnetic Particle
CT6-4	Ultrasonic
CT6-5	Eddy Current
CT6-6	Radiographics

VIDEOS

"Spate 9000" Ometron Corporation's NDT Series, Infrared Imaging for Composite Flaws.

"Manufacturing Insights #7: Composites." SME, Dearborn, MI

"Diatrim Tools"

"Large Boat Hulk Construction with the Venus Impregnator"

"Elas-Craft ISD-II and LPA-II Tooling"

"Operation of Venue H.I.S. Choppers and Gelcoaters"

"Hydrajector in Production," Venus Products

PERIODICALS

"Polymer Composites," Society of Plastics Engineers

"Journal of Composites Technology and Research," ASTM

"Plastic Engineering," Society of Plastics Engineers

"Plastics Technology," Bill Communications, Inc.

SLIDE PRESENTATIONS

"Advanced Composite Materials and Practices"

Attachment 9

REFERENCE ARTICLES IN FACILITY LIBRARY

Blake, Robert A., Jr., "Robotic NDE and Ultrasonic Image Processing," Composite Workshop Paper, University of Delaware, May 16, 1986.

Brill, R. A., "The Future Evolving - Starship 1," COGSMF EM86-707, pp 1-16.

Browning, C. E., "Quality Assurance and Composite Processing I and II," Composite Workshop Paper, University of Delaware, May 14, 1986.

Deckert, C. A., "Chemistry and Laminates," P. C. Fab, April 1985, pp 30-58.

Eshbaugh, R. W., "Upgrading Mechanical Filament Winding Machines with Computer Controls," SPI 41st Annual Conference January 1986, pp 3B(1-4)

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Massey, M. L., "Epoxy Resin Laminating Technology," PC. Fab December 1984, pp 14-20.

, "New Structure Materials Technologies - Opportunities for the Use of Advanced Ceramics and Composites," U. S. Congress (1986) pp 43-71.

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Attachment 10

PROFESSIONAL ORGANIZATIONS

1. American Association for the Advancement of Science
2. American Chemical Society
3. Society of Plastic Engineers
4. Society for the Advancement of Materials and Process Engineering
5. Composites Groups of the Society of Manufacturing Engineers.