Great Lakes

Pre-Apprenticeship Center of Excellence

Technical Program

Program Overview: The pre-apprenticeship program sponsored by Bay Mills Community College & Great Lakes Composites will provide exposure and fundamental training to individuals considering careers in the advanced manufacturing industry. BMCC is positioned as an educational institution to sponsor the pre-apprenticeship program through Great Lakes Composites as an advanced manufacturing entity of the college. Students of this program will be taught the essential skills and work ethics deemed critical by employers in preferred candidate qualifications for hiring.

The program is also structured to provide a broad knowledge base of training within key elements of advanced manufacturing using the vehicle of plastics & composites to achieve this and better preparing students for higher technical career opportunities. A major component of the program is industry support through future endorsement, technical program participation and alignment of students with industry partner job opportunities.

Tuition: No cost for the training program

Instructors: GLC Staff, BMCC Faculty, Industry SME's/Lecturers

Locations: Great Lakes Composites; Bay Mills Community College Main Campus

Pre-Requisites: High School Diploma or GED

Instructional Materials: The majority of the program training content will be from instructor prepared lecture material. Supplemental text and additional reference information will be recommended or provided during each course.

Credits: Credits are not offered for the program. Completion certificate from BMCC

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Training Schedule Fall 2019

Essential Skills for Job Success (3 CR eq. 9/3-9/13)

- Working with Others-Teamwork
- Presence in the Workplace
- Confidence Building & Self Awareness
- Requirements/Preparedness for Job Opportunities
- Writing and Communications
- Time & Resource Management
- Regulatory Awareness and Compliance
- Cognitive, Critical and Creative thinking
- Math and Computer Skill Fundamentals

Environmental Health & Safety in Industry (3 CR eq. 9/16-9/27)

- Working in Industrial Environments
- Industrial Personal Protection Equipment (PPE)
- Levels of Safety
- Basics of LOTO & Corrective Actions
- Workplace Cleanliness and 5S
- Accident & Injury Statistics
- Classification of Workplace Hazards
- OSHA Compliance
- Employee & Employer Responsibilities

Fundamentals of Materials (4 CR eq. w/lab 9/30-10/25)

- Material Structures & Classifications
- Properties & Material Characterization
- Effects of Processes on Properties
- Material Performance & Selection
- Material Innovation in Metal, Ceramics and Plastics

Quality (4 CR eq. w/lab 10/28-11/22)

- Metrology methods-Contact & Non-Contact
- Measurement Accuracy, Precision and Calibration
- Statistics for Measurement Confidence Level & Error
- 5S, Measurement, Normal Distribution,
- Gauge R&R
- Quality tracking – incoming/outgoing, QC/QA
- Run Charts
- X-bar and R charts
- SPC Tools
- Quality within Industry & the Workplace

Casting – *Crucible furnace/casting forms* (2 CR eq. 11/25-12/06)

- Casting Safety
- Mold Parts and Design
- Green Sand Casting
- Lost Foam Casting
- Other Casting Techniques
- Casting Prep and Finishing
- Post Machining Requirements
- 3D Metal Sintering (SLS)
- Applications & New Technology

Bulk Metal Forming (2 CR eq. 12/09-12/20)

- Roll Processes
- Forging - Open/Closed Dies, Orbital
- Extrusion-Hot/Cold
- Powder Metal Forming
- Metallurgical, Temp & Pressure factors

Training Schedule Winter 2020

Sheet Metal Forming (3 CR eq. 1/13-1/24)

- Fundamentals of Deformation
- Basics of sheet metal coil supply
- Stamping
- Blanking
- Punching
- Deep Draw
- Sheet Metal Forming Dies-Single/Progressive
- Aluminum vs Steel
- Applications & New Technology

Machining/Subtractive Manufacturing (4 CR eq. w/lab 1/27-2/21)

- Machine Shop Safety
- Manual metal removal processes – Lathe, Vertical Mills, Drill presses, Surface Grinding, EDM
- Principles of CNC, CAM & GD&T
- Tooling/Cutting tools
- Machining parameters-RPM, travel speed, cut…
- Tool Wear
- Non-Metal Applications

Methods of Joining & Assembly (4 CR eq. w/lab 2/24-3/20)

- Welding Safety & Standard Practices
- Sample/material Preparation
- Oxy/Acetylene Gas Welding
- Arc Welding
- MIG/TIG Welding
- Specialty Metal Welding
- Robotic welding
- Methods of Mechanical Fastening
- Adhesive Bonding Technology
- Ultrasonic & Vibration Welding
- Applications & New Technology

Introduction to Plastic & Composite Mfg (5 CR eq. w/lab 3/23-5/8)

- Thermoplastic & Thermoset Forms-Basic Chemistries
- Extrusion/Compounding/Continuous Fiber
- Compression Molding
- Injection molding
- Thermoforming
- Blow Molding
- Roto Molding
- Composites
- Testing methods
- Applications & New Technology

Advanced Manufacturing Special Topics Workshop Training Modules

- 3D Scanning & Reverse Engineering-Advanced
- Universal Physical Test Systems-Advanced
- CAE-FEA Basic
- CAD- Creo Parametrics & Solid Works Basics
- Plastics/Composites Testing Methods-Advanced
- Robotics Programming-Basics
- Composite Fabrication-Advanced
- Compression & Injection Molding-Advanced

COURSE TITLE: **Essential Skills for Job Success**

DATES: 9/3/2019 through 9/13/2019

LECTURE/LAB HOURS: 40/0

COURSE DESCRIPTION:
The course is intended to engage students on the importance and practice of fundamental "soft" skills which are the primary success factor in professional and personal relationships. We frequently use the term "soft" because they are more difficult to quantify however it has been long established in studies of successful and fulfilling careers that 75% of long term job success is due to soft skills and 25% from technical "hard" skills. Secondly, soft skills define our social intelligence vs quantitative intelligence. Employers value both with a majority emphasizing what defines us as human beings and not machines.

The class is highly interactive and designed to initially assess the student's current strengths and weaknesses within nine areas to establish both a baseline profile and provide specific training areas for higher proficiency upon completion of the course;

- Working with Others-Teamwork
- Presence & Professionalism in the Workplace
- Confidence Building & Self Awareness
- Requirements/Preparedness for Job Opportunities
- Writing and Communications
- Time & Resource Management
- Regulatory Awareness and Compliance
- Cognitive, Critical and Creative thinking
- Math and Computer Skill Fundamentals

The greater benefit from the above to both the employer and employee is an ideal long term relationship building goal defined by 8 pillars to strive for including; leadership potential, communication excellence, recognition & reward, positive workplace culture, personal & professional growth potential, accountability & performance, vision & values and social responsibility.

COURSE DELIVERABLES:
- Communication – oral speaking capability, written, presenting, listening, clear speech & writing.
- Courtesy – Respect of others & business etiquette
- Flexibility – adaptability, willing to change, lifelong learner, accepts new things, adjusts, teachable.
- Integrity – honesty, ethics, morals, personal values, do what is right!
- Interpersonal skills – nice, personable, sense of humor, friendly, nurturing, empathetic, self-control, patient, sociability, warmth, social skills.
- Positive attitude – optimistic, enthusiastic, encouraging, happy, confident.
- Professionalism – businesslike, well-dressed, appearance, poised.
- Responsibility – accountable, reliable, gets the job done, resourceful, self-disciplined, wants to do well, conscientious, common sense.
- Teamwork – cooperative, gets along with others, agreeable, supportive, helpful, collaborative.
- Work ethic – hard working, willing to work, loyal, initiative, self-motivated, on time, good attendance.

COURSE TITLE: **Environmental Health & Safety within Industry**

DATES: 9/16/2019 through 9/27/2019

LECTURE/LAB HOURS: 24/8

COURSE DESCRIPTION:
Environmental Health & Safety is the number one priority in the workplace and a mutual responsibility of the employer and employee. In this course students will be trained in all aspects of industrial EH&S including 1) types of industry environments (e.g. office, laboratory, manufacturing…); 2) Levels of safety (engineered, protective, preventative); 3)Hazard classifications; 4) Accident injury frequency and severity statistics; 5) Accident treatment and emergency response; 6) Procedures for corrective action; 7) Cost & impact of injuries; 8) Workplace cleanliness & 5S practices; 9) Regulatory compliance; and 10) Employer & employee rights/responsibilities. Students will benefit in understanding what to expect in the workplace and as an employee, the responsibilities both they and their employer have to insure a safe work environment.

COURSE DELIVERABLES:

- Knowledge of industrial environments that would be acceptable as a factor in considering job opportunities.
- Realization that EH&S programs are an indicator of a potential employer's commitment and concern to the employee.
- Demonstration of proactivity and engagement as an employee in pre-preparing in EH&S training
- Knowledge in use and appropriate application of PPE as a protective level of safety
- Understanding of the differences between engineered, protective and preventative safety
- What are corrective actions (e.g. lock out-tag out) and how/when are they implemented
- Proficiency in explaining benefit of basic preventative measures (e.g. 5S, cleanliness, ergonomics, organization…)
- Awareness in accident/injury statistics (frequency/severity) and overall cost/other impacts
- Ability to classify workplace hazards and apply appropriate levels of safety practices
- Competency in understanding EH&S regulatory compliance importance & governing organizations
- Understanding the role of both the employee & employer in supporting EH&S as a key quality management system element

COURSE TITLE: **Fundamentals of Materials**

DATES: 9/30/2019 through 10/25/2019

LECTURE/LAB HOURS: 40/20

COURSE DESCRIPTION:
The fundamentals of material science are based on the disciplines of physics and chemistry. It's development and growth which began in the early 1900's in pursuing new discoveries and applications through engineering is considered one of the most significant drivers for technical innovation in the last century. It's referred to as the "field of dreams" in 21st century academic research. This course covers the basic concepts of material science in understanding the relationship between the structure and properties of materials including metals, ceramics/glass, polymers, wood and composites.

Material classifications are first presented as a method to manage the complexity of structural forms that exist today. The concepts of crystalline vs amorphous materials, organic vs inorganic and physical phases of materials (solid, liquid & gas) are expanded to explain the mechanisms of chemical and physical bonding at the atomic/molecular level that differentiate materials and determine many of their properties (e.g. metal ductility via covalent bonds vs ceramic brittleness due to ionic bonds, carbon vs diamond lattice structure change) at the macro level. Students will gain further insight with lab based microscopy visualization analysis and a broad range of material types represented.

Material Properties are reviewed extensively both in what characterizes a material and how the properties are measured. Although material properties are considered "inherent", the importance of how materials respond to external factors (e.g. light, electricity, heat, force) is emphasized in understanding that material properties are a response measurement. Dedicated lab time will be given in demonstrating and training students in how to conduct material characterization testing including, physical testing (strength, stiffness, strain, elasticity, hardness/durometer), thermal analysis (TGA, CTE), conductivity, spectroscopy (chemical content), fracture toughness, wear, moisture absorption, material flow and mass/density/specific gravity properties.

The last section of the course explains how processes modify material properties and can be engineered to create new materials and new applications. Laboratory based demonstration using composites will illustrate how process parameters can be modified in a controlled manner to improve physical strength properties.

COURSE DELIVERABLES:
- Ability to explain how materials are classified with respect to their structure and relate that to the effect on material properties.
- Knowledge of what are the types of material properties that are used for characterization/identification and methods for testing these properties.
- Awareness of how processes can modify material properties to enhance performance as well as the importance of engineering properties to meet a given product application.

COURSE TITLE: **Measuring Quality-Product & Process**

DATES: 10/28/2019 through 11/22/2019

LECTURE/LAB HOURS: 40/20

COURSE DESCRIPTION:
The course teaches what product quality means in manufacturing and how it is measured. A simple definition of quality is "fit for purpose" which describes conformance to expected performance requirements. The science of measurement or "metrology" provides the technical principles and methods to quantify quality.

Beginning with the basic overlapping disciplines of scientific, industrial and "legal" metrology, the types of measurement units are covered including concepts/definitions of accuracy, precision, calibration, dynamic range and traceability. Basic and advanced contact & non-contact metrology tools are reviewed. The first lab session will demonstrate these concepts and how proper measurement methods consider these factors.

In the next phase of the class, measurement statistics are introduced. The overall objective in assessing quality is quantifying how accurate the measurement is (closest approximation to expected or known value) as well as the confidence level in the measurement. First discussed is the importance of sampling and having a representative measurement population of the product you are studying. The second principle affecting accuracy and confidence in measurement is "uncertainty". These relate to both the variation in the product as well as variation in how it is measured. Understanding these two types of variation provide both confidence levels and uncertainty bounds through the principles of ANOVA. Students are not expected to have in-depth knowledge of these theories, however will be seeing in laboratory demonstration how they influence the validity of measurements.

How to measure and minimize variation in manufacturing is presented in detail as the primary factor leading to poor quality products. Statistical Process Capability and the methods used for monitoring manufacturing are demonstrated by example in how quality issues are diagnosed and corrected using the 7 QC quality tools of industry as well as methods of continuous improvement to increase the level of quality (e.g. DFSS, DFM).

Quality in the broader scope of business/industry impact is discussed as a corporate goal influencing cost, product price, value and overall growth dynamics. The importance of Quality Management Systems (QMS) is also described as a fundamental structure within corporations today.

COURSE DELIVERABLES:
- Basic understanding of how metrology quantifies product quality and the types of metrology methods used within industry
- Proficiency in conducting measurements with awareness in measurement variables that affect the goal of high accuracy with high confidence.
- Use and practice of the basic principles in statistics and how confidence levels and uncertainty are established in industrial metrology measurements for assessment of quality.
- Ability to apply the 7 QC tools in industry as they apply to manufacturing processes to maintain quality target performance. Awareness of continuous improvement methods/tools utilized for increasing product quality.
- Cognizance of the impact of overall quality as it relates to business performance metrics

COURSE TITLE: **Casting Technologies**

DATES: 11/25/2019 through 12/6/2019

LECTURE/LAB HOURS: 32/0

COURSE DESCRIPTION:
Casting offers a manufacturing method that can produce complex and organic shapes difficult if not impossible by other methods. The course is comprised of understanding the basic process, types of casting molds/processes, common metal/non-metal materials used, pre-mold machining, secondary manufacturing/post casting requirements, applications as well as new technologies emerging in the industry.

The casting process concept is simple in introduction of a liquid material into a hollow cavity with subsequent solidification and removal. Various materials including thermoset/thermoplastic resins, concrete, plaster, clay and metals are used. The focus in this class is metals starting with the molten state crucible furnace operating conditions (e.g. temperature, gas environment), types of metals used (aluminum, iron/steel, magnesium and copper) and proper alloying/ladle chemistries to achieve high quality cast parts.

Two types of casting mold classes will be covered; Expendable and non-expendable. Expendable systems include sand, plaster, shell, waste mold, investment, evaporative/lost foam and full mold. Non-expendable systems range from permanent mold, die cast, semi-solid metal, centrifugal and continuous castings. Types of sprue/runner fill design along with the use of gravity, vacuum and low pressure flow techniques are introduced.

There are two stages in casting that require other machining operations. The first is the mold cavity shape and surface. This is explained in detail through historic methods as well as today's approaches using CAD/CAM/CNC/CIM to create the mold. The second post-casting operation referred to as "fettling" (removal of anomalies or other imperfections occurring during the casting) is also addressed in how modern automated methods reduce this time consuming process.

With respect to new technologies; the use of high pressure castings for decreased porosity and higher complexity shape applications, thin wall castings for lightweight components and advancement of 3D metal sintering methods reducing casting mold fabrication costs and lead times is presented.

COURSE DELIVERABLES:
- Basic understanding in how the casting process works including types of metals used, methods of material fill/flow, expendable vs non-expendable mold constructions
- Knowledge of pre & post operations for the mold & cast part, methods for fabricating molds and casting technologies (HPC, TWC & sintering) with higher quality, lower weight and increased complexity shape applications.

COURSE TITLE: **Bulk Metal Forming Manufacturing Methods**

DATES: 12/09/2019 through 12/20/2019

LECTURE/LAB HOURS: 32/0

COURSE DESCRIPTION:
Among traditional and advanced manufacturing methods, bulk metal forming processes are recognized as highly effective methods to achieve hardness, strength and stiffness from simple base metal chemistries and structures. It continues to re-invent itself. The course first addresses the physics that describe basic principles including effect of the surface area/volume ratios, compatible pre-mold metallurgical states/ladle chemistries, temperature, stress states during molding and interfacial friction factors.

The main processes covered and summarized in the following sections include roll forming, extrusion, forging and powder metal techniques. Each of these processes subjects the raw billet or bulk metal to a combination of compressive, tensile or shear stresses either in a cold or hot condition to force a final shape with superior physical properties to that of the base metal through work hardening and in some cases phase transformation.

Roll forming is a compressive & bending deformation process. It is considered the lowest cost method and is used for producing semi-finished products such as bars, sheets, plates and finished products such as angles, channels and sections. Roll forming can be carried out in both hot or cold metal states as a continuous process.

Forging is conducted in either open or closed dies as flat or shaped pairs respectively. Coining and orbital forging are variants of this method. Forging imparts a significant amount of work-hardening increasing hardness and temper.

Direct & Indirect Extrusion involves forcing the raw material through a narrow opening of constant cross-section or varying cross-section in order to reduce the diameter and increase the length. Extrusion can be done hot or cold. Extruded products include shafts, tubes, cans, cups, gears. Basically there are two methods of extrusion, forward and backward extrusions. In forward (direct) extrusion the work and the extrusion punch move along the same direction. In backward (indirect) extrusion the punch moves opposite to the direction of movement of the work piece. Wire drawing is a form of indirect extrusion.

Powder forming is gaining importance due to its unique capabilities. One of the unique merits of powder forming is its ability to produce parts very near to final dimensions with minimum material waste. It is called near-net-shape forming. Material compositions can be adjusted to suit the desirable mechanical properties. Formability of sintered metals is greater than conventional wrought materials. However, the challenge in powder forming continues to be the complete elimination or near-complete elimination of porosity. Porosity reduces the strength, ductility and corrosion resistance and enhances the risk of premature failure of components.

COURSE DELIVERABLES:
- Fundamental knowledge gained in the use/benefits of bulk metal forming as low cost metal process methods to achieve superior physical properties.
- Thorough understanding of what metals can be used in bulk forming and the material properties & process parameters which must be considered in specific applications.
- Proficiency in being able to differentiate, rolling, forging, extrusion and powder metal techniques as they relate to process conditions, die design and types of products made.

COURSE TITLE: **Basics of Sheet Metal Fabrication & Forming**

DATES: 1/13/2020 through 1/24/2020

LECTURE/LAB HOURS: 28/12

COURSE DESCRIPTION:
Sheet Metal Forming is considered the largest industry in metal working applications. It offers the highest versatility in the material type, size and shapes of ferrous/non-ferrous metal products. It differs from bulk metal forming in requiring pneumatic or hydraulic presse for deformation, larger & more expensive tools and base metal supply requirements as processed coils, sheets or strips. The exception to this and addressed in the course is metal forming using bench brake press applications (e.g. HVAC, large sheeting, siding…). In general sheet metal forming uses a higher surface area to volume material shape than bulk metal forming.

The course first reviews prior "fundamentals of materials" concepts in elasticity with focus on material ductility and strength properties. Plastic deformation is significant in metal forming. Using the correct metal grade and alloy is also critical for a specific forming application. How metal sheet is produced and selected is explained. Particular emphasis is placed on the challenges of aluminum forming. A brief overview of press designs and requirements for stamping is presented.

Two major classifications of forming are covered. The first is stamping which using a coil or sheet blank material feed undergoing one (single die) or more than one (progressive die) shearing or bending operation with a punching tool and mating die surface to form the part shape. The terms punching, blanking, piercing, embossing and flanging fall under this classification as well. The second is deep drawing. It differs from stamping in how the punch contacts/deforms the material with respect to the force is applied and controlled modulation during the drawing process. Significant shear stress occurs in drawing operations which can lead to part thinning/stretch and unacceptable wall surfaces.

The metal forming "tool & die" industry was the first to implement CAD/CAM in manufacturing. A single tool can contain hundreds of parts that are quite complex and must be precise with respect to proper clearances/tolerances. The methods & benefits of the CAD/CAM process are covered in detail within the course in design of single, progressive, fourslide and deep draw tools. New technologies in sheet metal forming are also discussed (e.g. gen3 UHSS, hybrid aluminum/steel coil, fluid forming, extended life & short run tooling).

COURSE DELIVERABLES:
- Awareness of how metal material properties control sheet metal forming methods and their suitability in specific applications (e.g. aluminum, DDS/DD/, UHSS,…)
- Ability to explain the primary and secondary operations of stamping and deep drawing methods
- Fundamental knowledge of single, progressive, fourslide and deep draw tool differences with respect to design as well as types of parts they can manufacture.
- Proficiency in describing the overall CAD/CAM process and its advantages in the design & development process.

COURSE TITLE: **Fundamentals of Machining & Subtractive Manufacturing**

DATES: 1/27/2020 through 2/21/2020

LECTURE/LAB HOURS: 32/28

COURSE DESCRIPTION:
In this course core machining processes/methods as the basis of subtractive manufacturing are presented in both lecture & lab. One definition of subtractive manufacturing is "the controlled removal of undesired materials through cutting, drilling or milling operations to achieve the desired form". The introduction of additive manufacturing processes usually described as rapid prototyping or 3D printing methods has not diminished the value of subtractive manufacturing within industry .

This class illustrates the complementary processes each with distinct advantages. Subtractive techniques are relied upon for functional prototyping as opposed to conceptual parts and products produced in 3D printing. This is due to the ability to manufacture the end use material, structurally integrated (not layered), greater accuracy/precision and representative surface finishes. High shape complexity at lower cost is more achievable through rapid prototyping. Industry today recognizes the two approaches working as hybrid processes.

Students will first become familiar with proper/safe hand tool use for cutting, drilling, sandind and grinding with metals, plastics and wood materiials. They will then receive training in the fundamentals of using vertical/horizontal mills, drill presses, lathes and surface grinding/finishing operations safely and how the processes vary with metal, wood and plastic materials. The effect of machining parameters including fixturing, cutting tool selection/wear, cutting speed, depth of cut, rotational speed, lubricant/heating factors and material removal methods will be demonstrated. The method of geometric dimension & tolerance (GD&T) checks during these operations will also be shown.

After gaining a firm understanding of the skills required for manual machining operations, concepts of how CAD, CAM, CIM, and CNC as computer based simulation & control tools automate the subtractive manufacturing process. Several CNC machining systems will be demonstrated to illustrate the overall process as well as manufacturing systems which hybridize subtractive/additive operations. Finally, applications and new technologies are reviewed.

COURSE DELIVERABLES:
- Firm understanding of the differences between subtractive and additive manufacturing capability and why they are used together in the machining industry as a hybrid
- Gain fundamental skills in the manual safe operation of mills, drills, lathes and grinders. Knowledge gained in what factors control/influence machining operations. Competency in conducting GD&T checks for QC/QA.
- Knowledge of how CNC based subtractive manufacturing automates the machining process and associated steps through computational simulation and control tools.

COURSE TITLE: **Methods of Joining & Assembly**

DATES: 2/24/2020 through 3/20/2020

LECTURE/LAB HOURS: 36/24

COURSE DESCRIPTION:
This course introduces the student to methods of welding, fastening and joining. Methods of attachment are categorized as permanent, semi-permanent or removable and the particular method chosen depends on the subassemblies being combined as well as requirements for subsequent inspection or repair. The course will include extensive hands-on training as well as lecture covering basic principles.

Beginning with welding, students will learn how to safely use basic cutting (plasma, oxyacetelene) and grinding tools used within welding applications. Training in shielded metal arc welding (SMAW), gas tungsten arc welding (TIG), gas metal arc welding (MIG) and oxyfuel gas welding will be conducted. Understanding weld integrity including heat affected zones, methods of testing and factors due to metal types (ferrous/non-ferrous) as well as fixturing/surface preparation will be presented. Additional welding technologies for specialty metals/alloys and plastics (vibration/friction and ultrasonic) are also covered.

The next two sections of the course cover fastening and joining methods with respect to mechanical attachment and bonding respectively. Primary function of bolted and threaded fasteners including spacing/number/depth, operating conditions, types of materials and modes of failure are described. Detailed fastener design criteria will also be discussed including principles of stress area, pitch diameter, thread type/form and pre-tensioning/pre-loading techniques. Rivet design, selection and fastening are demonstrated.

Adhesive bonding methods provide joining between components/subassemblies that have intimate surface contact and sufficient bond area. Metals, ceramics, wood, plastics and composites all use adhesive bonding technologies in product assembly applications for permanent attachment. First discussed are factors for successful adhesion including surface prep, surface area, mechanical surface roughness, compatible adhesive formulation for chemical bonding, surface energy, thickness of the substrate to the adhesive layer and modes of failure (cohesive, adhesive and mixed mode). Various types of adhesives are explained including PSA's, curing thermosets, thermoplastic resins and solvent/water based materials. Specific challenges in aluminum, plastics and other difficult to bond materials are addressed as well of the tradeoffs between adhesive bonding vs mechanical fastening with respect to strength.

COURSE DELIVERABLES:
- Competency in understanding traditional welding processes with a basic level of hands-on experience. Awareness of material differences which determine the type of welding process as well as factors to consider in good weld integrity.
- Proficiency in the application of mechanical fasteners in basic subassemblies/components with various material types. Ability to select the bolting/threading design that meets functional performance requirements through the fastener physical specifications. Basic understanding in the use of rivet applications.
- Awareness in what are the appropriate applications/criteria for use of adhesive bonding within metals, ceramics, wood, plastics based on factors that determine functional performance. Knowledge of critical preparation factors.

COURSE TITLE: **Introduction to Plastic & Composite Manufacturing**

DATES: 3/23/2020 through 5/8/2020

LECTURE/LAB HOURS: 40/32

COURSE DESCRIPTION:
The introduction of plastics in the early 1900's along with accelerated development since the 1960's has provided a material technology with applications that extend well beyond those of metals, wood and ceramics. The course is intended to increase the awareness and knowledge of students with respect to how plastics are manufactured and processed to create innovative products within industry.

First covered are general characteristics and differences between thermosets and thermoplastics as the two major material classifications. How plastics are made from polymers is described as well as physical, chemical and other property comparisons to traditional materials. The flexibility and ease to modify plastic properties through various chemical additives and other processes is explained in lecture and lab. Pre-molding steps including dispersion blending, continuous/vortex/paddle mixing, extrusion, and compounding are presented in lab & lecture.

Technologies presented in this section of the course cover additive manufacturing methods in molding explaining how plastic materials subject to pressure, temperature and time create finished products. Compression molding, injection molding, thermoform/vacuform molding, roto molding and RTM/RIM processes are explained in lecture as well as lab. Techniques in mold fabrication are discussed as well.

An in-depth presentation of composites is part of the course. The benefit of reinforcing plastic formulations with various forms of random and continuous fiber as well as other materials (via filler/embedding) combined with structural design construction strategies (multiple layer materials) is covered extensively. Methods of processing and fabrication are presented in lecture and lab.

The measurement of plastics and composites with respect to material characterization is essential for their acceptance within industry for product applications. Students will be trained in the fundamental testing methods used today including TGA, FTIR, Melt Flow, ASTM/ISO Physical Property testing, Drop Dart Impact, Hardness/Durometer, Mass/Density/Specific Gravity, microscopy, moisture and methods of flaw detection.

COURSE DELIVERABLES:
- Students will gain basic understanding of the two major classes of plastics, their material property differences and how they are used within products today.
- Methods two modify plastic properties through both chemistry and process are presented
- The molding technologies that are used as additive manufacturing methods is covered along with how molds are fabricated. Differences in each process are emphasized and how/why they are used for different types of plastic products
- The importance of composites and how plastics are reinforced is covered in depth. The addition of reinforcement materials as well as how they are constructed is demonstrated in lab and lecture.
- Methods of characterizing material properties of plastics and composites are demonstrated with students gaining a basic level of skill/understanding in how/why the specific material property tests are conducted.

SPECIAL TOPICS: **Advanced Manufacturing Training Workshop Modules**

DATES: Scheduled through Fall & Winter Semester-TBD

LECTURE/LAB HOURS: 2 full days per Module

3D Scanning & Reverse Engineering: Both structured white light and laser line scan methods are demonstrated in how to accurately acquire and generate 3 dimensional shape geometries as well as data files for metrology, QC/QA, CAD and 3D printing applications. The course covers the process of calibration, image acquisition, image alignment/integration, noise filtering, smoothing algorithms, "watertighting"/void correction, file output formatting and mesh decimation.

CAE-FEA Basics: The workshop presents Computer Aided Engineering Concepts/Methods used in industry including CFD, BEA, FEA, SEA, Topology Optimization and Generative Design. How to build (material properties, loads/constraints, model meshing) and analyze (statics, dynamics & thermal) a Finite Element Model from existing CAD models will be covered in detail.

CAD Basics: This module first reviews the basics in the 2D creation & interpretation of drawings including GD&T principles. Also covered is critical dimension analysis based on reverse engineering data. Both Solid Works and Creo Parametric platforms are used to demonstrate creation of sketch planes from dimensional data, methods of extrusion/surfacing to build the 3D solid body volume representation and techniques of featuring/detailing to complete the model. Model build/error checks for subsequent CAE, CAM or 3D printing applications are discussed.

Universal Physical Test Systems: The measurement of material strength, stiffness, modulus, compression/recovery, flex/bending, impact and related physical characteristics are presented in this training. The workshop will demonstrate ASTM/ISO testing protocols used in industry including test specimen preparation, test protocol conditions, data acquisition and data analysis.

Plastics & Composites Testing: This workshop extends the basic introduction of plastic and composite material testing within the training program to advanced techniques for material identification/characterization including DSC, SEM/EDX, mass chromatography, X-Ray diffraction, rheometry and environmental testing.

Composite Fabrication: Construction & applications of thermoplastic and thermoset composites are discussed and demonstrated including, resin & fiber types, methods of material fabrication, laminate structures, random vs continuous reinforcement and comparison of structural performance.

Compression & Injection Molding: The workshop demonstrates the process steps used in compression molding and injection molding including material blending, methods for material feed/ extrusion parameters and flow/molding temperature, pressure and dwell time factors.