

## STRUKTUR KURIKULUM PROGRAM STUDI TEKNIK METALURGI DAN MATERIAL

Kode MK 2016	Mata Kuliah	Subject	SKS			
			Kekhususan / Major		Fast Track	
	Semester 1	1st Semester	Manufaktur	Korosi	Manufaktur	Korosi
ENMT 8 0 1 001	Kinetika & Transformasi Fasa	Kinetics & Phase Transformation	3	3		
ENMT 8 0 1 002	Material Teknik	Engineering Materials	2	2		
ENMT 8 0 1 003	Metode Penelitian & Komputasi	Research & Computational Methods	3	3		
ENMT 8 0 1 104	Mekanika Material	Mechanics of Materials	3		3	
ENMT 8 0 1 205	Prinsip Korosi	Principles of Corrosion		3		3
		<b>Sub Total</b>	<b>11</b>	<b>11</b>	<b>3</b>	<b>3</b>
	Semester 2	2nd Semester				
ENMT 8 0 2 006	Disain & Pemilihan Material	Design & Selection of Materials	3	3		
ENMT 8 0 2 007	Karakterisasi Material	Material Characterization	3	3	3	3
ENMT 8 0 2 008	Praktikum Karakterisasi Material	Material Characterization Laboratory	1	1	1	1
ENMT 8 0 2 109	Manufaktur Lanjut	Advanced Manufacture	3		3	
ENMT 8 0 2 210	Korosi Lanjut	Advanced Corrosion		3		3
ENMT 8 0 2 211	Pelapisan & Inhibisi	Coating & Inhibition of Materials		3		3
	Pilihan	Elective	3			
		<b>Sub Total</b>	<b>13</b>	<b>13</b>	<b>7</b>	<b>10</b>
	Semester 3	3rd Semester				
ENMT 8 0 3 012	Analisa Kerusakan & Lab.	Failure Analysis + Laboratory	4	4		
ENMT 8 0 3 113	Metalurgi Las	Welding Metallurgy	3		3	
ENMT 8 0 3 114	Komposit Lanjut	Advanced Composites	3		3	
ENMT 8 0 3 215	Proteksi Katodik	Cathodic Protection		3		3
	Pilihan	Elective		3		
		<b>Sub Total</b>	<b>10</b>	<b>10</b>	<b>6</b>	<b>3</b>
	Semester 4	4th Semester				
ENMT 8 0 0 016	Makalah Penelitian	Research Journal	2	2	2	2
ENMT 8 0 0 017	Seminar Proposal Tesis	Seminar of Thesis Proposal	2	2	2	2
ENMT 8 0 0 018	Tesis	Thesis	6	6	6	6
		<b>Sub Total</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>
		<b>TOTAL</b>	<b>44</b>	<b>44</b>	<b>26</b>	<b>26</b>

## MATA KULIAH PILIHAN

KODE	MATA AJAR	SUBJECT	SKS
ENMT 8 0 3 919	Manajemen Proyek	Project Management	3
ENMT 8 0 3 920	Material Elektronik	Electronic Material	3
ENMT 8 0 3 921	Material Turunan Polimer	Polymer Derivative Materials	3
ENMT 8 0 3 922	RBI & Integrity	RBI & Integrity	3
ENMT 8 0 4 923	Manufaktur Lanjut Polimer	Advanced Polymer Manufacture	3
ENMT 8 0 4 924	Metalurgi Ekstraksi Lanjut	Advanced Extractive Metallurgy	3
ENMT 8 0 4 925	Rekayasa Permukaan Material Lanjut	Advanced Surface Treatment	3
ENMT 8 0 4 926	Teknologi Manufaktur Polimer	Polymer Manufacture Tehcnology	3
ENMT 8 0 4 927	Teknologi Nano	Nano Technology	3

Silabus Mata Kuliah - Kurikulum 2016  
Jenjang Magister - Dept. Teknik Metalurgi & Material

**ENMT 801001 - KINETIKA & TRANSFORMASI FASA - (3 SKS)**

Pengantar termodinamik, Efek Thomson, difusi, antar-muka dan energi/tegangan permukaan, kinetika pertumbuhan butir, pergerakan batas butir, nukleasi homogen dan heterogen, pertumbuhan kontinu dan lateral, pembekuan paduan, pembekuan kesetimbangan, pembekuan non equilibrium, pembekuan cellular dan dendritik, constitutional super-cooling, pembekuan eutektik, struktur eutektik, pertumbuhan eutektik, pembentukan rod dan lamellar, efek pengotor, antar-muka antar-fasa, koheren, semi-koheren dan non-koheren, migrasi antar-muka, pertumbuhan endapan, kinetik transformasi, rekristalisasi, pengkasaran butir, pertumbuhan butir, age hardening, presipitasi ferrit dan austenite, reaksi pearlite, transformasi bainite, transformasi martensite, transformasi spinodal, tempering martensite, studi kasus.

**ENMT 801002 - MATERIAL TEKNIK - (2 SKS)**

Teori dasar material mencakup teori atom, ikatan atom, bonding system, struktur kristal, struktur dan sifat material, seleksi material besi, klasifikasi penandaan dan spesifikasi baja, baja paduan rendah, heat treatable carbon steel dan low alloy steel, seleksi tool steel, seleksi stainless steel, besi tuang, seleksi material non ferrous, (Al, Ti, Mg dan Ni serta paduannya), shape memori alloy (material cerdas), material in organik: keramik dan glass, mechanical behaviour of ceramic, material polimer, seleksi plastik, polimerisasi dan material komposit

**ENMT 801003 - METODE PENELITIAN & KOMPUTASI - (3 SKS)**

Pengertian ilmiah, metodologi penelitian, perumusan masalah, hipotesa, penelaahan pustaka, pengumpulan dan pengolahan data, penyusunan usulan penelitian serta penyajian karya ilmiah; Pengantar komputasi, dasardasar matlab, ekspresi logika, vektorisasi, mengontrol aliran dengan if dan while, loop dalam matlab, fungsi dan m-file, test output, programming matlab, bilangan binary, bilangan titik ambang (floating point), presisi mesin, persamaan linier, fitting kurva, persamaan diferensial biasa, statistik dan analisis proses data

**ENMT 801104 - MEKANIKA MATERIAL - (3 SKS)**

Pengantar mekanika material, jenis-jenis kegagalan material, rekayasa dan seleksi material, deformasi elastis dan teori kekuatan, deformasi in-elastis, proses logam dan paduannya, komposit, keramik dan gelas, polymer, konsep tegangan dan regangan, model reologi, deformasi plastis, deformasi creep, material anisotropik, teori uji mekanik material, sifat tegangan-regangan, kecenderungan perilaku tarik, interpretasi tegangan-regangan sesungguhnya, uji kompresi, kekerasan, dampak, uji bending dan torsi, plane stress, plane strain, keadaan tegangan tiga dimensi, tegangan pada bidang oktahedral, keadaan regangan kompleks, bentuk umum kriteria kegagalan, kriteria, konsep mekanika patahan, nilai fracture toughness, aplikasi nilai K pada disain dan analisa, kelelahan berdasarkan tegangan, siklus pembebanan, kurva tegangan-waktu, tegangan rata-rata, tegangan multiaxial, fatigue crack growth, kelelahan berdasarkan regangan, regangan vs umur, efek tegangan rata-rata, estimasi umur untuk komponen struktur dan creep.

**ENMT 801205 - PRINSIP KOROSI - (3 SKS)**

Konsep elektrokimia: dasar dan aplikasinya, definisi korosi, bentuk korosi, cost of corrosion, konsep elektrikal yang relevan dengan korosi, konsep kimia dan elektrokimia yang relevan, prediksi kecenderungan korosi secara termodinamika, elektrolit, Kinetika korosi, over-potential (polarisasi), pasivasi, pengukuran kecepatan korosi, aspek metalurgi, bentuk-bentuk korosi, dan teori potensial gabungan, pengujian korosi (metoda kupon kehilangan berat, elektrokimia).

**ENMT 802006 - DESAIN & PEMILIHAN MATERIAL - (3 SKS)**

Klasifikasi material teknik, faktor dan sistematika desain dan pemilihan material, Kriteria pemilihan material, diagram sifat material (material property chart) dan indeks kinerja (performance index), disain untuk ketahanan korosi, disain penggunaan material temperatur tinggi serta disain material tahan aus dan tahan fatik, disain untuk plastik dan komposit serta pemilihan berbagai jenis baja karbon, besi tuang dan baja paduan (baja perkakas, baja tahan karat, baja tahan panas, baja tahan aus, pemilihan paduan super (super alloys), serta studi kasus pada pemilihan material.

**ENMT 802007 - KARAKTERISASI MATERIAL - (3 SKS)****ENMT 802008 - LABORATORIUM - (1 SKS)**

Pendahuluan, prosedur dan standar pengujian, prinsip dan metoda analisis lanjut untuk komposisi kimia material teknik (AAS, OES, EDS, XPS), identifikasi struktur kristal (difraksi sinar X), metalografi lanjut (SEM, EPMA, TEM), serta analisis termal (DTA, TGA, DSC dan TMA).

**ENMT 802109 - MANUFAKTUR LANJUT - (3 SKS)**

Pembentukan logam sebagai bagian dari proses disain dan manufaktur; prinsip umum, fenomena dan mekanisme terkait pengecoran logam; cetakan (pasir, keramik, logam), sistem tuang (gating system) dan simulasi, proses pembekuan besi tuang dan aluminium, liquid treatment untuk logam ferrous (inokulasi, Mg treatment) dan non-ferrous (modifier, grain refiner), berbagai metode pengecoran, cacat cor (casting defect); prinsip umum, fenomena dan mekanisme pembentukan logam fase padat, melalui proses penempaan, canai, ekstrusi, penarikan, pembentukan logam lembaran, dan perlakuan termo-mekanik. Penomena dan mekanisme pada metalurgi serbuk, fabrikasi serbuk logam dan mekanisme pembentukan serbuk, karakteristik dan karakterisasi serbuk, pemaduan mekanik (mechanical alloying), proses pra-kompaksi, kompaksi, karakteristik bakalan, proses sinter dan konsolidasi serbuk, pemrosesan densitas penuh, Jenis peralatan sinter dan aspek terkait, aplikasi dan penggunaan produk metalurgi serbuk. Studi kasus pemilihan proses dan evaluasi proses manufaktur.

**ENMT 802210 - KOROSI LANJUT - (3 SKS)**

Pendahuluan, larutan encer dan air, aspek termodinamik korosi aqueous, kinetika korosi, aplikasi korosi aqueous di lapangan (korosi air laut, korosi bawah tanah, korosi pada lingkungan tanah), aplikasi korosi untuk logam selain besi, korosi atmosferik, reaksi oksidasi temperatur tinggi, termodinamika oksidasi, pertumbuhan lapisan oksida, sifat dan karakteristik oksida, pilling-bedworth ratio, laju reaksi oksidasi, pengaruh tekanan oksigen korosi di lingkungan spesifik, temperatur tinggi karburisasi, dekarburisasi, metal dusting, hot corrosion, pengujian korosi temperatur tinggi, proteksi material pada temperatur tinggi, material tahan temperatur tinggi, coating (aluminizing, chromizing, siliconizing). Studi kasus korosi.

**ENMT 802211 - PELAPISAN & INHIBISI - (3 SKS)**

Pelapisan (coating): metallic coating, tipe dan klasifikasi metallic coating, mekanisme proteksinya, electroplating dan electroless plating, anodizing, phosphating, chromating, hot-dip galvanizing, service life prediction, Organic Coating (paints), sifat organic coating, klasifikasi dan formulasi 'paints', mekanisme proteksinya, standard preparasi permukaan, metode aplikasi, cacat pelapisan dan kegagalan 'painting'. Inhibisi; Jenis, klasifikasi dan mekanisme inhibisi (inhibitor anodic, katodik, dan campuran), formulasi inhibitor korosi secara umum, aplikasi dan keterbatasan (untuk otomotif, pendingin air, sistem air minum, petrokimia dan refinery plant) VCI, material tahan karat pembentuk lapisan.

**ENMT 803012 - ANALISA KERUSAKAN + LAB - (4 SKS)**

Definisi & tujuan analisa kerusakan, faktor-faktor kerusakan material secara umum, prosedur umum dalam teknik analisa kerusakan, klasifikasi sumber-sumber kegagalan, karakteristik & mekanisme kegagalan material, patah ulet, patah getas, patah fatik, serta kegagalan maupun kegetasan akibat kondisi lingkungan (thermal/ creep, korosif/corrosion, dan keausan/wear), pemilihan metoda & alat pengujian (tools) pada material yang gagal, yield criteria, initiation of plastic deformation, stress concentration, residual stress, static failure, prinsip dasar mekanika perpatahan (fracture mechanics), analisa studi kasus kegagalan, serta pembuatan laporan dan presentasi hasil analisa kegagalan

**ENMT 803113 - METALURGI LAS - (3 SKS)**

Introduksi penyambungan material, klasifikasi, prinsip dasar dan karakteristik proses las busur listrik, keuntungan dan keterbatasannya, klasifikasi & karakteristik mesin las dan kawat las, fluks dan gas, parameter las dan masukan panas (heat input), prinsip dasar metalurgi las, transfer logam dalam las busur listrik, struktur mikro sambungan lasan, pengaruh pemaduan (alloying), perubahan temperatur dalam lasan (HAZ), faktor-faktor yang mempengaruhi proses kecepatan pendinginan (cooling rate) logam lasan, kemampuan (weldability) logam ferrous (baja dan paduannya, baja tahan karat serta besi tuang) & non-ferrous (Al, Cu, Mg, Ni, serta paduannya), cacat las dan pencegahannya, perlakuan panas lasan (preheating & PWHT), serta kontrol kualitas hasil lasan. Studi kasus pengelasan

**ENMT 803114 - KOMPOSIT LANJUT - (3 SKS)**

Konsep, definisi dan klasifikasi komposit, matrik dan penguat (reinforcement), fabrikasi komposit, hukum campuran, teori antar-muka dan pembasahan, komposit nano, mekanika komposit, aspek geometri dalam komposit, lamina dan laminat, perilaku elastis, efek ujung serat, teori laminat, kekuatan lamina satu arah, kekuatan laminat, kekuatan komposit serat pendek, energi perpatahan komposit dan studi kasus komposit.

**ENMT 803215 - PROTEKSI KATODIK - (3 SKS)**

Teori dasar proteksi katodik, kriteria proteksi, sistem katodik proteksi dengan anoda korban, sifat material anoda korban dan pemilihannya, aplikasi proteksi katodik anoda korban, sistem proteksi katodik impressed current (ICCP), instrument untuk proteksi korosi, proteksi katodik pada lingkungan air laut, tanah, dan struktur dalam beton (semen), klasifikasi material, hubungan material dan lingkungan secara spesifik, petunjuk mendesain untuk pencegahan korosi, sifat ketahanan material baja tahan karat dan super duplex SS, ketahanan korosi material teknik yang umum dipakai (baja tuang, baja karbon, baja paduan rendah, nikel, aluminium, tembaga, seng, titanium dan paduan-paduannya, ketahanan korosi material bukan logam (rubber, plastic, composite, ceramic).

**ENMT 800016 - MAKALAH PENELITIAN - (2 SKS)**

Hasil penelitian yang ditulis dalam format jurnal dan diterbitkan minimal dalam jurnal nasional atau prosiding internasional.

**ENMT 800017 - SEMINAR OF THESIS PROPOSAL - (2 SKS)**

Kertas kerja/makalah yang disampaikan dalam seminar sesuai dengan proposal yang diajukan dalam tesis. Makalah meliputi : Permasalahan serta hipotesisnya, metodologi dan pembahasannya

**ENMT 800018 - THESIS - (6 SKS)**

Penerapan/pelaksanaan berbagai mata kuliah yang diikuti secara integrasi dalam suatu penelitian guna memecahkan suatu permasalahan dibidang teknik metalurgi dan material. Hasil penelitian disajikan dalam bentuk laporan ilmiah dan dipresentasikan didepan tim dosen penguji.

## MATA KULIAH PILIHAN

**ENMT 803919 - MANAJEMEN PROYEK - (3 SKS)**

Konsep manajemen proyek, pendekatan system dan system enjirening, system dan prosedur, dasar perencanaan, estimasi biaya dan anggaran, manajemen kualitas proyek, eksekusi dan control proyek, organisasi proyek, dan konteks manajemen proyek, komunikasi proyek, serta manajemen risiko proyek

**ENMT 803920 - MATERIAL ELEKTRONIK - (3 SKS)**

Konsep dasar teori elektron (dualitas gelombang - partikel, elektron bebas, elektron hampir bebas, struktur pita, isolator - konduktor - semikonduktor). teori modern padatan (teori band padatan, kepadatan materi, statistik Boltzmann dan Fermi-Dirac, elektron massa efektif dan energi Fermi). konduksi listrik dalam bahan (teori elektron klasik, pertimbangan kuantum mekanik, magnet, superkonduktivitas, dielektrik dan isolator, fenomena termoelektrik). Semikonduktor (intrinsik dan ekstrinsik semikonduktor, semikonduktor merosot, recombination and minority carrier junction, persimpangan Schottky dan kontak ohmik, perangkat semikonduktor)

**ENMT 803921 - TURUNAN POLIMER - (3 SKS)**

Pendekatan strategis industri di bahan turunan polimer. pengantar umum turunan polimer (poliblend, polyalloys, elastomer termoplastik, komposit matrik polimer, polimer cair kristal, polimer konduktif, pyro dan piezo polimer, polimer memori. polimer biodegradable (definisi, jenis, proses manufaktur). polymer pemilihan material untuk poliblend dan polyalloys sintesis. metode proses (fisika dan kimia) untuk polimer paduan. pengujian dan evaluasi studi polimer paduan. studi kasus.

**ENMT 803922 - RBI & INTEGRITY - (3 SKS)**

Definisi & Pengertian : Asset Integrity & Risk Based Inspection. Policy : Kebijakan TingkatProduksi serta Pertimbangan Health, Safety & Environment (HSE). Strategy /Prioritization : Berdasarkan Skala Prioritas. Program Planning : Perencanaan Program. Hazard/Threat Identification : Identifikasi Potensi Ancaman. Damage Mechanism : Mekanisme Kerusakan. Probability of Failure : Peluang Kegagalan. Consequence of Failure : Konsekuensi Kegagalan. Asset Register : Penamaan Fasilitas/Peralatan. Risk Assessment : Kajian Resiko. Program Implementation : Implementasi Program. Data Compilation-Evaluation-Interpretation : Kompilasi, Evaluasi & Interpretasi Data. Corrective Actions & Recommendations : Tindakan perbaikan & Rekomendasi. Inspection Interval : Jangka waktu Inspeksi. Inspection Methods : Metoda-Metoda Inspeksi. Inspection Scope : Ruang Lingkup Inspeksi. Inspection Work package : Rincian Pekerjaan Inspeksi.

**ENMT 803923 - MANUFAKTUR LANJUT POLYMER - (3 SKS)**

Proses fabrikasi produksi polimer (formulasi, pembentukan dan finalisasi). Tujuan dan proses finalisasi jenis produk polimer (deflashing,smoothing and polishing, sawing and cutting,drilling, grinding and sanding, routing, milling & turning, tapping & threading, cleaning, annealing, assembling, and decoration). Jenis proses perakitan (mechanical joining,welding and adhesive bonding). Jenis proses dekorasi (painting, plating, thermal spray coating, vacuum metalizing, hotstamping, coloring). mesin dan mekanisme konstruksi proses. Proses finalisasi pembuatan produk polimer. Studi kasus pada proses fabrikasi kemasan produk (rigid and flexible), otomotif, elektronik dan peralatan konstruksi.

**ENMT 803924 - METALURGI EKSTRAKSI LANJUT - (3 SKS)**

Karakterisasi Limbah untuk bahan baku proses. Inovasi proses metalurgi basah (hydrometallurgy) dan metalurgi panas (pyrometallurgy)untuk bahan baku kadar rendah dan efisiensi energi: mekanisme reaksi dan aplikasi, seperti ekstraksi logam dengan plasma, gelombang mikro. Proses daur ulang logam. Pemrosesan terak, debu dan partikel abu metalurgi. Pemrosesan dan pemanfaatan produk sampingan (by product): pemanfaatan terak, pemrosesan dross, pemrosesan abu terbang. Perolehan logam dari limbah proses (seperti *tailing*, *residue*, *sludges*): pemrosesan mineral dari *tailing*, perolehan logam dari *red mud*, perolehan logam dari *waste sludge*. Teknologi baru proses daur ulang logam.

**ENMT 803925 - REKAYASA PERMUKAAN MATERIAL LANJUT - (3 SKS)**

Dasar rekayasa permukaan, rekayasa permukaan konvensional, rekayasa permukaan lanjut, pelapisan permukaan, modifikasi permukaan, karakterisasi thin film.

**ENMT 803926 - TEKNOLOGI MANUFAKTUR POLIMER - (3 Credit Points)**

pPngenal polimer dan produknya. Jenis dan langkah mesin manufaktur polimer. Ekstrusi dan turunannya (blown film, callendering, blow molding, thermoforming and pultrusion). molding rotasi. Proses memperkuat. proses laminating.

proses pengecoran. Injection molding dan turunannya (stretch blow molding dan RIM). jenis mesin untuk produk karet (formulasi dan fabrikasi). konstruksi umum dan mekanisme kerja dalam pengolahan produk karet.

### **ENMT 803927 - NANO TECHNOLOGY - (3 Credit Point)**

Definisi dan ruang lingkup, kimia fisik permukaan padatan, struktur-struktur nano (zero, one and two-dimensional: 0D, 1D, 2D), material-material nano khusus, proses-proses fabrikasi (lithography, nanolithography, soft-lithography, assembly), karakterisasi (struktural, fisika dan kimia) dan aplikasi (sensor kimia, biosensor, MEMS/Microelectromechanical system, DNA chips, photonic crystals).

**Curriculum of 2016 - Subjects Syllabus**  
**Master Degree - Dept. of Metallurgy & Materials Engineering**

**ENMT 801001 - KINETICS & PHASE TRANSFORMATION- (3 Credit Points)**

Review on Thermodynamics and Phase Equilibrium: Single Component System, Binary Component System, The Phase Rule, Binary Phase Diagrams, Reactions in the solid state; Fe-Fe<sub>3</sub>C Phase Diagram; Ternary System Representation, Ternary System containing 2 phase; Diffusion in Materials: Atomic mechanism of diffusion, Interstitial diffusion, Substitutional diffusion, Tracer diffusion in binary alloys, Diffusion in multiphase binary system, Journal review; Crystal Interface and Microstructure: Interfacial free energy, Grain boundary, Interphase interfaces in solids, Interface migration, Morphology of precipitates, Case study in Crystal Interface; Solidification: Nucleation in pure metals, Growth of pure solid, Cellular and dendritic solidification, Solidification of alloy, Application of solidification theory in casting and welding, Solidification during quenching from the melts, Case study; diffusional Transformation in Solids: Homogeneous and heterogeneous nucleation in solids, Precipitate growth, Transformation kinetics, Eutectoid transformation, Ordering transformation, Case study; (8) Diffusionless Transformation in Solids: Theories of martensite nucleation, Martensite growth, Tempering of ferrous martensite, Martensite transformation in nonferrous metals, Spinodal transformation, Case study in Diffusionless transformation

**ENMT 801002 - ENGINEERING MATERIALS - (2 Credit Points)**

Fundamental theories of materials including theories of atom, atomic bonding, bonding system; crystal structures; material structures and properties; ferrous material selection: classification designation and specifications of steel, low alloy steel, heat treatable carbon steel, and low alloy steel; selection of tool steels, stainless steels, cast irons; non-ferrous material selection (Al, Ti, Mg, Ni, and their alloys); shape memory alloys (smart materials); inorganic materials: ceramics and glasses, mechanical behaviour of ceramics; polymer materials, selection of plastics, polymerisation and composite materials.

**ENMT 801003 - RESEARCH AND COMPUTATIONAL METHODS - (3 Credit Points)**

Scientific understanding, research method, problem specification, hypothesis, literature study, data collection and processing, elaboration of research proposal and scientific work presentation; Computation, matlab basics, logical expression, vectorisation, flow control using if and while, loop in matlab, function and m-file, test output, programming matlab, binary number, floating point numbers, device precision, linear equation, curve fitting, differential equation, statistics and analysis of process data.

**ENMT 801104 - MECHANICS OF MATERIALS - (3 Credit Points)**

Introduction to mechanics of materials, types of material failure, engineering and selection of materials, elastic deformation and theory of strength, inelastic deformation, metals and alloys processing, composites, ceramics and glasses, polymers, concept of stress and strain, rheological model, plastic deformation, creep deformation, anisotropic materials, theory of mechanical testing of materials, stress-strain properties, tendency of tensile behaviour, interpretation of true stress-strain, compression, hardness, impact, bending and torsion testings, plane stress, plane strain, three dimensional stress condition, stress on octahedral plane, complex strain condition, common form of failure criteria, concept of fracture mechanics, fracture toughness value, application of K value in design and analysis, fatigue based on stress, loading cycle, stress-time curve, average stress, multiaxial stress, fatigue crack growth, fatigue based on strain, strain usage, effect of average stress, lifetime estimation of structural components and creep.

**ENMT 801205 - PRINCIPLES OF CORROSION - (3 Credit Points)**

Fundamental concepts of electrochemistry and its application, definition of corrosion, forms of corrosion, cost of corrosion, electrical concept relevant to corrosion, relevant concept of chemistry and electrochemistry, thermodynamic prediction of corrosion propensity, electrolyte, Kinetics of corrosion, over-potential (polarisation), passivation, corrosion rate measurement, metallurgical aspects, forms of corrosion and joint potential theory, corrosion testing (weight loss coupon method, electrochemistry).

**ENMT 802006 - DESIGN AND SELECTION OF MATERIALS - (3 Credit Points)**

Classification of engineering materials, factors and systematics of design and selection of materials, material property chart and performance index, design for corrosion resistance, design of high temperature materials and design of wear and fatigue resistant materials, design of plastics and composites, design of various carbon steel, cast iron and steel alloys (tool steel, stainless steel, heat resistant steel, wear resistant steel), super alloys, and case studies of material selections.

**ENMT 802007 - MATERIALS CHARACTERIZATIONS - (3 Credit Points)****ENMT 802008 - LABORATORY - (1 Credit Points)**

Introduction, standards and procedure of testing, principles and methods of advanced analysis for engineering materials chemical composition (AAS, OES, EDS, XPS), identification of crystal structure (x-ray diffraction), advanced metallography (SEM, EPMA, TEM), and thermal analysis (DTA, TGA, DSC, TMA).

**ENMT 802109 ADVANCED MANUFACTURE - (3 Credit Points)**

Metal forming as part of design and manufacture process; general principles, phenomena and mechanism related to casting of metals; mold (sand, ceramics, metals), gating system, and simulation. Solidification process of cast iron and aluminium, liquid treatment for ferrous metal (innoculation, Mg treatment) and nonferrous (modifier, grain refiner), various methods of casting, casting defects; General principles, phenomena and mechanism of solid phase metals through forging, rolling, extrusion, drawing, sheet metal forming, and thermo mechanical treatment. The phenomenon and mechanism of powder metallurgy, fabrication of metal powder, and mechanism of powder formation, characterisation and characters of powder, mechanical alloying, pre compaction process, compaction, preform characteristics, sintering, and powder consolidation, full density processing; types of sintering devices and related aspects, application and utilization of powder metallurgy products. Case study of processing selection and evaluation of manufacturing process.

**ENMT 802210 - ADVANCED CORROSION - (3 Credit Points)**

Introduction, thin and aqueous solution, thermodynamics aspects of aqueous corrosion, kinetics of corrosion, application of aqueous corrosion in practice (sea water corrosion, under soil corrosion, corrosion on soil environment), application of corrosion for non-ferrous metal, atmospheric corrosion, oxidation reaction at high temperature, thermodynamics of oxidation, growth of oxide layer, characteristics and properties of oxides, pilling-bedworth ratio, oxidation reaction rate, effect of oxygen pressure corrosion in specific environment, carburization at high temperature, decarburization, metal dusting, hot corrosion, high temperature corrosion testing, material protection at high temperature, high temperature resistant material, coating (aluminizing, chromizing, siliconizing). Case studies.

**ENMT 802211 - COATING & INHIBITION OF MATERIALS - (3 Credit Points)**

Coating: metallic coating, type and classification of metallic coating, protection mechanism, electroplating and electrodeless plating, anodizing, phosphating, chromating, hot dip galvanizing, Service life prediction, Organic Coating (paints), properties of organic coating, classification and formulation of paints, mechanism of protection, standard of surface preparation, application method, coating defects and painting failure. Inhibition; types, classification, and mechanism of inhibition (anodic, cathodic, and mixed inhibitor), formulation of corrosion inhibitor in general, application and limitation (in automotive, water coolant, drinking water system, petrochemical and refinery plant) VCI, layer forming corrosion resistant materials

**ENMT 803012 - FAILURE ANALYSIS + LAB - (4 Credit Points)**

Definition and goals of failure analysis, general factors contributing to material failure, general procedure in failure analysis techniques, classification of failure origins, characteristics & mechanism of failure analysis, ductile fracture, brittle fracture, fatigue fracture, and failure or brittleness affected by environmental conditions (thermal/ creep, corrosion, and wear), method and tool selections on failed material, yield criteria, initiation of plastic deformation, stress concentration, residual stress, static failure, fundamental principles of fracture mechanics, failure analysis case study analysis and report making and presentation of failure analysis results.

**ENMT 803113 - WELDING METALLURGY - (3 Credit Points)**

Introduction to material joining, classification, basic principles and process characteristics of electric arc welding and its benefits and drawbacks, classification & characteristics of welding machines and welding electrodes, flux and gas, parameter of welding and heat input, fundamental principles of welding metallurgy, metal transfer inside electric arc welding, microstructure of weld joint, alloying effect, temperature change in welding (HAZ), factors affecting cooling rate of weld metal, weldability of ferrous metal (steel and alloys, heat resistant steel and cast iron) & non-ferrous (Al, Cu, Mg, Ni, and their alloys), welding defects and prevention, heat treatment for welding (preheating & PWHT), weld joint quality control, case studies.

**ENMT 803114 - ADVANCED COMPOSITES - (3 Credit Points)**

Concepts, definition and classification of composites, matrix and reinforcement, composite fabrication, rule of mixture,



interfacial and wetting theory, nano composites, composites mechanics, geometric aspect in composites, lamina and laminate, elastic behaviour, fire effect, theory of laminate, unidirectional strength of lamina, strength of laminate, strength of short fibre composites, fracture energy of composites, and case studies of composites.

**ENMT 803215 - CATHODIC PROTECTION - (3 Credit Points)**

Fundamental theory of cathodic protection, protection criteria, cathodic protection system using sacrificial anode, properties of sacrificial anode material and its selections, application of sacrificial anode cathodic protection, impressed current corrosion protection system (ICCP), instrument for corrosion protection, cathodic protection in sea water, soil, and internal structure of concrete (cement) environment, classification of material, specific relation of material and environment, corrosion protection design guidelines, resistant properties of stainless steel and super duplex SS, corrosion resistance of commonly used engineering materials (cast iron, carbon steel, low alloy steel, nickel, aluminium, copper, zinc, titanium, and their alloys), corrosion resistance of non metallic material (rubber, plastic, composite, ceramic).

**ENMT 800016 - RESEARCH PAPER - (2 Credit Points)**

Research result written in journal paper format and published in minimum of national journal or international proceeding.

**ENMT 800017 - SEMINAR OF THESIS PROPOSAL - (2 Credit Points)**

Work sheet/paper that will be presented in a seminar according to thesis proposal. Paper includes: problem and hypothesis, methodology and its discussion.

**ENMT 800018 - THESIS - (6 Credit Point)**

Application of various courses attended in an integral manner in a research to solve a metallurgical and materials engineering problem. The research result is written to a scientific report and presented before a panel of lecturer.

**ELECTIVES****ENMT 803919 - PROJECT MANAGEMENT - (3 Credit Points)**

The concept of project management system and system approach, engineering systems and procedures, basic planning, cost estimation and budgeting, project quality management, execution and project control, project organization, and context of project management, project communication, and project risk management.

**ENMT 803920 - ELECTRONIC MATERIALS - (3 Credit Points)**

concepts of electron theory (wave - particle duality, free electrons, nearly free electrons, band structure, insulators - conductors - semiconductors). Modern theory of solids (band theory of solids, density of states, Boltzmann and Fermi-Dirac statistics, electron effective mass and Fermi energy). Electrical conduction in materials (classical electron theory, quantum mechanical considerations, magnetism, superconductivity, dielectrics and insulator, thermoelectric phenomena). Semiconductors (intrinsic and extrinsic semiconductors, degenerate semiconductors, recombination and minority carrier junction, Schottky junctions and Ohmic contacts, semiconductor devices)

**ENMT 803921 - POLYMER DERIVATIVES - (3 Credit Points)**

Industrial strategic approaches in polymer derivatives material. General introduction in polymer derivatives (polyblends, polyalloys, thermoplastic elastomer, polymer matrix composites, liquid crystal polymer, conductive polymers, pyro and piezo polymers, shape memory polymers. Biodegradable polymer (definition, types, manufacturing process). Polymer material selection for polyblends and polyalloys synthesis. Process method selection (physics and chemical) for polymer alloying. Testing and evaluation of polymer alloying. Case studies.

**ENMT 803922 - RBI & INTEGRITY - (3 Credit Points)**

Definition: Asset Integrity & Risk Based Inspection, Policy including Health, Safety & Environment (HSE), Strategy / Prioritization, Program Planning, Hazard/Threat Identification, Damage Mechanism, Probability of Failure, Consequence of Failure, Asset Register, Risk Assessment, Program Implementation, Data Compilation-Evaluation-Interpretation, Corrective Actions & Recommendations, Inspection Interval, Inspection Methods, Inspection Scope, Inspection Work package.

**ENMT 803923 - ADVANCED POLYMER MANUFACTURING - (3 Credit Points)**

Fabrication steps of polymer production (formulation, establishment and finalization). Purpose and process of finalizing the type of polymer products (deflashing, smoothing and polishing, sawing and cutting, drilling, grinding and sanding, routing, milling & turning, tapping & threading, cleaning, annealing, assembling, and decoration). Types of assembling processes (mechanical joining, welding and adhesive bonding). This type of decorating process (painting, plating, thermal spray coating, vacuum metalizing, hot stamping, coloring). Construction machinery and mechanisms work finalization processes. The selection of the process of finalizing the fabrication of a polymer product. Case studies on the fabrication process of finalizing the product packaging (rigid and flexible), automotive, electronics and construction equipment.

**ENMT 803924 - ADVANCED EXTRACTIVE METALLURGY - (3 Credit Points)**

Waste characterization processes for raw materials. Innovation wet metallurgical process (hydrometallurgy) and metallurgical heat (pyrometallurgy) for low grade raw materials and energy efficiency: reaction mechanisms and applications, such as metal extraction with plasma, microwave. Metal recycling process. Slag processing, metallurgical dust and ash particles. Processing and utilization of by-products (by product): the use of slag, dross processing, processing of flash. Obtaining metals from waste processes (such as tailings, residue, sludges) from the mineral processing tailings, red mud from metal recovery, metal recovery from waste sludge. The new technology of metal recycling process.

**ENMT 803925 - ADVANCED SURFACE ENGINEERING - (3 Credit Points)**

Fundamental of surface engineering, conventional surface engineering, advanced surface engineering practices, surface coatings and surface modifications, advanced topics on characterizations for thin film

**ENMT 803926 - POLYMER MANUFACTURING TECHNOLOGY - (3 Credit Points)**

Polymer introduction and its product. Types and steps of polymer manufacturing machines. Extrusion and its deriva-

tives (blown film, calendering, blow molding, thermoforming and pultrusion). Rotational molding. Reinforcing process. Laminating process. Casting process. Injection molding and its derivatives (stretch blow molding and RIM). Machine types for rubber product (formulation and fabrication). General construction and work mechanism in rubber product processing.

**ENMT 803927 - NANO TECHNOLOGY - (3 Credit Point)**

Scope and definition of nanotechnology, physical and chemical of solid surface, nanostructures (zero, one and two dimensional), special nanomaterials, fabrication processes (lithography, nanolithography, soft lithography, assembly), nanomaterial characterizations (physical, chemical and structural) and applications (MEMS, DNA chips, photonics, crystal)