



ENGINEERING DESIGN AND NATURAL RESOURCES MANAGEMENT

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ABSTRACT

Up till now design was taught purely on engineering factors, performance, requirement of the product, physical properties of the material and the machining and treatment procedures. Lately the concept of cost is considered as well. With the passage of time environmental aspects have to be considered. Just like ISO 9000 covers 'quality' ISO 14000 covers environmental aspects of design and production. The design requires that engineering students be acquainted with heat transfer, mechanical design, and principals of radiation, shock and vibration in addition to special technologies etc. They should also be able to make a holistic environmental view of the product from raw materials through production to distribution and final disposal.

An undergraduate course titled Natural Resources Management was developed jointly by the Faculty of Mechanical Engineering, Ghulam Ishaq Khan Institute of Science and Technology, Pakistan and by Faculty of Environment, University of Waterloo, Canada under the sponsorship of Canadian International Development Agency. The purpose of this course is to provide engineering students with a broad and comprehensive introduction to the background and issues involved in Natural Resources Management and Engineering Design.

This paper presents the salient objectives of the course, a detailed course outline of and its relation to design related courses as offered by different engineering faculties.

Keywords: *Engineering design, system, design, manufacturing and environment relationship, natural resources management course outline*

1. INTRODUCTION

Environmental pressures are beginning to change the course of business, at all levels of management and across all industry sectors. The pressures come from a variety of sources. These sources can be grouped as legislation, market forces, stakeholders and financial pressures. The companies are required to respond in a positive manner to these pressures and yet to produce product of adequate quality and cost that is acceptable to customers.

The pressure exerted by legislations is evident as new and demanding environmental laws are increasingly affecting all business sectors. The range and scope of legislations and regulations have extended very quickly throughout the world. Failure to comply with legislations and regulations can affect a company's profitability not through fines but also through potential clean up cost if action results in causing pollution.

Companies have to respond to environmental forces, which comes from the market place. Customers expect increasingly higher quality products and environmental requirements can be a part of quality expectations.

In addition to customers pressure a company must respond to the requirements of other stakeholders, which includes investors, lenders, shareholders, employees and neighbors. Poor environmental performance can also be seen in terms of general poor management. It is obvious that environmental considerations can have a negative effect on a company's bottom line. A good environmental management which can be termed as Natural Resources Management can reduce energy consumption, minimize waste, optimize transport operations thus making production more efficient and results in increased profitability for the company. Design is an essential component of basic engineering education. At Ghulam Ishaq Khan Institute of Science and Technology design forms a component of different courses taken by students in different disciplines. A list of such courses covering aspects of design is shown in Appendix 1.

It was considered necessary that undergraduate students at GIKI be exposed to the nexus that exist between design and environment. Under the sponsorship of the Canadian International Development Agency and in collaboration with University of Waterloo a course on Natural Resources Management was developed.

In this paper a system for design, design-manufacturing-environment relationship along with the approach taken to cover Natural Resources Management for developing a course is presented. A course manual, which includes a course guide for the preparation of and teaching of the course is presented as well.

2. SYSTEM FOR DESIGN

Engineering design is predominantly concerned with wealth creation. Every design can be 'design to manufacture'. It necessitates a holistic approach, including effective cost. It involves the use of scientific principle, the technical information, numeracy, synthesis, analysis, creativity and decision-making. It requires the consideration of human and environmental factors with the maximum practicable economy and efficiency (Schwartz, 1). A model of overall system for design is shown in Figure-1.

The mainstream of design is from wealth creation, via process needed to effective cost. The other streams go in parallel from process needed to environmental requirements with a field feedback loop; the basic design runs in parallel with safety design.

Every design problem aims at a solution, which balances the costs of different aspects and is technically and economically viable.

3. DESIGN – MANUFACTURING – ENVIRONMENT RELATIONSHIP

Until now design was taught purely on engineering factors; performance requirement, requirement of the product, physical properties of the material and the machining and treatment process. [Dhillon, 1996] These factors are necessary for designing a product but not sufficient. A process to evaluate the environmental burden associated with a particular design and the process selected for manufacturing, which identifies and quantifies energy and material usage and environmental releases has to be developed. The design and the process selected should be the one which minimize environmental burden. A diagrammatical illustration of design-manufacturing-environment relationship is shown in Figure-2.

One of the required characteristics of good design of a product can be employed to reduce environmental burden by changing the amount and type of material used. More efficient manufacturing operations can be selected which reduce energy and material consumptions.

This aspect of designing process is not adequately presented to engineering undergraduate students. Although students in all the engineering disciplines have to study design. A list showing courses involving design and related areas taken by all the all the students at GIKI is shown in Appendix-1.

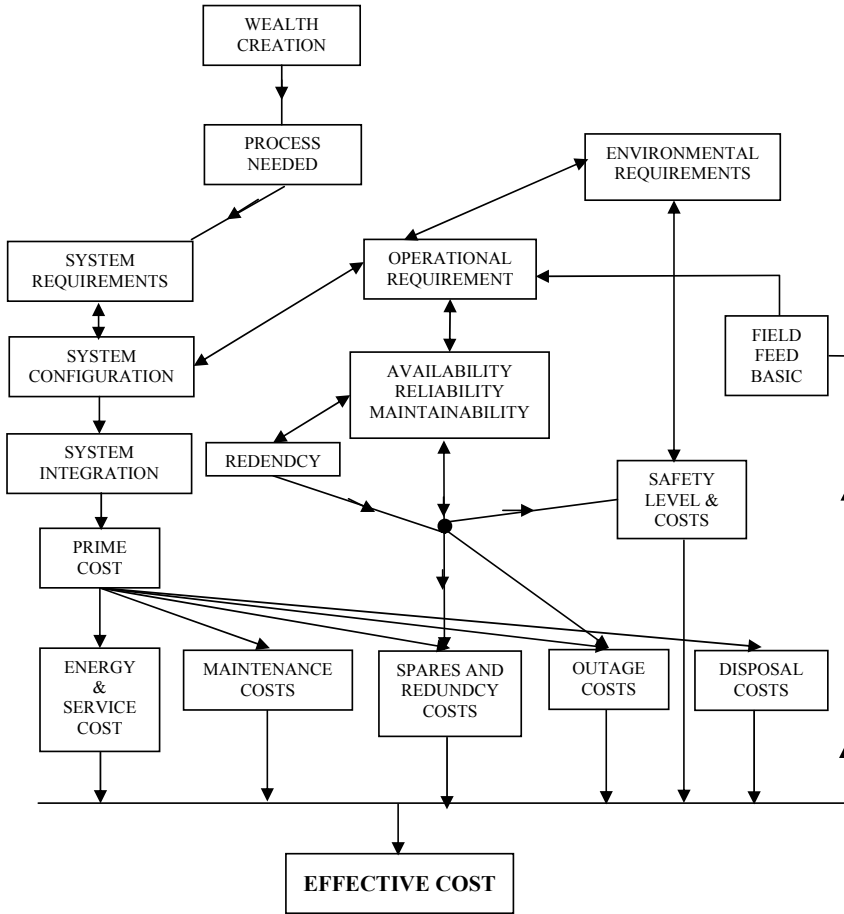


FIGURE 1 Model of system for design

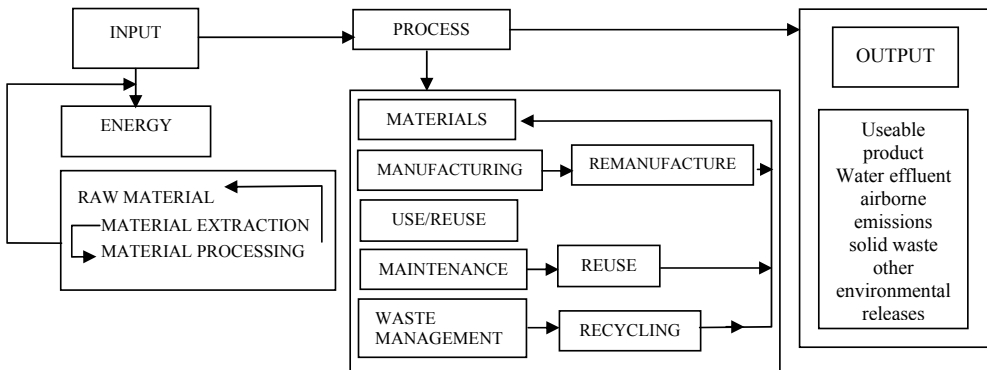


FIGURE 2 Design – Manufacturing – Environment Relationship

4. NATURAL RESOURCE MANAGEMENT

It was considered necessary that a comprehensive introduction to the background and issues involved in natural resource management be provided to students. Environment management, environment protection and technology application to environment were involved in this course. Topics to be covered under each of these groups are shown in Figure 3.

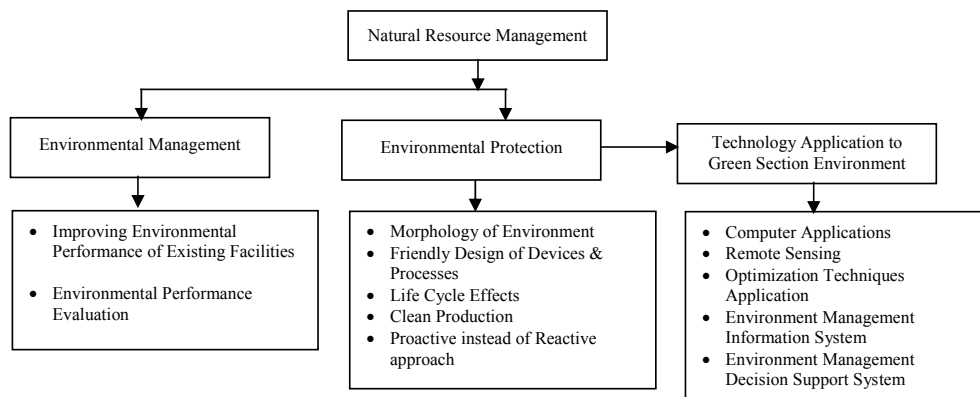


FIGURE 3 Natural Resource Management

5. MANUAL

This manual is intended to provide a complete resource guide for the preparation and teaching of a modularized course introducing the concept of Natural Resource Management (NMR) to students at the Ghulam Ishaq Khan Institute (GIKI) of Engineering Science and Technology. As well as setting out the description, objects and teaching approaches for the course the Manual also includes a detailed time table for classes, outlines for the instructors to use in preparing and presenting lectures, suggested reading assignments and a set tests, written assignments and quizzes for the evaluation of students' achievement in understanding the material presented.

5.1. Course Outline

5.1.1. General Course Description

The purpose of this course is to provide engineering students at GIKI with a broad and comprehensive introduction to the background and issues involved in Natural Resources Management. This is done in keeping with the Institute's stated objectives and orientation in terms of business and industry. The course is intended to equip GIKI graduates to take their place in the management of Pakistan's growing economy while protecting the natural resources on which the country depends.

5.1.2. Course Objectives

Those successfully completing the course will have mastered the following objectives:

- They will be able to recognize the environmental impact of various engineering initiatives/designs
- They will be equipped to analyze potential problems resulting from human interventions in the environment
- They will be able to incorporate the principles and acceptable practices of Natural resources Management in their problem solving efforts
- They will have a firm context and background for future learning in the field of NMR

5.1.3. Learning Approaches

The course comprises of lectures, field trips, laboratory exercises, written assignments and projects.

5.2. Schedule

When taught as an undergraduate course all the lectures would be given in sequence as shown below. When offered as a set of modules for professional upgrading the course could be broken into three sections as indicated.

Class Date	Preparatory Readings	Lecture Topics	Lab	Assignment Due
Section 1		Perspectives on Natural Resources Management		
Week 1				
Week 2		Sustainability-Integrating Economics/Society/Environment		
Week 3		Key Environmental and Resource Issues in Pakistan		
Week 4		Integrated Approach/Watershed Management		
Week 5		Field Trip-IUCN and Muree Hills		
Section 2		The Role of Engineer in Natural Resource Management.		
Week 6				
Week 7		Selected Case Studies of the Role of Engineers in Natural Resource Management	FIELD TRIP	
Week 8		Hazards		
Week 9		Environmental Monitoring and assessment		
Section 3		Methods and Tools for Natural Resource Management		
Week 10				
Week 11		Application of the Tools-Cost Benefit Analysis. Resource Surveys/Mapping Techniques	FIELD TRIP	
Week 12		GIS (Introduction)		
Week 13		Remote Sensing (Introduction)		
Week 14		Application of the Tools-GIS/Remote Sensing		

Note: The titles of lectures, amount covered and exact sequencing might change somewhat when detailed lecture outlines emerge in their final form.

6. INSTRUCTION MANUAL AND SUGGESTED READINGS

Required pre-course reading for instructors is required and a guide to preparation for teaching "Introduction to Natural Resource Management in Pakistan" should be developed. A list of reference material and suggested reading is provided. This is not an exhaustive list by any means.

6.1. Outlines for Individual Lectures

6.1.1. Section 1

6.1.1.1. Perspectives on natural Resource Management

6.1.1.2. Key Themes:

- Sustainability/Integration
- Technology/Social Systems
- Monitoring/Assessment
- Global/Local

6.1.1.3. Sustainability

- The concept of acting today in ways that will not compromise the ability of future generations to live
- Integrating economics/society/environment
- The requirement to better manage the use of natural resources

6.1.1.4. Key Environmental Issues in Pakistan identified in National Conservation Strategy:

- Water
- Supply for drinking and industry
- Flooding
- Health of stream ecology and fishery'
- Wetlands

6.1.1.5. Land degradation

- Desertification
- Salinity
- Erosion
- Wildlife

6.1.1.6. Pollution

- Air
- Water sewage
- Pesticides

6.1.1.7. Waste

- Industrial
- Municipal
- Landfill sites

6.1.1.8. Integrated Approach

- Need for a cross disciplinary and cross sectoral approach
- Integration of law, regulation, policy, assessment, training and professional practice in producing better outcomes
- Watershed management

6.1.2. *Section 2*

6.1.2.1. The Role of Engineers

- Why engineers need to be aware about natural resources management
- The potential roles and contribution that engineers can make

6.1.2.2. Examining the Particular Ways in Which Engineering is Involved in Selected Cases (GIKI experience)

6.1.2.3. Hazards

- Hazard is the result of interaction between humans and the environment
- Engineers can focus on the understanding of and management of potential environmental hazards

6.1.2.4. Environmental Assessment and Monitoring

EA is the most useful tool in Natural Resource Management, the steps of EA are

- Identifying potential problems
- Measuring the results of various development options
- Planning for the mitigation of negative aspects
- Developing strategic plans
- Monitoring outcomes
- Adjusting future actions to compensate for problems

6.1.3. *Section 3*

6.1.3.1. Tools that Assist in Natural Resource Management

- Resource and environmental surveys and mapping
- Remote sensing
- Satellite imaging
- Geographical information systems GIS

6.1.3.2. Application of the Tools

6.1.3.3. Notes on Specific Points Covered in the Outlines

In addition to the slides outlining each lectures there should be a set of annotations, detailed enough to provide the final user with all the references and background they need to familiarize themselves with the topic-to the extent they can lecture confidently and respond to questions. The annotation should include references to background material that can be read to provide lecturer with the requisite knowledge.

6.1.4. Course Organization

6.1.4.1. Field Trips

- Logistics, transportation
- Student preparation
- Objectives of field trips and recording of observations

6.1.4.2. In-Class Exercises, Quizzes, Assignments, Projects and Exams

6.1.4.3. Visual Aids

6.1.4.4. Timing

6.1.4.5. Computer Resources and Other Technical Requirements

7. STUDENT EVALUATION

7.1. In-Class Exercises

7.2. Quizzes

7.3. Assignments and Lab Reports

7.4. Projects

7.5. Examinations

8. REFERENCE SOURCES

8.1. General (International)

- Natural Environment and Ecological Theory and Practice
- Resource Management
- Environmental Hazards

8.2. Official Documents

- International Agreements, Conventions, Protocols
- Government Studies (Other Countries)
- Government Studies (Pakistan)

8.3. Case Studies (International)

8.4. Pakistani Sources

- General Environmental Studies
- Case Studies, Regional Reports or Site Specific Research

8.5. Technical Resources

- Maps
- GIS Data
- Remote Sensing Data

8.6. Internet Resources (Websites)

<http://www.business.com>

<http://www.nrm.or.id>

<http://www.g7.fed.us/enrm>

<http://www.oecsnrmu.org>

<http://www.massey.ac.nz/changelinks>

http://ag.udel.edu/academicprograms/majors/natural_resource_management.htm

<http://www.iupr.20m.com>

<http://www.utexas.edu/courses/resource/>

9. CONCLUDING REMARKS

This course aims at demonstrating the engineering students the environmental problems, suggests a way while designing alternate material and processes should be considered. For choosing the material and process, efforts should be made to minimize environmental burden. This course is ideal for classes that have a mix of students from different engineering disciplines. We have seen that students are very creative about the products they choose as class exercise.

10. ACKNOWLEDGEMENT

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APPENDIX 1: Courses needing NRM Awareness

Courses	Selection of Material	Material Recycling	Product Design	Manufacturing	Disposal
Metallurgy	MM 101: Introduction to Engineering Material MM 221: Material Evaluation Techniques	MM 212: Iron and Steel Production	MM 471: Application & Selection of Engineering Materials MM 472: Design Standards	MM 323: Manufacturing Processing MM 314: Non Ferrous Metallurgy	MM 332: Heat Treatment & Processing MM 452: Surface Engineering
Mechanical	ME 361: Design of Machine Elements	ME 453: Advanced Material Processing ME 465: Introduction to Automobile Engineering	ME 362: Mechanical Engineering Design ME 494: Total Quality Management	ME 352: Manufacturing Technology II ME 492: Operation Management	ME 471: Power Plant ME 291: Engineering Economy ME 493: Industrial Safety ME 474: IC Engine
Electronics		EE 416: Power System Design	EE 333: Solid State Electronics	EE 443: Industrial Process Control	
Computer Science		CSE 434: Project Management & Operation Research			CS 418: Digital Image Processing CS 413: Computer Communication & Networking