ABSTRACT
The paper focuses on the evolution of environmental issues from a concept to a system leading to a new manufacturing system known as environmentally conscious production that impacts the manufacturers from product/process design to disposal of the product after its use. Various enablers that make the organizations to embrace environmentally conscious production along with the obstacles that hinder the implementation of environmentally conscious production have been identified. Some performance measures for the evaluation of environmentally conscious production are presented for the managers/decision makers to assess the impact of environmentally conscious production implementation.

Keywords: Environmentally Conscious Production; Evaluation; Performance Measures.

1. INTRODUCTION
With growing awareness of environmental issues – from global warming to local waste disposal and pollution problems – business and government have come under increasing pressure to reduce the environmental impacts involved in the production and consumption of goods and services. Until quite recently the usual response to environmental problems involved measures to reduce pollution and waste after they had been produced; for example, by installing flue gas desulphurization equipment in a power station or waste water treatment plant in a factory or adding catalytic converters for cars or banning sale of polythene bags. However, from the late 1980’s onwards some organizations began to shift their attention from these ‘end of pipe’ approaches towards developing ‘clean’ manufacturing, which generates less pollution and waste in the first place and make efficient use of energy and materials.

Current practices of product development in manufacturing organizations are still predominately based on traditional cost/profit models, aiming at achieving high quality of a product at low cost and high profit. Environmental requirements are mainly considered as an unavoidable ‘must’, which generates additional design constraints and increases the costs. In an approach like this, environmental assessments are carried out fairly late in the product development process. They are not integrated with existing development activities, and are likely to increase the development costs. This paradigm of product development towards low cost and high profits is unlikely to change significantly as organizations have to make profits for their existence. However, the integration of environmental requirements through life-cycle stages of a product is a likely approach, leading to a new paradigm of environmentally conscious production (ECP). Being an integrated approach, it will not purely add-on some constraints, but it will identify new environmental features of a product that have the potential to create additional market and profits (Kaebernick, Kara and Sun 2003).
European Union, Japan and parts of United States lead in the implementation of environmentally conscious production. In India, the Ministry of Environment and Forest (MOEF) brings out new regulations, norms and standards on pollution prevention and control. Various arms of MOEF have forced industries to comply with these norms and failure to comply with has led to the closure of many industries. In addition, the recent judgments of the Supreme Court of India - ban on diesel run public transport vehicles in Delhi, shifting of polluting industries out of Delhi or closure of mining in Aravali ranges around Delhi – has translated into losses of crores of rupees and joblessness for millions related to these business and industry. The compliance with the regulations and norms does improve the environmental conditions but it makes the environmental issues and norms ‘monsters’ which the industry and business always try to avoid by just complying with these regulations and norms. Need of the hour is to make the environmental issues and norms friendly for business and industry so that they can improve their bottomlines by embracing these regulations and norms. This can be done, first, by understanding thoroughly the enablers and obstacles in the implementation of ECP and then implementing ECP as a system.

The single largest problem in implementing ECP as a system is the lack of performance measures (Sangwan 2006). The traditional performance measures such as return on investment, profit and cash flow are invalid for the measurement of ECP practices as they are based on outdated traditional cost management systems, lagging metrics, not related to corporate strategy, inflexible, contradict continuous improvement and not necessarily reflecting the organization’s core competency. Therefore, proper performance measures, derived from corporate strategies and capabilities, are a prerequisite for the implementation of advanced manufacturing systems like environmentally conscious production systems to survive in today’s competitive environment. This paper defines the systems approach of ECP, lists the enablers and obstacles for the implementation of ECP and finally provides the performance measures for ECP.

2. ECP: A SYSTEMS APPROACH TO ENVIRONMENTAL CONCERNS
Organizations have three approaches to become environment friendly – concept approach, compliance approach and system approach. Concept approach considers implementation of simple environmental protection measures like installing energy saving systems, waste recycle bins or by using rechargeable batteries or biodegradable materials etc. or by switching off lights, fans, computers photocopiers when not in use. This approach is the first stage wherein the organization’s concern for the environment is reflected in implementation of protection measures. In compliance approach organization comply with the environmental regulations. Here, the organization’s concern is being reflected throughout the organization by implementation of national or international standards like ISO 14001 standards. Systems approach embraces an integrated approach to environmental concerns in design, production, distribution, use and disposal of the products. Here, the organization’s concern for environment is being reflected in organizations strategies and business practices inside the organization as well as outside the organization. The ECP system considers supplier concerns and market considerations along with production, distribution, service, use and disposal issues during the design of the product. Today, ECP involves continuous improvement of environmental attributes of products, processes and operations. The most far-reaching implication of ECP is the need to take an environmental life cycle approach to production.
This approach requires that environmental impacts – with ‘environmental’ taken broadly to include relevant safety, health, and social factors – be understood and summed up across the life-time of the product, process, material, technology, or service being evaluated. The goal is to reduce to a minimum the overall environmental impact of a product or process, and not simply address one aspect of the impact, as minimizing the impacts of subsystems does not ensure that the impacts of the entire system are minimized, or even reduced.

Environmentally conscious production is also known by plethora of different names – clean manufacturing, environmentally conscious manufacturing, environmentally responsible manufacturing, total quality environmental management, and sustainable manufacturing. Irrespective of the name, the goal remains the same – designing and delivering products that minimize negative effects on the environment through their production, use and disposal.

3. ECP ENABLERS

ECP raises several questions of market response, material choices, energy use, product development, customer relations, trade relations, waste management, information needs, and public policy choices. The current environmental practices of manufacturers are primarily organized under environmental health and safety concerns (Richards, 1994). ECP challenges industry and business to address environmental concerns at the level of their core competency. ECP is increasingly forcing a fundamental rethinking of the manufacturing systems. The goals, objectives, performance measures, effectiveness & efficiency, and the organization as a whole are affected by this new thinking. The primary factors or enablers for ECP, identified through literature review (Sangwan, 2006; Ammenberg and Sundin, 2005; Nielsen and Wenzel, 2002; Handfield, 2001; Melnyk and Smith, 1996; Jaffe et al, 1995; Dowie, 1994;) and discussions held with the experts, are given in table 1. A thorough understanding of the enablers helps the decision makers in framing the strategies to be adopted for the successful implementation of environmentally conscious production systems in their organizations.

<table>
<thead>
<tr>
<th>ECP Enabler</th>
<th>ECP Enabler</th>
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<tr>
<td>Government/Regulatory authorities</td>
<td>Influencing industrial standards</td>
</tr>
<tr>
<td>Management Commitment &amp; support</td>
<td>Improved corporate image and public perception</td>
</tr>
<tr>
<td>Business issues</td>
<td>Improved competitiveness</td>
</tr>
<tr>
<td>Consumers &amp; Suppliers</td>
<td>Sense of responsibility/company social responsibility</td>
</tr>
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<td>Environmental advocacy groups</td>
<td>Market demand from end-users</td>
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<tr>
<td>Investors</td>
<td>Market demand from end-users</td>
</tr>
<tr>
<td>Local community</td>
<td>Activities of competitors</td>
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<tr>
<td>Politicians</td>
<td>Research and technology innovation</td>
</tr>
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<td>Workforce</td>
<td>Improved employee motivation</td>
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<tr>
<td>Technology</td>
<td>Market demand through supply chain pressure</td>
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<td>Empowered teams/individuals</td>
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<td>Reward system</td>
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<td>Reduced liabilities</td>
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4. ECP OBSTACLES
In spite of the numerous factors encouraging introduction of environmentally conscious production systems, it has not seen widespread acceptance and use. Industries are still considering environmental issues as ‘something’ to comply with for government regulations and norms. Some of the obstacles faced by ECP, identified through literature review (Sangwan, 2006; Melnyk and Smith, 1996; Dowie, 1994) and discussions held with the experts, are given in Table-2. Managers/decision makers should use these obstacles as checklist before they start ECP implementation in their organizations.

<table>
<thead>
<tr>
<th>ECP Obstacle</th>
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<tr>
<td>1. No strategic impact</td>
<td>10. Fears that alternatives may pose different problems</td>
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<td>2. Tight finances</td>
<td>11. Short product life cycles</td>
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<td>3. Lack of resources</td>
<td>12. Conflicting standards</td>
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<td>4. Lack of top/middle management commitment</td>
<td>13. Regulation confusions</td>
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<td>5. Regulatory compliance is enough</td>
<td>14. No explicit environmental policy</td>
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<tr>
<td>6. Defining ‘green’</td>
<td>15. Lack of human resources</td>
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<tr>
<td>7. Inadequate performance measures</td>
<td>16. Lack of proactive approach</td>
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<td>8. Lack of frameworks</td>
<td>17. Lack of change management policy</td>
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<tr>
<td>9. Uncertainty over future regulations</td>
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5. ECP PERFORMANCE MEASURES
In recent years the ECP has been widely considered for implementation to maintain competitive advantage. However, the implementation of such systems is expensive and relative investments tend to be irreversible, thus necessarily requiring careful consideration before a decision can be made. At present, managers have difficulty in assessing the impact of green manufacturing because of the lack of appropriate performance measures (Azzone and Noci 1998). Without such measures, it is difficult to justify ECP as an alternative option. As a result judgments about ECP become costs in ethical or moral terms. Some of the suggested performance measures for ECP, identified through literature review (Sangwan, 2006; Vandermeulen et al, 2001; Melnyk and Smith, 1996; Dowie, 1994) and discussions held with the experts, are given in table 3. These performance measures are broadly classified as quantitative measures or qualitative measures. Further, quantitative performance measures are categorized as measures related to cost, material consumption (product as well as packaging), energy consumption and Pollution/Toxicity emission.

Although, during production it is not possible to completely avoid the use of water and energy or to prevent the output of waste and emissions, but organizations can concentrate on optimizing them by judicious selection of materials, processes, assembly methods, packaging, and logistics to decrease the harmful effect on environment.
### Table-3. Performance Measures for ECP

<table>
<thead>
<tr>
<th>Category</th>
<th>Quantitative Performance Measures</th>
</tr>
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| Cost (Indian Rupees)      | • Material cost  
                           • Labour cost  
                           • Process cost  
                           • Transportation cost  
                           • Warehousing cost  
                           • Disposal cost  
                           • Production overheads cost  
                           • Administrative expenses  
                           • Waste handling cost  
                           • Waste storage cost  
                           • Waste categorization cost  
                           • Waste treatment/disposal cost  
                           • Reduced product cost |
|                           | • Material consumption  
                           • Amount of restricted materials  
                           • Amount of prohibited materials  
                           • Fraction recycled materials  
                           • Fraction recyclable materials  
                           • Fraction renewable materials  
                           • Fraction reused components  
                           • Amount of water used |
| Material (product and packaging) (Kg/piece) | • Energy consumption in production  
                           • Energy consumption in use  
                           • Energy consumption in service/maintenance  
                           • Energy consumption in disposal |
| Energy (KW)               | • Air pollution (ppm)  
                           • Water pollution (gm per cubic meter)  
                           • Solid waste (tones per annum)  
                           • Hazardous waste (tones per annum) |
| Pollution/Toxicity        | • Customer loyalty  
                           • Improved profitability  
                           • Improved company social responsibility  
                           • Stimulated staff morale  
                           • Enhanced market opportunity  
                           • Minimal future liabilities  
                           • Improved performance  
                           • Reduced regulatory concerns  
                           • Durability  
                           • Odor pollution |

**CONCLUSIONS**

Today, organizations have to think environmentally conscious production (ECP) as a system that affects them throughout the product life cycle – design of products and processes, distribution, use, and disposal – to reduce the harmful impact of environment and to create...
additional market share. Organizations have to include environmentally conscious production at the level of their core competency and should not merely think it as a tool to comply with the environmental regulations and norms. However, the lack of performance measures is a handicap for the widespread implementation of environmentally conscious production. Researchers have to come forward to develop easy to use, easy to understand and general performance measures for ECP. This paper presents enablers, obstacles and performance measures, identified through literature review and discussions held with the experts, for environmentally conscious production.

REFERENCES