Simulation Based Impact Analysis for Sustainable Manufacturing Design and Management

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Outline

• Research Aims & Objectives

• Sustainable Manufacturing Developments & Directions
  • Practices, Problems and Challenges

• Current Sustainable Manufacturing Systems Research

• Future Research Direction

• This Research Direction

• Conclusion
Research Aims & Objectives

The aim of this research is to develop a simulation based framework for the support of a holistic assessment of sustainable manufacturing design and management.

The objective is to deploy Discrete Event Simulation (DES), sustainability assessment methodologies, methods and tools into a common framework that will enable assessment of both production and sustainable performance of a manufacturing system.
Sustainable Manufacturing Developments and Directions

In the beginning...

The skilled manufacturing designer designs for Competitive Advantage

- Lean Manufacturing
- Just In Time
- Agile Production
- Total Quality Management
- Lean Six Sigma
- Design for Manufacture...

Problem: It is not sustainable!
Sustainable Manufacturing Developments and Directions

- Nowadays, the task is highly complex and uncertain

- Competitiveness
- Sustainability
- Technology
- Globalisation
- Supply chain
- Value chain
- Service chain

Problems: Huge Data, lack appropriate tools & Support for Decision Making!
Sustainable Manufacturing Developments and Directions

What is Sustainable Manufacturing?

USA Department of Commerce defined Sustainable manufacturing as “the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound”.

Sustainability factors

- Economic development
- Social development
- Environmental protection

Need Balance

Economic
Environmental
Social

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Current Sustainable Manufacturing Systems’ Research

- Frameworks, Methodologies, Methods & Tools:
  - ISO 14040 –Life Cycle Assessment Framework
  - Life Cycle Costing
  - Social Life Cycle Assessment
  - Energy Management system
  - Simulation

- Optimisation
  - Competitiveness
  - Sustainability
  - -Layout
  - -Process
  - -Labour
  - -Cost...
  - -Energy /water Consumption
  - -Embodied energy
  - -Waste...

- Problem: Lacks integration of the 3 factors!
- Problem: Does not support corporate policy and decision making!

- Environment Life Cycle Assessment (LCA) with...
  - Lean Manufacturing
    - Or
    - Value Stream Mapping
      - Or
      - Activity Base Costing
        - Or
        - Corporate Social Responsibility
  - Or
  - Decision Making & Evaluation Decision Making

The need for a Holistic assessment tool
Current Sustainable Manufacturing Systems’ Research

- **Frameworks:**
  - ISO 14040 – Life Cycle Assessment (LCA)
  - Life Cycle Sustainability Assessment (LCSA)

Problem: Independently assessed!

Failed to consider the mutual interaction amongst the three sustainability pillars hence, devoid of holistic understanding of the system under consideration.
Lesson Learnt From History......

Law of unintended consequences (or revenge effect)

The Great Sparrow Campaign in China

The campaign against the 'Four Pests' was initiated in 1958 as a hygiene campaign by Mao Zedong.

Result: – Near extinction of the birds, Locust population ballooned, Rice yield declined by at least million people died of starvation

http://blogs.discovermagazine.com/bodyhorrors/2014/02/26/mao-four-pests-china-disease/

Midgley had more impact on the atmosphere than any other single organism in Earth's history”. J. R. McNeill

Thomas Midgley, Jr. (1889-1944)

Developed the Tetraethyl lead (TEL) additive to gasoline as well as some of the first chlorofluorocarbons (CFCs).

Awarded 1923 Nichols Medal for the "Use of Anti-Knock Compounds in Motor Fuels"
Future Research Direction

From Sustainability Assessment to Sustainability Analysis

- ISO 14040 –Life Cycle Assessment (LCA)
- Life Cycle Sustainability Assessment (LCSA)

System Thinking & Life Cycle Thinking

Holistic LCSA tool

Life Cycle Sustainability Assessment (LCSA)

United Nations Environment Programme (UNEP) and Society of Environmental Toxicology and Chemistry (SETAC) Life Cycle Initiative framework

Incorporating Sustainability Science and Sustainability Analysis!
This Research Direction

Simulation Based Sustainability Analysis

Simulation Platform

- Sustainability tools
- Life Cycle Thinking
- Competitive tools

Gate-to-Gate Manufacturing Boundary

Energy
Materials
Processes
Product Quality
Health & Safety
Training & Education
New Technology & Innovation

SimaPro

CIP

Simio

forward thinking

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This Research Direction

**SYSTEM THINKING**

**LIFE CYCLE THINKING**

Integrated Framework for Sustainability Analysis
This Research Direction

Challenges
- Commercially available simulation software only considers competitive factors as standard
- Standardised Sustainability Indicators and Metrics
- Acceptable thresholds
- Integration of Sustainability factors into simulation

Simulation-Based Conceptual model for Life Cycle Sustainability Analysis (LCSA)

https://www.youtube.com/watch?v=rxpJN7hUTzo
Example of Simio Simulation Manufacturing Software

https://www.youtube.com/watch?v=rxpJN7hUTzo
Conclusion and Potential Benefits of the Framework

The framework will:

- Integrate the three Sustainability Factors
- Enable analysis of the interdependences
- Be effective for Cost and Risk Reduction
- Enable Consistency in Reporting
- Provide effective Stakeholders’ Engagement
- Provide effective Sustainability Indicators and Metrics
- Provide effective support for Manufacturing Decision Making
Simulation Aided Life Cycle Sustainability Assessment (LCSA) Framework for Manufacturing Design and Management

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Questions..