A Framework for Integrating Systems Thinking into Sustainable Manufacturing

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Abstract

Understanding the relations of sustainability behaviors in manufacturing systems and actively engaging with manufacturers (especially SMEs) in sustainability efforts is key to the long-term success of U.S. industry and the ecological environment. This study addresses this urgent need by establishing a systemic approach for the design of costing methods by linking the economic, environmental, and social domains of sustainable manufacturing with systems thinking principles, and by understanding the actual sustainability-related behaviors in a real metal product manufacturing setting with the collaboration of a small manufacturer. The proposed system dynamics based method identifies sustainability factors and behaviors of the manufacturing system and depicts their relations across three system levels, the enterprise level, the shopfloor level, and the process/operation level. The creative method design approach from the domain of systems thinking principles, manages to integrate economic assessment, environmental assessment, and social assessment methodologies and quantify the assessment results, which are embedded in the systems dynamics model. The model, consisting of identified manufacturing behaviors, for example product design, environmental impact control, process safety improvement, is able to assist decision makers by providing sustainability performance changes over a determined time period. Based on the results of this research, U.S. manufacturers will be able to develop systemic costing approaches towards improving worker well-being, energy efficiency, and cleaner production at lower cost.

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