Material Flows and Environmental Impacts of Manufacturing Systems via Aggregated Input–Output Models

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Abstract

Manufacturing processes may be viewed as operational units in the overall manufacturing/production system. Changes in technology, production patterns, and process settings are typically made at the process (unit) level. Very often, environmental problems are apparent when the manufacturing/production system is viewed as a whole (many units joined together). However, with the units aggregated to form a system, it is often difficult to identify the source of an environmental problem or judge the singular effect of changes to a process unit; the changes become lost in the complexity of the system as a whole. Recent efforts have employed input–output modeling to describe the flow of materials and the environmental consequences associated with manufacturing processes. A method is introduced for aggregating process-level material input–output models to form a combined material input–output model for a manufacturing system. The resulting model serves as a bridge between unit-level changes and broader system behaviors. The model form permits identification of opportunities for reducing environmental impacts at the process level (e.g., reduction of emissions, waste generation, and material use) and driving the system toward zero emissions based on an examination of the aggregated manufacturing system level model. Case studies are used to illustrate the application of the aggregated material input–output model to minimize waste and resource consumptions.

Keywords: Input–output; Material flows; Environmental impact; Model aggregation; Zero emission