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Notes Regarding a Database of Basic "Transformation" Processes

Introduction

A starting objective of the US LCI Database project is to develop a database of parameterized basic "material transformation" processes. Such a database of unit process modules would in principle quantify energy and material input requirements and pollution and waste output flows per unit of processed material or "process output." The feasibility of achieving this objective requires investigation.

The contents of such a database would be parameterized models at as high a level of generality as possible, together with estimates of the variability or uncertainty in the models. Thus, the database would contain modeling information sufficient to allow users to generate a linear unit process description appropriate for a given modeling application.

As an introductory example, the database may contain a process description for bending metal sheet. The database might characterize how the energy requirements per unit length of bend depend primarily upon the type of metal, the finished angle, and the thickness of the metal sheet. The database might contain tables of unit energy input factors per unit length of bend, with table entries for different materials, finished angles, and sheet thicknesses. Or it might contain a smaller table of equations, one for each metal type, characterizing unit energy input as a function of metal thickness and finished angle.

Of course, LCA process descriptions used in LCI models ultimately are linear in nature, specifying unit factors of input and output flows per process functional output. But rather than containing only linear LCI process descriptions per se, the transformation process database would contain more general data, providing the basis for creating linear LCI processes for as many possible standard transformation processes as possible.

Draft Typology of Unit Processes

There are hundreds of manufacturing processes to consider for potential inclusion in the LCA process database. Criteria for inclusion will need to be developed, and would likely include the prevalence of the given process type, the likely environmental importance of the process type (in terms of energy or material inputs and/or pollutant or waste outputs), and the ability of a practical parametric model or table to characterize a breadth of application situations within acceptable error levels.

A 1995 report by the National Research Council[1] provides a potential starting point for classifying process types. The report suggested five distinct unit process families, summarized in the table below. This process taxonomy of unit processes is independent of the type of material being worked; they are applicable to the full range of workpiece materials: metals, polymers, ceramics, and composites. In addition to these processes, the authors noted such other potential process categories as chemical synthesis, fabrication of electronic materials, component assembly, alloy development, and raw materials production.

A Unit Process Typology

Process Family	Description	Examples
Mass change	Removal or addition of material by mechanical, electrical, or chemical means	Machining, grinding, finishing, plating, electro-discharge, electrochemical machining
Phase change	Production of a solid part from material originally in liquid or vapor phase	Casting of metals, manufacture of composites by infiltration, injection molding of polymers
Structure change	Altering the microstructure of a workpiece, either throughout its bulk or in a localized area such as its surface	Heat treatment, surface hardening, precipitation hardening, laser processing
Deformation	Altering the shape of a solid workpiece without changing its mass or composition	Bulk-forming metalworking processes such as rolling and forging; sheet-forming processes such as deep drawing and ironing
Consolidation	Combining materials such as particles, filaments, or solid sections to form a solid part of component	Joining processes such as welding and brazing; powder metallurgy, ceramic molding, polymer-matrix composite pressing

Source: *Unit Manufacturing Processes: Issues and Opportunities in Research,* 1995, Washington, DC: National Academy Press; p.

[1] *Unit Manufacturing Processes: Issues and Opportunities in Research*. Washington, DC: National Academy Press. 1995.