Manufacturing Technology Platform (MTP)

MTP Theme: Sustainable Manufacturing

GOAL

Sustainable manufacturing is a platform for development of innovative manufacturing technologies which address world wide resources shortages and excess environmental load to enable an environmentally benign life cycle.

Initiative Title:

CO_2PE!
Cooperative Effort on Process Emissions in Manufacturing

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1 Initiative Title: CO_2PE !: Cooperative Effort on Process Emissions in Manufacturing

1.1 Overview of the Initiative

In contrast with material production, manufacturing processes, as used for discrete part manufacturing, are poorly documented in terms of environmental footprint. Accordingly LCA-dbases are very incomplete when it comes to process documentation and the data they contain are often crude and not based on an intensive study of the underlying processes. This lack of thorough analysis of manufacturing processes has as a consequence that optimisation opportunities are often not recognised and that improved machine tool design in terms of ecological footprint has only been targeted for a few common processes (mainly material removal processes such as milling).
At the same time a trend can be observed towards more energy intensive processes (e.g. the evolution in sheet metal cutting from energy efficient guillotine cutting, over punching, nibbling, oxyfuel and plasma cutting, up to laser cutting as dominant solution today). The energy consumption impact of the manufacturing sector is in consequence growing steadily. At the same time the intensifying use of non-conventional processing techniques, such as electro-chemical and laser based processes, results in the generation of emissions that have hardly been investigated from an environmental perspective. These undocumented and hard to control material flows are likely to imply significant potential human health hazards.
As a result of these observations, a coordinated effort to document the emissions linked to a wide range of processes and to identify potential improving measures on a machine design level is proposed. Recognition of the need for such a coordinated effort has emerged in the context of the CIRP Working group on Life Cycle Engineering (STC-A). Recent workshops, organized in the framework of the CIRP General Assembly (Paris, 23-25/01/08) and the CIRP LCE2008 Conference (Sydney, 17-19/03/09), revealed a wide interest in this domain and a willingness to contribute to a joint effort, driven by a generally recognised need to lower the environmental footprint of manufacturing processes. A special interest in CO_2 emission reduction could be noticed. However, this does not reduce the scope of the recognised research need to energy consumption only. Although an important contribution to the environmental footprint, the Global Warming Potential of manufacturing processes exceeds the CO_2 emissions linked to power requirements of production facilities.

Objective of the CO_2PE! initiative is to cluster forces in different continents, involving machine builders as well as academics, to analyse existing and emerging manufacturing processes for their ecological impact in terms of direct and indirect emissions. Possible measures for systematic reduction of the footprint of a wide range of manufacturing processes will be identified in the process. A better knowledge of the impact caused by different manufacturing unit processes, will contribute to a more systematic quantification of the production impact associated with a given product design and corresponding process plan. As such the proposed coordinated effort will contribute to

LCI data as required for systematic LCA studies, covering the production stage of individual products.

The involvement of a large number of parties will assure an appropriate, statistical approach, covering multiple machine types and process-material combinations for every studies manufacturing process. As such the credibility of the outcome of the effort will be high. Taking into consideration that the machine tool market is situated at a truly global level, an international cooperative effort, as facilitated by the IMS framework, forms a prerequisite for systematic progress in this domain.

An important target of the initiative is to derive ecodesign guidelines for machine tool builders and best practice reference specifications for future generations of machine tools. Case studies performed by the initiative takers of CO_2PE! prove that significant improvements in terms of, for example, CO_2 emissions can be achieved, sometimes with fairly simple design measures. Based on these experiences, a 20% reduction seems a reasonable target for a wide series of processes. As such the CO_2PE! initiative will provide a direct return of investment to the involved companies by providing clear insight in design improvement opportunities with consequences both in terms of environmental impact and life cycle costs.

Specific targets are:

1. LCA knowledgeable analysts, in close cooperation with domain specialist in different manufacturing process categories, will conceive **parametric emission estimation models for a wide range of processes**. Towards product developers this will provide a tool to assess the influence of choices made during the manufacturing stage on the impact of products.
2. Towards machine builders the underlying process analyses will provide **insight in achievable emission reducing measures**. Case studies have demonstrated that intelligent control of peripherals can already lead to significant CO_2 emission reductions through systematic energy savings. When taking into account the idle time during which the principal process-material interaction is absent, systematic transition to power saving modes during stand-by periods can also contribute to substantial savings.

   Towards machine developers, the availability of **detailed knowledge of the impact share linked to different machines modules, allows quantification of the possible consequences of the implementation of innovative technologies** in the core process (e.g. fibre laser substitution of CO2 laser sources).
3. As an output to be widely spread, **eco-design recommendations for different machine type**s will be derived from the analysis. Reference energy consumption levels and best practice checklists will be compiled that can be used for the creation of an eco-label system for machine tools. The international cooperation between machine builders and academics from a wide range of countries will facilitate the acceptance of the results of the co-operative effort by different governmental institutions and the final implementation of the envisaged eco-label system.

1.2 Planned Work, Resources and Timing

The following activities are envisaged for the proposed MTP initiative:

Activity 1: Joint methodology development.

Intensive interaction and cooperation between experts in the domains of manufacturing processes research, LCA methodology development and product design techniques will be required to conceive a consistent methodology suitable for systematic data collection and analysis. The methodology to be developed will respect the achievements in terms of LCA studies as covered by the ISO 14040 standards. Purpose is to conceive parametric models for process related impact quantification through estimated emission volumes.
This methodology development is expected to involve process categorisation, functional unit determination, extensive study of correlations between process emissions and indicators that can be derived from workpiece feature analysis as quantifiable parameters.
A number of workshops are planned here in order to intensively discuss the different methodological approaches that can be called upon for data collection and analysis requirements. Multi-media communication tools will be used to support a continuous discussion between key players in between workshops.
Output of these efforts will be procedures and recommendations for the following activities.

Activity 2: Coordinated data collection.

Based on a systematic taxonomy of manufacturing unit processes, a worldwide data collection effort will be coordinated. The large number of research institutes and associated industrial partners in different continents, that has confirmed the intention to contribute to the proposed joint effort, requires a large coordinative action in order to efficiently link the required expertise and facilities to each other. Exchange of researchers and equipment as well as sharing of experience and comparison of data is envisaged here.
A centralised overview and coordinating effort will allow to avoid undesirable redundancy in data collection efforts while facilitating direct communication between parties with overlapping interests and expertise needs.
The coordinative effort will be based on the matrix scheme shown below:

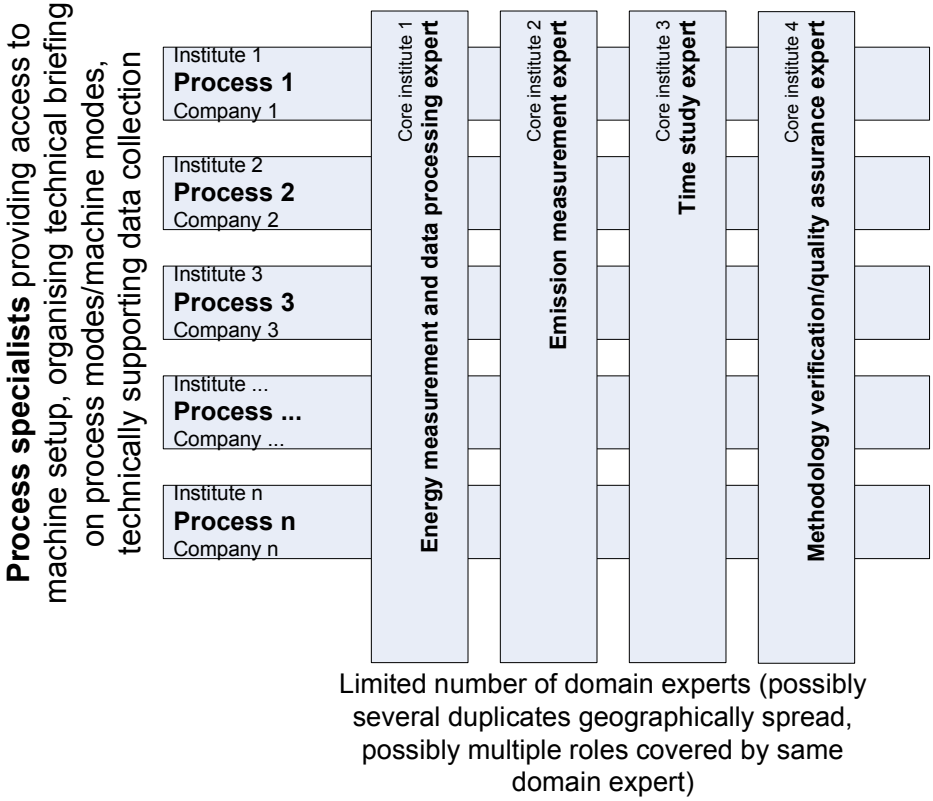

Figure 1: Operational cooperative scheme for data collection and analysis

Activity 3: Data sharing in function of systematic analysis

Several research institutes have committed to allocating master and PhD students to the analysis of the data that will be obtained as result of the efforts coordinated in Activity 2. Using the methodologies emerging from Activity 1, parametric models need to be conceived linking workpiece features, that can be derived from part specifications, to emission estimates for the selected manufacturing processes. In order to assure a statistically sound outcome of these analysis efforts, systematic access will need to be provided to the data collection results of all CO_2PE! partners focussing on a specific manufacturing process. For this purpose "process communities" will need to be constructed sharing data and analysis expertise. Timely feedback of obtained analysis results will provide a return for data sharing.

On an operational level, parallel working sessions, dedicated to the different process communities, are envisaged as part of the workshops that will be organised regularly. A pace of three workshops a year is expected to provide sufficient direct interaction to assure fluent direct communication in between workshops in function of data exchange

and feedback. In order to minimize the logistical load, the workshops will typically be scheduled as part of or immediately before or after relevant international conferences.

Activity 4: Output dissemination

Extensive documentation of data collected and analysis results obtained for the different manufacturing processes is an explicit target. These results will be made available through easily accessible channels (such as on-line databases supported by different partners in the initiative) and on a cost sharing basis ("shareware" or whenever feasible "freeware") and provided to LCA tool developers for inclusion in unit process LCI databases.
Obtained results will be announced to a broad public through dedicated symposia and workshops at conferences (e.g. CIRP LCE conference series and Global Conference series on Sustainable Manufacturing).
Best practice recommendations will be derived from the analysis results. While device specific advice will be provided to the involved machine tool builders as direct feedback and return of investment for the time and effort spent in the data collection phase, generic recommendations will be formulated towards worldwide machine tool developers. The manufacturing process taxonomy tree will be screened for appropriate recommendations levels that can lead to the generation of "a best available technology reference" as a first step in the direction of eco-labelling of machine tools.

1.3 Prospective participants as of 15 March 2008

Regions involved: EU, USA, Japan (discussions with potential partners from other regions are in progress).

Projects involved: Several partners have already secured individual funding. The partners not involved in an IMS partner region (Australia, Brazil, Canada) have agreed to join in on a self-financing basis. An FP7 initiative is envisaged to provide systematic financial support for EU partners and associated parties.

Partners involved:
EU: K.U.Leuven, Belgium (Prof. J. Duflou, Dr. W. Dewulf), DTU, Denmark (Prof. M. Hauschild), TUWien, Austria (Prof. W. Wimmer), TUBerlin, Germany (Prof. G. Seliger, Prof. E. Uhlman), Univ. Braunschweig (Dr. C. Hermann)
Japan: University of Tokyo (Prof. F. Kimura), Waseda University (Prof. S. Takata)
USA: Georgia Tech. Univ. (Prof. B. Bras, Prof. L. McGinnis), Virginia Tech. Univ. (Andre Clarens), Northeastern Univ (Dr. J. Isaacs), MIT (Prof. T. Gutowski), Wichita State Univ. (Prof. M. Overcash, Dr. Jan Twomey), Univ. of Michigan (Dr. S. Skerlos), Michigan Technological Univ. (Prof. J. Sutherland)
Australia: UNSW (Prof. H. Kaebernick, Dr. S. Kara)
Brazil: Univ. of Sao Paolo, (Prof. A. Ometto, Prof. J. Oliviera)
Canada: Queens University (Prof. J. Jeswiet)

All of these research institutes have established cooperations with one or more machine tool builder and/or major manufacturing companies interested in the manufacturing process footprint in general and CO_2 emissions in specific. In a next round these industrial partners will be formally included in the MTP Initiative description.

1.4 Contact Information

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