Chapter 102
Green Computing as an Ecological Aid in Industry

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ABSTRACT

This chapter concerns the use of computing for ecological evaluation in the manufacturing industry. Here, ecological evaluation means identification and quantisation of various manufacturing process characteristics from the point of view of the environment. Manufacturing is a complex process with many different interactions between the parameters controlling the manufacturing machine tools. In the past, manufacturing planners and operators have set these parameters without understanding the consequences, leading to waste of energy, cutting fluid, and so on. This chapter presents a computer tool for evaluating and quantifying the effects of different manufacturing choices using chosen criteria. The tool was implemented as part of the work for a European project. It is based on an extensive analysis of machine tools to provide a way of handling the complexities of understanding the use phase of products.

INTRODUCTION AND BACKGROUND

The aim of this chapter is to explain the use and practice of one aspect of green computing in the manufacturing sector. The contents of the chapter concerns work done for a doctoral dissertation (Avram, 2010) performed as part of a European project on the next generation of machine tools (the NEXT project). The work is important for manufacturers to evaluate the consequence of different manufacturing strategies and to quantify the effects of these on the environment. Manufacturing is a very complex task with many interactions making it difficult or impossible to understand the consequences of manufacturing decisions.

The major environmental aspects of machine tool use come during the use phase of the machine tool. At the same time, existing evaluation tools

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are not sensitive enough to cope with the multiple manufacturing variants. Some work has been reported in the literature (Munoz & Sheng, 1995; Dornkudwar, et al., 1998; Srinivasan & Sheng, 1999a, 1999b; Akbari, et al., 2001; Dahmus & Gutowski, 2004; Jayal & Balaji, 2007; Narita, et al., 2006; Zhigang, et al., 2008, etc.) considering green machining issues; however, in most cases the focus has been limited at the process and process planning level.

Munoz and Sheng developed a model with the three dimensions of material, energy, and time as a basis. The material inputs are the primary material and secondary catalyst material, with output of primary material, waste primary material, and waste catalyst. For the energy dimension, Munoz and Sheng identified thermal, electrical, and chemical as input energy with thermal, chemical, and radiative energy as possible outputs. For the time, there is the initiation time as input and the processing time as output. They found that the geometry of the part, the workpiece material and cutting fluid were the dominant factors affecting process energy.

Domkundwar et al. used features as a basis for analysis for environmental impact assessment. The features were treated on a global basis with additional process or process parameter constraints.

Srinivasan and Sheng worked on quantifying health hazards in wet and dry machining of a simple part with one drilling operation and two end-milling operations. No account was taken of solid particles released in completely dry machining.

Akbari et al. worked with energy consumption in the machining process. An interesting element introduced in this work was the notion of fixed energy consumption versus dynamic energy consumption. This energy is needed for production but is not connected with the production itself. In addition, there is the energy needed for the production itself which can be reduced by improving manufacturing strategies.

Dahmus and Gutowski also worked with energy analysis of the machining process. They categorised the energy consumed into three main types: "Constant start-up operations," "Run-time operations," and "Material removal operations." Based on a set of usage scenarios, which they defined, they compared the energy needs for machining both steel and aluminium on modern and conventional machines.

Jayal, Balaji et al. compared drilling of aluminium with both dry and wet cutting conditions. They concluded that flood application for drilling was needed for high accuracy.

Narita et al. developed a method for estimating the environmental burden of machining in terms of contribution to the global warming potential. They converted different elements, like the electrical consumption, the coolant, lubricants and so on, into equivalent CO_2 emissions and used the total as a measure of the environmental effects.

Zhi et al. investigated the environmental impacts of cutting fluids for cutting processes. They also studied some design aspects for machine tools and thermal deformations of both workpieces and machine tools during cutting.

Informatics is needed as a tool for industry, this can be thought of as 'green applied computing.' The work mentioned above needs to model manufacturing processes explicitly or implicitly and to calculate and present a multitude of diverse factors. This is an application of computing for improving environmental awareness, hence the term "green applied computing." Industry is doing a great deal to improve the environmental impact of manufacturing and computing tools are needed to understand and quantify the effects of manufacturing options. In addition, by exposing students to the topic, future engineers are made aware of their social responsibilities and how they can be managed. This research, on measurement and quantification, is important and needs to be extended so as to gain a better picture of environmental loading. The chapter will describe how