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MANUFACTURING PROCESS FOR ENVIRONMENT

Izabella ICHIM
Transilvania University of Brasov, B-dul Eroilor nr. 29, 500036 Brasov, Romania,
+40(0)268477113, e-mail: izabella.ichim@gmail.com

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Abstract: The growing interest in pollution prevention determines several industries to develop and implement various strategies for waste reduction. Design of the product, selection of raw materials, manufacturing process, delivery of the product and reuse or recycling options for products, all have ramifications for the level of environmental degradation. The paper presents several aspects regarding the environmental impact of manufacturing process and the necessity of changed process for preventing polluting generation.

1. INTRODUCTION

Pollution can be more effectively handled by reducing upstream sources of pollutants than by using extensive downstream (or end-of-pipe) treatment processes. Equivalently, "Do your best, and then treat the rest."

Since the early 1970s environmental regulation directed at manufacturing has tended to target either the product or the manufacturing process. For example, cleaner technologies can extract and use resources and energy more efficiently, reduce the release of pollutants during manufacture and delivery and encourage recycling of components and products. In addition to environmental benefits, economic benefits are purported to flow from these investments, creating a 'win–win' scenario.

2. CHANGED MANUFACTURING PROCESSES

Many facets of manufacturing processes have important implications for the condition of the natural environment. But, many products can be manufactured by use of two or more alternative processes. Often, one of the process types involves the use of substances of less vicious than the others. So we can say that there is usually a choice to make among several sources for the equipment, and one type may be more desirable from a pollution prevention standpoint than others.

From the beginning of any manufacturing process, pollution prevention should be a fundamental objective. That objective should be pursued through process development, process design, engineering to construction, startup, and operation. It should also be a continuing objective of plant engineers and operators once the unit begins production (Fig.1). The best time to consider pollution prevention is when the process is first conceived. Once the process has started at the pilot plant, making major process changes or modifications is generally difficult and costly. [4]

Today, because of the waste materials and related emissions from the basic processes, metals processing is considered a significant source of environmental problems. The wastes include contaminated cuttings and chips, waste coolants, lubricants, casting sands, parts washing fluids, etc. Because of the high disposal costs for each of these, manufacturers are self-motivated to reduce, reuse and eliminate, but they need new technologies from which to choose.

In materials manufacturing, the coolants and lubricants are an important source of pollution because they determine water degradation and air quality problems. So, we can say that cleaning is one of the processes within an industrial system that almost always

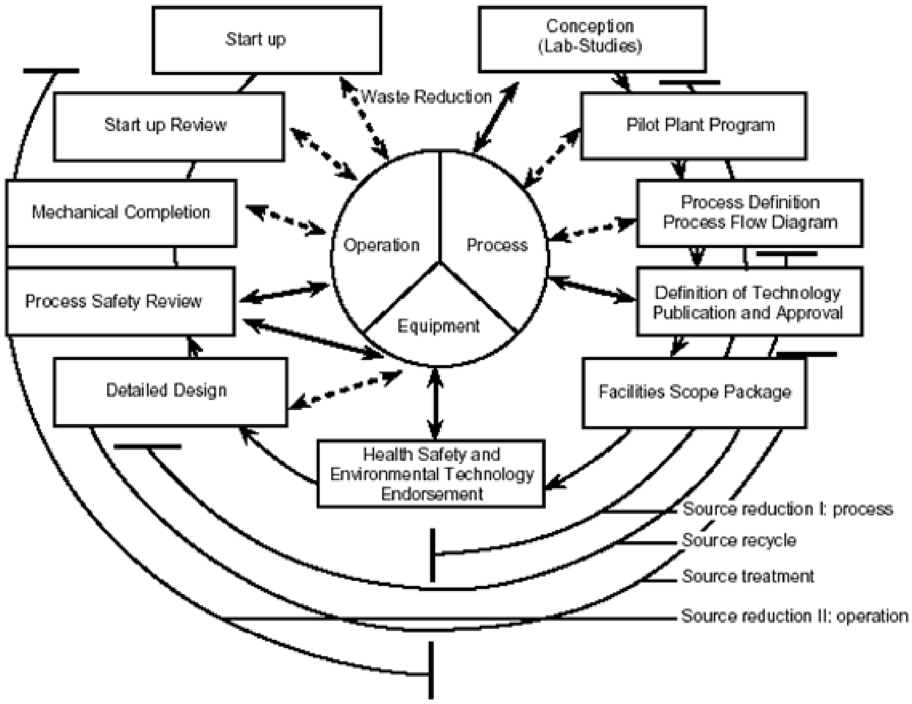

Fig. 1 Waste reduction and new technology development. (Ronald L. Berglund and Glenn E. Snyder, 1990, Waste minimization: The sooner the better, Chemtech)

produces wastes that must be handled and disposed of. Often, the clean-up wastes contain the same substances as the production wastes, plus whatever substances the cleaning agents are composed of. Also, they can contaminate scrap used in remelting.

Because the complete elimination of lubricants is unlikely, new methods of reducing or eliminating coolants in machining processes must be developed.

For instance, an item of equipment that is air-cooled might perform as well as an item that is water-cooled, and would thus preclude the need to discharge wasted cooling water. Of course, it should be ascertained that the air used to cool the equipment would not become degraded in quality before a decision is made regarding replacement.

It is feasible to reduce the use of lubricants substantially in manufacturing processes and whenever possible, nontoxic substances should be used for degreasing and cleaning. If toxic substances must be used for degreasing or other cleaning processes, containment, recycle, and reuse must be practiced to the maximum extent possible. Drips must be contained and returned to the source tanks and prevent drag out and consequent contamination of the next sequential bath or other process. The temperature and viscosity of bath should be included in those variables that can be adjusted to minimize drag out. There should be a constant and consistent program to substitute less-polluting and nonpolluting substances for those that require expensive treatment and disposal. [5]

Another approach is to add a polymer that resists shear to the cutting fluid and reduce the formation of the small droplets and aerosols that determines environmental concerns in machining operations. Of course, wherever possible, machining can be eliminating. For instance, at Volvo, holes in the truck chassis are punched instead of drilled. This is done to facilitate recovery of the metal removed, as punchings are easier to remelt than turnings.

In concert with the previous point, there should be a consistent program for replacing process controls, including sensors, microprocessors, and hardware, with the objective of decreasing waste and maximizing retention, containment, recycle, and reuse of all substances. Also, there should be developed new techniques for recovering and regenerating chemicals, as well as separating and removing contaminants.

In every manufacturing process, solutions must be found, to treat wastes as close as possible to the source and to reuse as much material as possible. It is very important to realize advance research to discover methods of recovering advanced materials either in their original form, or in separating the individual metal values from the material. Research needs include, for example, methods of removing contaminants and trace elements from recycled alloys, methods of economically recovering and reprocessing composite materials, development of true net-shape metal casting and forging methods, methods of recycling and recovering alloying elements in highly engineered materials.

Metal manufacturers have always been interested in reduction the use of energy. And for that manufacturing process designers should always consider energy conservation including, for example: using waste heat to preheat process streams or do other useful work, reducing the energy requirement for pumping by using larger diameter pipes or cutting down frictional losses, saving energy by using more efficient equipment, reducing energy use through proper maintenance and sizing of motors. Also, renewable energy sources such as the sun, wind, and water offer electricity for the cost of the generating equipment. A decrease in the demand for electricity resulting from the use of renewable resources increases the environmental quality.

In cases where equipment is old, worn, and subject to leaks, spills, and inefficient use of materials, it might be cost effective to replace it, based on the savings in cost of materials, cost of operation, and cost of handling and disposing of the wastes.

3. MANUFACTURING AND THE PRODUCT LIFE CYCLE

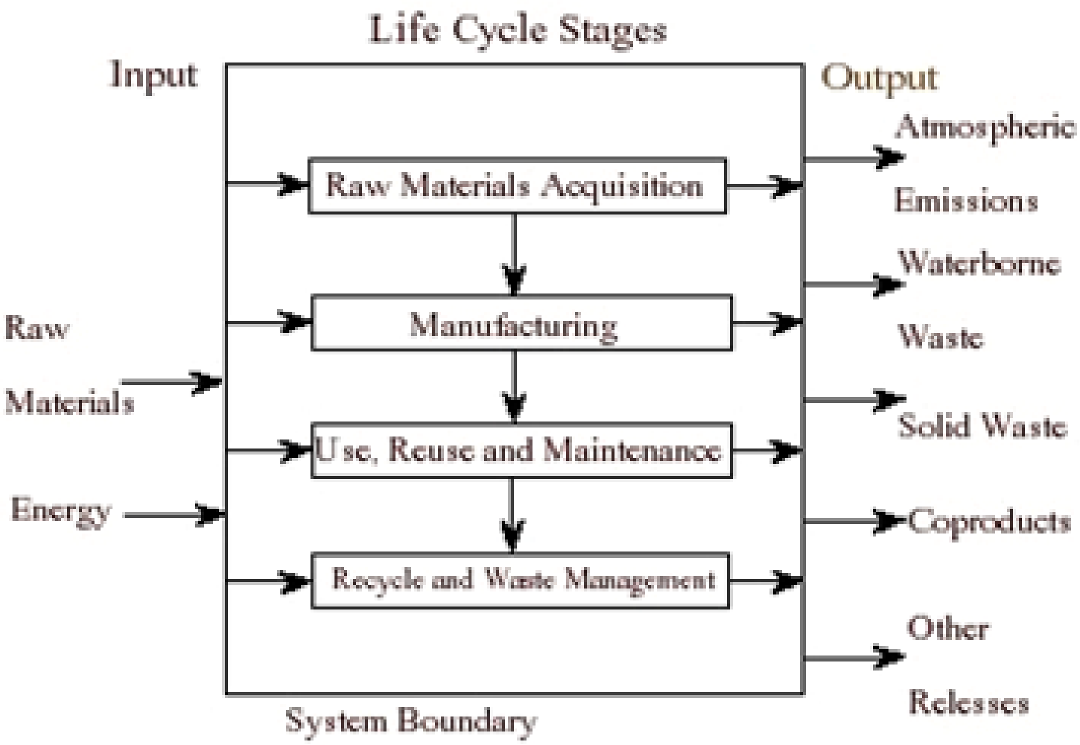

Fig. 2 Defining system boundaries (from G.A.Keoleian, Dan Menerey and M.A. Curran, 1993, Life cycle design guidance manual, EPA/600/R-92/226, January, Cincinatti)

Pollution prevention includes all of the aspects of wastes minimization, whereby pollutants are generated during the manufacturing process, plus all of the effects of the product throughout its life cycle from initial product development to final disposal (Fig. 2).[5]

We must specify that extending the life of a product can directly reduce environmental impact. In many cases, longer-lived products save resources and generate less waste because fewer units are needed to satisfy the same need. Doubling the life of a product translates into a pollution prevention of 50% in process transportation and distribution and a waste reduction of 50% at the end of the product's life. In general products are retired because of technical and fashion obsolescence, degraded performance or structural fatigue caused by normal wear over repeated use, environmental or chemical degradation, damage caused by accident or inappropriate use.

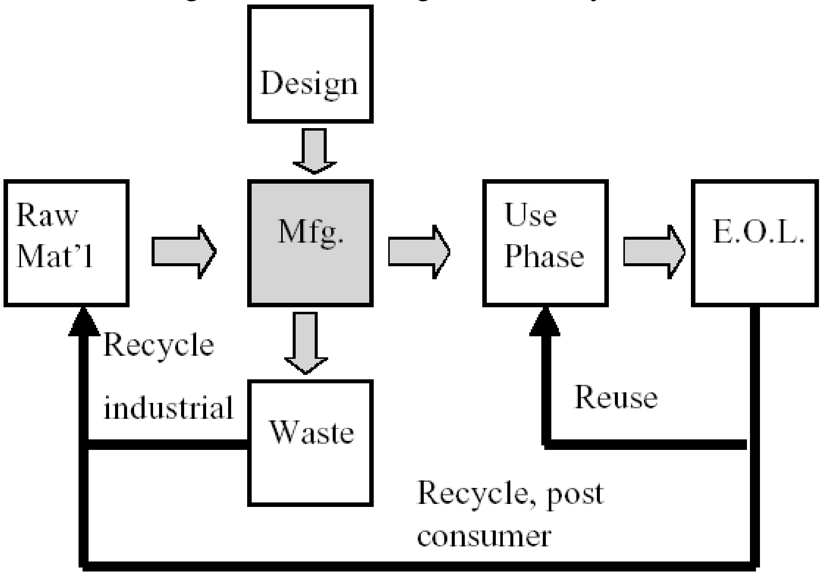

Fig. 3 A closed systems view of manufacturing [6]

In fig. 3 is presented the "closed" systems view of manufacturing, with all of the major activities and the connecting paths for reuse and recycling. In the center of the figure we can see the "open" systems view of manufacturing, which features only the box labeled "Mfg.", along with two input arrows representing design and raw materials, and two output arrows representing wastes and products.[6]

Material selection offers many opportunities for reducing environmental impact. In life cycle design, designers begin material selection by identifying the nature and source of raw materials. Then, they estimate the environmental impact caused by resource acquisition, processing, use, and retirement. Then, they compare the proposed materials to determine the best choices. Minimizing the use of virgin material means maximizing the incorporation of recycled material. A process designed to use material in the most efficient manner reduces both material input and waste. Environmental strategies for product design are also applicable to facilities and equipment. Designers can extend the useful life of facilities and processes by making them appropriately durable. Flexible manufacturing can be an effective life extension for facilities.

Finding new sources of energy and materials is becoming increasingly difficult. As a result, society's interest in reuse, recycling, and recovery of materials from refuse has grown. ***Reuse*** of materials involves either the voluntary continued use of a product for a purpose for which it may not have been originally intended, or the extended use of a product. In materials reuse the product does not return to the industrial sector, but remains within the public or consumer sector. Reuse of materials is a non-polluting, eco-friendly and economically smart thing to do more of and creating new products from recycling paper versus from raw materials reduces air pollution and water pollution. ***Recycling*** is the collection of a product by the public and the return of this material to the industrial sector.

This is very different from reuse, where the materials do not return for remanufacturing. Recycling is beneficial in two ways: it reduces the inputs (energy and raw materials) to a production system and reduces the amount of waste produced for disposal. ***Recovery*** differs from recycling in that the waste is collected as mixed refuse, and then the materials are removed by various processing steps. For example, refuse can be processed by running it under a magnet that is supposed to remove the steel cans and other ferrous materials. This material is then sold back to the ferrous metals industry for remanufacturing. [7]

4. CONCLUSIONS

A number of companies pointed out that the three largest contributors to pollution in metal manufacturing are machining (the use of lubricants), casting (air pollution from binders) and surface conditioning (cleaning, painting and plating). Existing processes and facilities must minimize flows and loads wherever possible, and nontoxic substances must be substituted for toxic substances wherever possible.

There is an ongoing search for new and innovative ways by which industry can lessen its impact on the environment. Efforts are currently being made to: minimize the environmental effects of energy production; improve wastewater systems for cleaner, more efficient use of resources; and, use wind power, or fuel cells to generate electricity and conserve energy.

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