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ScienceDirect

Procedia CIRP 61 (2017) 22 – 27

www.elsevier.com/locate/procedia

The 24th CIRP Conference on Life Cycle Engineering

# Development of 1/N machines for optimization of life cycle cost responding to globally varying production environment

Yasuhiko Yamazaki[a]*

[a]*DENSO CORPORATION, 1-1 Kariya-shi Show-cho, Aichi 448-8661, JAPAN*

* Corresponding author. Tel.: +81-566-25-5513; fax: +81-566-25-4615. *E-mail address:yasuhiko_a_yamazaki@denso.co.jp*

**Abstract**

International business competition is becoming intense along with economic growth among emerging countries. One of the most significant issues in the expansion of global production involves the localization of parts. Parts processing requires sophisticated techniques, and its localization requires a certain level of production volume and investment. These needs have caused delays in localization, now among the most significant hindrances to competitiveness. We developed 1/N machines in order to solve these issues and build a new lean production system with high cost competitiveness. This system is expected to reduce environmental footprints and generate steady competitiveness throughout the entire product life cycle.



*Keywords: Lean production system; 1/N machine; Die casting; Forging; Parts localization; Global manufacturing*

## 1. Introduction

Global corporate competition continues to intensity amid the development of emerging economies and the creation of new IT-aided business models. Such environmental changes and the need to respond more effectively to market needs are pushing many manufacturing companies to relocate their activities to or near their markets. However, many parts continue to be manufactured at mother plants and then exported because their manufacturing cannot be localized due to their complexity and production volume. In most such cases, economies of scale can be attained only with a high level of output. In other words, localization is not an attractive investment option unless parts are produced in large quantities. In addition, the processing of parts whose optimal production volume is large often involves considerable waste in terms of total life cycle cost since it is generally highly energy-consuming and is not flexibly adaptable to market changes. Moreover, given the long investment cycle of these large-volume processes, equipment and process upgrading tends to be slow. To overcome these problems, we have developed what we call “1/N Machines” that enable us to significantly reduce the optimal production volume of certain parts, thus achieving greater cost efficiency and realizing lean production, and in turn avoiding waste throughout the manufacturing processes. These machines constitute a manufacturing system that promotes parts localization, greatly improving our cost competitiveness and responsiveness to market changes. The system has also proven effective in substantially reducing energy consumption and improving competitiveness throughout the product life cycle. This paper describes the concepts behind the development of 1/N Machines, illustrated using concrete examples [1][2][3][4][5].

## 2. Optimal output level and responsiveness to market fluctuations

Manufacturing comprises various processes. It is generally known that each process has an optimal level of output at which economic efficiency is attained under given conditions (“optimal output level” hereafter). As indicated in Fig. 1,


doi:10.1016/j.procir.2016.12.002

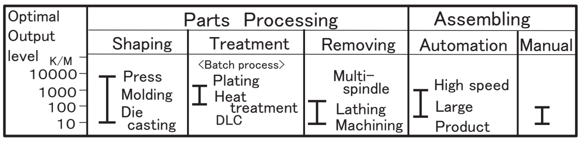


Fig. 1 Optimal output level of representative processes

molding generally has a high optimal output level, followed by the levels for treatment and removal.

Using the formula for the average capital and depreciation cost of processing, equipment cost divided by production output shows that a process with a high optimal output level inevitably sees costs rise if the production volume is small. Since a process with high optimal output usually involves large-scale equipment, a change of product model requires a complex and time-consuming setup. Consequently, such a process is often employed most advantageously for mass production with a large production lot and inventory. Such a process can realize low-cost production if a fixed quantity of output is secured. However, once output decreases, not only does it push up the processing cost, but it also generates much wasted energy, factory space, and many other manufacturing factors. It also has the disadvantage of drastically reducing production efficiency once multiple-model manufacturing develops in response to market needs. Therefore, to maintain cost competitiveness in manufacturing that uses such a process, priority is given to ensuring output volume. This type of manufacturing is not suited for localization, nor is it capable of flexibly responding to ever-diversifying market needs. Moreover, in terms of life-cycle cost, given the difficulty of accurate long-term forecasts, manufacturing must constantly allow for ample leeway in order to be kept reasonably responsive to future fluctuations. This generates significant long-term waste across the board, ranging from equipment and labor and material costs to environmental impacts. Thus, a process with a high optimal output level is a low-robustness process that can be competitive only under extremely limited conditions.

## 3. Development of 1/N machines

### *3.1. Target area of 1/N Machine development*

Processes that have a high optimal output level, lack flexibility, and can be competitive only in large-volume production can be classified into two types: those that have large capacity per unit equipment because of large-lot batch processing, used to ensure efficiency despite its extremely long processing time (e.g., plating and heat treatment) and those that have large capacity per unit equipment because the processing time is extremely short (e.g., pressing). Neither type has a cost-efficient method or equipment suited for low-volume production, as shown in Fig. 2. Improving in these areas requires developing processing methods that reduce equipment costs, rather than reducing the number of pieces processed per unit equipment for the former type or slowing down the processing time for the latter type. We attempted to develop such a processing method, to be performed by what we call "1/N Machines." The "1/N" signifies their goal:

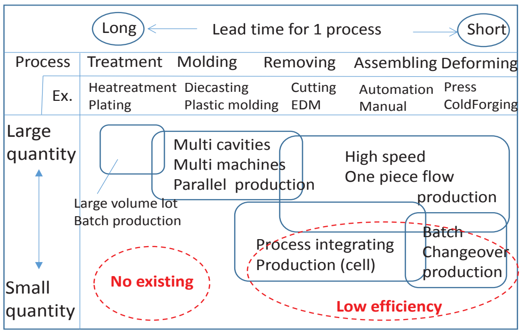


Fig. 2 Classification of manufacturing system based on economic efficiency of production volume

significant improvement through the multiple of an integral number.

### *3.2. 1/N machine development to change the optimal output level*

As described in section 2, processes with a large optimal output level are difficult to relocate overseas or adjust to market fluctuations. As a result, they generate much waste during the product life cycle, pushing up costs. This used to be accepted as inevitable, and manufacturing lines were designed to achieve the best possible results under unavoidable conditions. However, this approach is no longer valid in the face of ever-intensifying global competition. This problem can be addressed in several ways. One is to develop new equipment and technologies that lower the optimal output level. The conventional improvement cycle for reinforcing the competitiveness of parts processing begins under pressure to cut costs and arrives at higher processing speed or multiple-piece processing, intended to increase output per unit time and thus reduce costs. This approach eventually reduces manufacturing flexibility, which is maintained through various improvement efforts (such as mixed production lines and improved setup times to handle multiple-model production), thereby increasing the operating rate, which is then linked to the next improvement target. Such a cycle has been maintained thus far. Although effective in increasing the operating rate of equipment through higher-speed, multiple-piece, and/or multiple-model processing, this cycle is based on the premise that substantial processing volume is maintained and thus cannot effectively handle a change of product model. We therefore developed a new problem-solving cycle based on a new wide-ranging concept that encompasses the overall global production system, with an eye to overseas relocation. The cycle we envision minimizes the optimal output level of certain manufacturing processes to achieve cost reduction; by doing so, the cycle facilitates investment in manufacturing, either at home or overseas, while at the same time making manufacturing more resistant and responsive to changes of volume or model, as investment is possible in a smaller amount in the precise way required for production. Moreover, beyond separate processes, the cycle enables the streamlining of the entire production system, eliminating waste and transforming it into a highly cost-