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USE OF FLEXIBLE KANBAN FOR MATERIAL FLOW CONTROL IN A DISASSEMBLY PROCESS

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ABSTRACT

Disassembly is one of the proposed solutions to today's increased environmental problem of large-scale disposal of manufactured products. Disassembly process brings with it a lot of unresolved material control issues. In this paper we illustrate the implementation of the recently developed Flexible Kanban System to cope with the uncertainties that are unique to the disassembly system.

INTRODUCTION

The tremendous growth in consumer waste in recent years has seriously threatened the environment. Today's consumer is far more educated and understands the importance and the value of a healthy environment. It was an outcry from the consumers that forced many fast food companies to stop using Styrofoam products, which are not biodegradable and start using the recycled and biodegradable paper products. In a large number of states, it is now routine to recycle cans, glass and plastic bottles etc. disposed of by consumers. Lately, there has been an increase in the quantity of used and outdated products scrapped. With the shrinking number of landfills, there is an urgency to come up with a solution to dispose of the scrapped products. Besides, it is necessary that the use of virgin resources be minimized. Recycling is one of the options available to solve this problem.

Many European countries have already passed regulations that force manufacturers to take back and disassemble their used products so that the components and materials may be reused and/or recycled [10]. Many other countries such as the United States are in the process of passing similar regulations. The two legislative acts that are expected to be enacted at the beginning of the next century in the U. S. are the Automotive Waste Management Act (which will enforce the complete reclamation of the automobiles) and Polymers and Plastic Control Act (which will enforce the complete reclamation of polymers and plastics).

In order to recycle consumer products with complex product structures, such as automobiles, household appliances, electronics goods and computers, they must be disassembled and separated first. In other words, disassembly is the first step for recycling of most products. Disassembly is defined as the process of separating the individual parts and components of a product in a systematic manner.

Our interest here is in the operational aspects of disassembly [1,7,8,9,10,11]. That is, we are interested in scheduling disassembly. Although, the scheduling problems of assembly and disassembly share many characteristics, such as dependent demand concept in discrete parts production systems, they also have their differences, and often the approaches to solve these two kinds of problems are very different. Perhaps the most important difference is in the number of demand sources. In an assembly setting, the parts tend to converge to a single demand source as they move on the manufacturing floor. This single demand source is the final product, and the governing principles are constrained by this "convergence" property. Under a disassembly setting, as the parts start moving away from their source(s) of origin, they tend to diverge from each other leading to the "divergence" property. In addition to this "divergence property", each leaf item constitutes a source of demand, and fulfilling the demand of those separate leaf items cannot be done in an independent manner, since some of these leaf items share the same procurement source(s) [8,10,11].

A typical scenario of a disassembly system is as follows. Various types of products arrive to the disassembly system. They are first sorted into families of products based on the percentages of common parts. On the average products that share between 60-80% of its parts and components are considered a family. Each family of products is disassembled in a separate cell. Each cell is divided into stations. The product is partially disassembled at each station. The disassembled components are cleaned, refurbished and stocked at the station. The material flow from the disassembly cell to remanufacturing is controlled using the Just-In-Time technique.

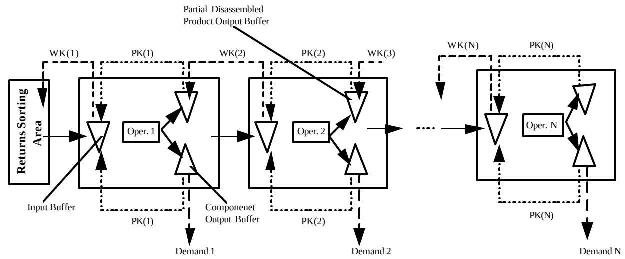
In recent years, Just-In-Time (JIT) technique has become very popular. Originally, only larger companies used JIT. However, lately the popularity of JIT has spread to medium and even smaller companies [6]. The JIT philosophy evolved from a number of principles such as the elimination of waste, reduction of production cost, total quality control and recognition of employees' abilities. An element of the JIT system is the Kanban system. An advantage of the Kanban system is its ability to control production. Other advantages include its simplicity in production scheduling, reduced burden on operators, ease of identification of parts by the Kanbans attached to the containers and substantial reduction in paper work.

Since, the JIT system was designed for a deterministic environment (e.g. constant processing times and smooth and stable demand), its performance is optimum in that environment. However, once implemented, JIT is fraught with numerous types of uncertainties such as processing time and demand variations, and other types of sudden or planned interruptions. Recently, a new technique called "Flexible Kanban System" (FKS) was introduced in the production environment [2,3,4,5], which fluctuate the number of Kanbans during the production cycle to compensate for discrepancies introduced by unpredictability.

In this paper we illustrate the implementation of the FKS to cope with the uncertainties that are unique to the disassembly system.

MODEL DESCRIPTION

In this paper we model a disassembly cell. A disassembly cell is composed of *N* workstations in series. Each station has one disassembly operator, one input and two output buffers (viz. "partially disassembled product output buffer" (PDB) and "component output buffer" (CB)). The products arrive from the customers to the sorting area where they are grouped into their respective families. When a returned product arrives to the first station of a given cell, it is partially disassembled. The components that are disassembled at that station are cleaned and refurbished at the same station and placed in the "component output buffer". Similarly, the partially disassembled product is placed in the "partially disassembled output buffer". Note that the demand for the components disassembled at a station can be directly fulfilled at that station. Here, the re-manufacturing facility or direct customer orders for components generate the demand. In a typical production system with *N* stations in series, demand occurs for finished goods at station *N* which triggers a "pull" action starting from station *N* to station 1 via the use of withdrawal and production Kanbans. In the proposed disassembly model, this trigger effect can start at any given disassembly station. For example, there may be demand for one of the components that is disassembled at station 2, which will trigger a "pull" action to station 1. The following is a schematic diagram of the model.



The disassembly environment is fraught with uncertainties For example, the disassembly times of components are probabilistic because the same component may be retrieved from different types of products. Similarly, in order to maintain the desired level of quality, more components may have to be retrieved just to satisfy the demand. In short, the disassembly times are probabilistic. In order to cope with these uncertainties, we implement the FKS.

METHODOLOGY

A simulation model using the PC version of SIMAN (version V) was developed to study the disassembly model. The disassembly model consisted of one cellular area with three disassembly stations and used the FKS for material control.

EXPERIMENTATION

We tested the behavior of the proposed disassembly model under variable processing times using FKS for the material flow control. The experimental model consisted of three disassembly stations in series. The daily demand for components at each station was constant and was 120, 80 and 40 units respectively. Due to the stochastic nature of disassembly, exponential processing times were used (with mean 6, 4, and 5 minutes respectively). The number of components retrieved from each product were 3, 2, and 1 at the disassembly stations 1, 2 and 3 respectively. At each station, the base number of Kanbans were 4 withdrawal Kanbans and 4 production Kanbans (2 related to CB and 2 related to PDB). The release of the CB production Kanban triggered when the number in the buffer went below 4 components and there was pending demand. This was a measure taken to control the increase in the partially disassembled units in the PDB. At the beginning of each day the number of withdrawal Kanbans at stations 2 and 3 were increased to 8 and 4 respectively (representing 10% of the daily demand for components at that station). The objective here was to choose parameters for the Flexible Kanban System that would react to the changes in the processing times and manipulate the number of withdrawal Kanbans to satisfy the daily demand. The appropriate statistics was collected.

CONCLUSIONS

Based on the results of the experimentation, FKS proved to be a viable methodology to use in the disassembly environment. FKS was able to minimize the work-in-process, reduce the order completion time and minimize backlog.

Future research will deal with variable demand, higher processing times and variable returned product rates.

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