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Efficient reel inventory control - a trade-off between waste and inventory performance

ABSTRACT

The traditional aims of production planning in a paper mill have been high utilization of production resources together with minimization of waste. This paper argues that an approach with an enhanced inventory control component yields an overall efficiency that is unattainable with the traditional approach. A schematic stepwise approach is presented for efficient reel inventory control. Preliminary empirical results indicate that by applying the approach, reel inventory turnover will increase significantly and the throughput time at the mill will decrease. Thus, by creating the basic elements needed for flexible paper production, overall efficiency can be significantly improved.

Introduction

The main task of production management is to produce goods with the right quality, at the right time and at minimum costs. Satisfaction for the customer and profitability for the mill are seen as the ultimate goals. These are, in fact, the main objectives of any kind of manufacturing-based business. With the exception of the pulp and paper industry and process industry in general, industry in the 1980s made its operating practises considerably more flexible and product oriented. Concepts such as team-work, group technology, and distributed and customer-driven production were much discussed. The focus was on inventory control, set-up times and overall throughput times. The pulp and paper industry was concentrating on other issues (Table 1).

Year	Speed m/min	Total effic. %	Lost time/hours	Machine width/m
1975	750	90	150	6.5
1990	1200	75	600	8

Table 1. Developments during the past 15 years /1/.

The capacity-driven approach, with high machinery utilization rates and low waste production, was seen as the main route to success for the future /2/. But as Table 1 indicates, efficiency was not increased. At the beginning of the 1990’s, overcapacity was one of the main reasons for low product prices, which constitute a major problem in the industry. Other studies indicate an increase in capital invested in pipeline inventories, implying long throughput times and poor performance throughout the distribution chain.

This paper argues that by enhancing the production principles in slitting and sheeting operations, work-in-process and throughput time can be reduced. Using the experience gained from discrete production control, the reel inventory between these work operations can be buffered with flexibility. The applicability of the stepwise approach presented below is limited to paper mills producing sheeted papers of different sizes (e.g. art printing papers). However, the results can also be used in reel production for determining standard reel widths. The application generates greater overall productivity in terms of faster throughput times and improved delivery performance.

The rest of the paper is organized in the following way. First the problem is formulated and its relevance to the whole delivery chain from the paper mill to the end customer is described. The approach itself, together with a software tool for supporting decision making, is then presented. The method is then tested in practice. Finally, conclusions are drawn.

The problem

Trends taking place in the late 1980s, with improved customer service, more specialized products and the increasing internationalization of markets, have forced the paper mills to re-evaluate their operating practices. Throughput times, improved capital management and logistic efficiency have become central issues in today's paper production. Previous studies /3/ indicate that poor performance stems from rigid production management and inflexibility in delivery performance, issues that are tackled by stepping up investment in pipeline inventories. Fig. 1 shows the average throughput times at one paper mill producing sheets of different sizes.

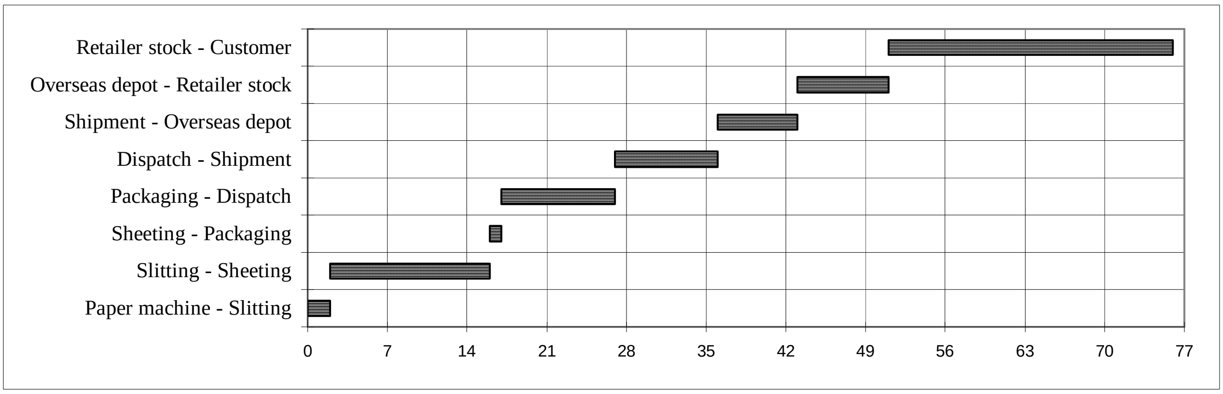

Fig. 1. Average throughput times (in days) at one paper mill.

Our empirical studies /3/ indicate that the situation depicted in Fig. 1 is not an exception but describes a common situation at most paper mills. The distribution of throughput times is even more alarming: in our case studies the average value of all capital tied up in products (finished or not) inside the mill area was 10-15% of mill's gross annual turnover. The main reasons for this are

- unplanned production
- too early production
- incorrect sales forecasts
- too long production cycle times
- poor product mix
- a capacity-driven approach in production management, i.e. importance is attached to high utilization rates.

The above list actually illustrates the effects of the traditional approach of high-volume production with minimized waste levels in production management. High productivity is equated with high output /4/. From the point of view of efficient reel inventory control, this has caused the following problems:

- long throughput times
- high work-in-process
- poor delivery performance

- inefficiency in logistics.

Without going into details on every point in the list, we concentrate on one single part of the value-adding process, namely the process between slitting-winding and sheeting. These operations have been seen as the bottleneck of the entire process, particularly by mills turning out sheeted products of different sizes. Also, long production cycles in the paper machine lead to poor performance in this step of the production flow. To get an understanding of the extent of the problem, let us assume a production unit with 30 different paper grades (grammages and shades) and 50 different sheet dimensions per grade. This results in 1,500 different products. The traditional reason for trimming slitting and sheeting operations is to minimize waste, and the tools used are usually based on LP-models /5/. This means that certain sheet dimensions require certain reel widths, which ultimately determines what kind of trims are needed in the sheeting operation. Yet, with 1,500 different products, this approach is inadequate and does not support overall efficiency; it is therefore partly responsible for the above problems.

The method

The idea of the method is to use different planning procedures for reels with different production statuses. Production status is specific to each paper grade and is based on reel's order stock in the following way:

Status 1: reels are made to order and the traditional approach is the most efficient one,

Status 2: reels have no order inside the planning cycle (usually the same as paper machine cycle) but they have orders outside the cycle,

Status 3: reels have no orders at all.

To tackle the last two cases, we have to consider for each paper grade the inventory levels and the order history before deciding the width of the reel. Inventory level and order history gives the criteria for speeding up inventory turnover and reducing capital tied up in production, while the order stock provides the criteria for reducing the amount of waste produced. The final decision is based on a trade-off between these criteria. In order to process this approach the following data is needed:

- *production data*: the volume (tons, machine reels together with their width, waste cost per ton) of each paper grade in the planning cycle,
- *order data*: orders per paper grade with widths, tons, delivery dates and market value per ton,
- *inventory data*: reel inventory levels for each paper grade, i.e. tons, widths and inventory arrival date,
- *history data*: past orders per paper grade, including tons, widths and delivery dates.

Data on the value of waste production and market value is usually vague, but nevertheless provides a platform for making decisions on an economic basis. The underlying idea is that the total efficiency in reel inventory control stems from the optimum between waste production and inventory costs. The flow diagram for use with each paper grade is shown in Fig. 2.

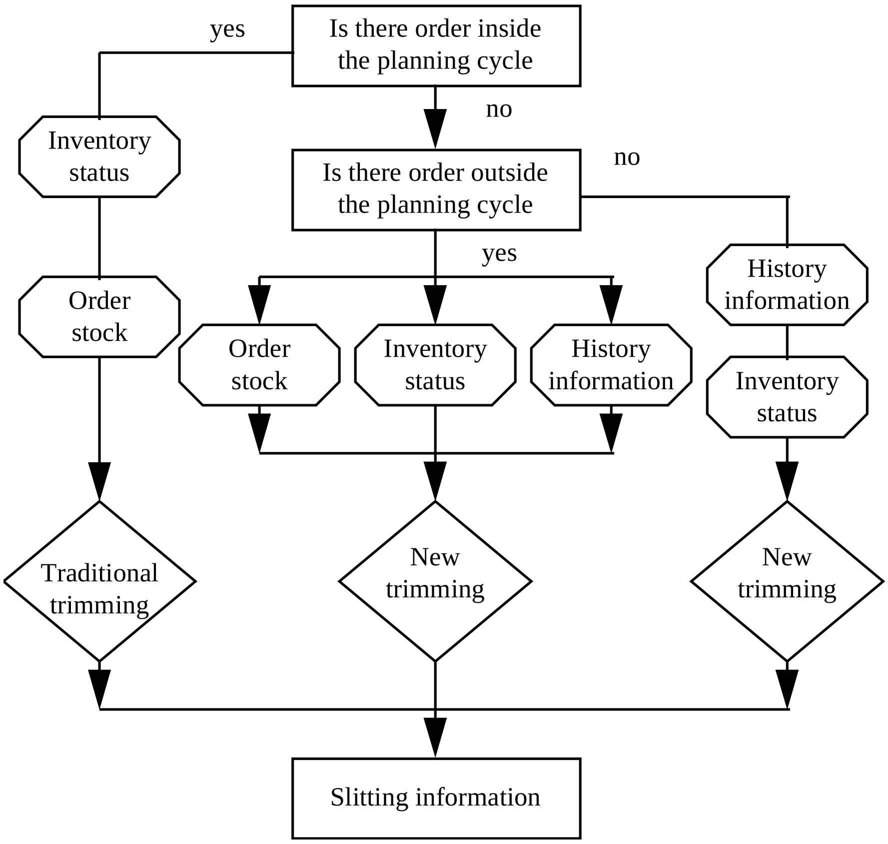

Fig. 2. Decision flow diagram for efficient reel inventory control.

Regardless of how well the gross production planning and scheduling is done, machine reels frequently do not match orders and paper machine cycles produce more paper than is actually needed. Traditionally, status 2 and 3 reels are handled according to sales forecasts or cut to obsolete standard widths. This has been the ultimate source of the problems mentioned earlier. Production with status 2 or 3 reels requires separate trimming principles based on heuristics, because the underlying problem would require the enumeration of all possibilities before the optimum could be found. Roughly, the heuristics used for these “loose” reels are the following:

Status 2: Future demand is the starting point for the calculation. If the order stock is small, then paper grade's past widths are also analysed to form the demand trends. Seasonal and other longitudinal trends in demand are also analysed (advanced forecasting systems may produce this information). Yet, in the calculation the order stock is valued with greater weight than the history data. These trends are used as the initial planning information for reels with few future orders. The inventory content is analysed and the net demand for widths in the slitting operation is calculated. The rest of the production is then planned according to the historical trends in such a way that the standard widths produce little waste and fulfil the known orders efficiently.

Status 3: In the absence of any future demand, the only available information for the planning is the paper grade's width history. Thus, the procedure is similar to that for status 2 reels without any future orders. The trends used as the starting point for the calculation are usually based on longer past periods than with status 2 paper grades.

In actual use, the method should be applied in conjunction with every planning cycle, and even in the handling of special situations (unplanned orders processed in the middle of the cycle, production interruptions, etc.). The following imaginary example shows how the planning status of each ton produced is determined.

> The net production of one paper grade in a certain planning cycle is 100 tons. The amount of this paper grade needed for orders to be delivered during the cycle or right after the cycle is 72 tons. An inventory reveals 28 tons that match the orders. Thus, the net demand of status 1 reels is 44 tons. This means that 56 tons of the production should be planned as status 2 or 3 reels. Outside the planning cycle there are 31 tons of ordered sheets, which are treated as status 2 reels, and the remaining 25 tons as status 3 reels. Status 2 and 3 reels enter the reel inventory.

The point here is that the standard widths generated by the method are not in fact standard but vary from cycle to cycle, depending on the situation in past and present order stocks and on inventory levels.

Empirical results

PC software based on the method has been tested with data gathered from two paper mills. The preliminary results are reassuring, indicating an average reduction of 80% in throughput times. In addition to the data described above the following parameters are needed:

- width of machine reel
- width of the slitter-winder together with its cutting tolerance
- minimum and maximum number of reels generated in slitting
- minimum and maximum widths of reels generated in slitting
- minimum and maximum number of sheets processed in parallel sheeting
- minimum and maximum width of trimmed strip
- minimum and maximum number of standard reels.

The software also requires several parameters concerning the search for standard widths, including the length of the search step, and termination condition of the search. These parameters have a significant effect on the time needed to reach the solution. The data needed has been described earlier and is collected from the mill’s production management system.

The results have been promising. First of all the amount of waste produced has decreased. Fig. 3 shows how the use of a mix of different widths has cut waste production (in slitting and sheeting operations) in comparison with the traditional approach of standard widths.

Fig. 3. Decrease in slitting and sheeting waste through the use of an alternating mix of widths.

The shaded area (Fig. 3) shows the direct savings stemming from the better “match” of the reels planned with the developed method. In practice, this means that the standard widths used were obsolete and provided a good match only temporarily. The traditional approach is too rigid to meet the market fluctuations. The second result of the new approach in reel inventory control is reflected in the smaller amount of capital invested in buffer inventories. To show this we consider again the waste production, but this time in terms of average figures. Figure 4 shows how the average amount of waste depends on the number of standard reels.

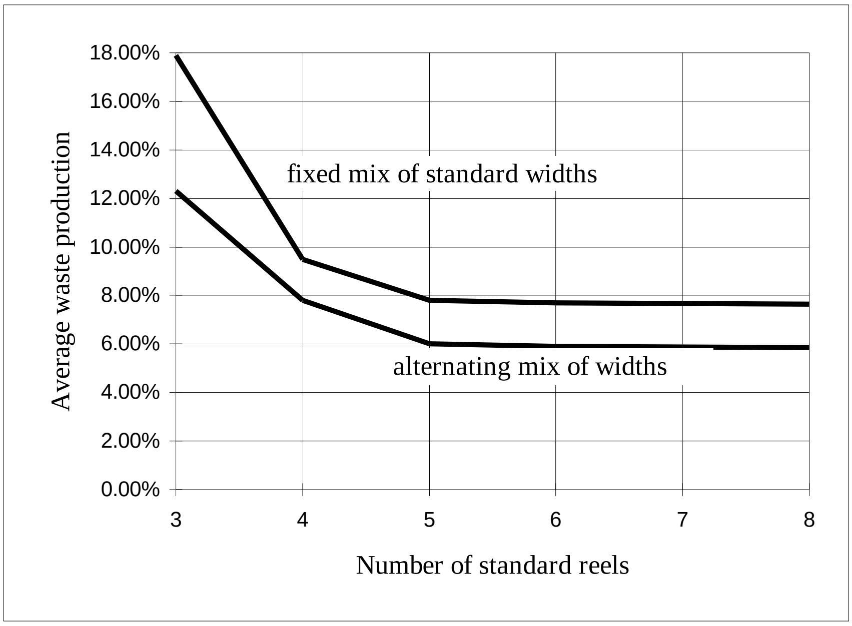

Fig. 4. Average waste vs. the number of standard widths.

Fig. 4 indicates that almost the same amount of waste is produced with the fixed amount of five standard widths as with alternating four standard widths. This means that less paper needs to be stored, and yet there is the same flexibility to react to market demand. This results in a better average throughput time in this step of the production, because reels are not kept in the buffer to wait for their best match but are allowed to take their first match. This in turn means that with certain reels more waste is sometimes produced, but the loss is covered through better inventory turnover and faster response to changes in the market. This conclusion leads to the third and most important result of the study: the trade-off between waste production and improved inventory control (Fig. 5). These constraints decide where the optimum lies; however, it should be understood that this optimum is not stable but constantly changing. When minimizing production waste is the main objective, the inventory efficiency goes down, and vice versa. The moving optimum should be found for every planning cycle.

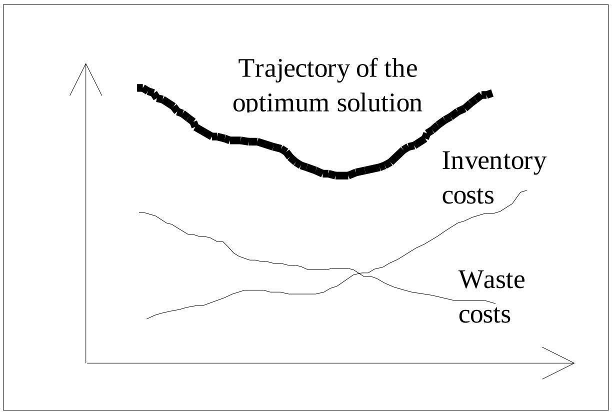

Fig. 5. The trade-off between waste costs and inventory costs.

During the tests it was also realized that the software could also be used for various simulation purposes, such as studying how various widths of the machine reel affect the inventory and waste production, or what kind of sheeting unit would be most suitable for the production. This utility of the tool will be enhanced further in future studies. The optimization of reel lengths and the integration of longitudinal analysis of the inventory status and its turnover will also be improved. The following list summarizes the outputs provided by the software:

- slitting information, i.e. cutting widths
- sheeting information per reel
- on-line and graphical analysis of the input data (past and future trends)
- various inventory profiles (tonnes per paper grade, tonnes per width)
- simulation of manually entered slitting information.

Conclusions

This paper has shown that by enhancing the traditional approach to controlling slitting and sheeting operations, significant cost savings can be achieved. The main idea of the developed approach is to utilize both the past and present databases of production management systems to find better solutions for production control. It is suggested that an alternating mix of standard widths should be used and that planning should take place in conjunction with every machine cycle or even more frequently (perhaps weekly for some paper grades). Overall planning should not be based solely on waste minimisation but also on efficient inventory control. The trade-off between these two operational constraints determine the ultimate success of production management. There is no stable optimum solution between these opposite constraints, which can only be tackled through frequent and short planning cycles and by pursuing ever-greater cost efficiency.

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