Scientific Journal Widya Teknik
Volume 22 No. 2 2023
ISSN 1412-7350 eISSN 2621-3362

INTEGRATION OF ROUGH CUT CAPACITY PLANNING (RCCP) AND CAPACITY CONSTRAINT RESOURCES (CCR) TO MINIMIZE THE RISK OF UNCERTAINTY IN FULFILLING PRODUCTION MATERIAL SUPPLY

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ABSTRACT

Managing the production capability of a company is undoubtedly the main concentration in the manufacturing industry. Industries must consider the materials and resources supplied for making a master production schedule. The lack of material supply from a supplier results in the inefficiency of the production process. The supply disruption of raw materials results in problems for the rest of the stages in the production process. As a result, companies experience difficulties in meeting the predetermined target. This research used an integration of RCCP and CCR to solve the problem. Optimization of CCR implies the TOC (theory of constraint) principle by reducing the percentage of overload until reaching a balanced (optimal) condition. This research aims to balance and optimize the ongoing production process. It took place in a manufacturing company that produces building materials serving the market in Indonesia. The results show that during the observation period, the current production system has experienced system overload for about 70% of the production period. The results of the RCCP analysis provide recommendations for improving the master production schedule to increase the effectiveness of the production system.

Keywords: CCR; RCCP; balancing in supply; TOC

ABSTRAK

Mempertimbangkan kemampuan supply material dan sumber daya yang dimiliki sebagai bahan pembuatan jadwal induk produksi merupakan hal yang kritis. Alokasi bahan baku pada proses produksi yang kurang tepat mengakibatkan terhambatnya proses produksi selanjutnya. Akibatnya perusahaan akan kesulitan untuk memenuhi target produksi yang telah ditetapkan. Akibatnya, perusahaan mengalami kesulitan dalam memenuhi target yang telah ditentukan. Penelitian ini menggunakan integrasi RCCP dan CCR untuk menyelesaikan permasalahan tersebut. Optimasi CCR mengimplementasikan prinsip TOC (theory of constraint) dengan mengurangi persentase kelebihan beban hingga mencapai kondisi seimbang (optimal). Penelitian ini bertujuan untuk menyeimbangkan dan mengoptimalkan proses produksi yang sedang berjalan. Penelitian ini diterapkan pada industri manufaktur di Indonesia yang memproduksi material bahan bangunan. Hasil penelitian menunjukkan bahwa selama periode pengamatan, sistem produksi saat ini telah mengalami kelebihan beban sistem sekitar 75% dari periode produksi. Hasil analisis RCCP memberikan rekomendasi perbaikan jadwal induk produksi untuk peningkatan efektivitas sistem produksi.

Keywords: CCR; RCCP; keseimbangan pasokan; TOC

I. Introduction

In general, the primary concern of a commercial organization is increasing revenue and sales. Organizations always focus on efficiently and effectively managing their resources, such as materials, employees, machines, and capital. The manufacturing industry includes balancing production through production planning and control by considering the capacity and production process [1]. Production planning is an activity to plan the operation by considering the company's ability to minimize the risk of differences between the actual and expected capacity. Thus, it can ensure the optimality of the production process. In other words, production planning and control (PPC) is an activity that regulates the production process. However, handling PPC involves management behavior, often resulting in decisions based on guess operation rather than data [2].

In manufacturing companies, production planning usually focuses on priority planning and production capacity [3]. Priority planning is making a plan based on the top priority of manufacturing operations to meet customer demand. Therefore, when preparing the Master Production Schedule (MPS), one has to consider capacity planning. Capacity planning becomes the company's constraint to achieving the production targets [4].

In the hierarchy of priority planning and capacity planning, RCCP (*Rough Cut Capacity Planning*) is at level two, which plays a role in MPS development and validation [5], [6]. RCCP is useful for estimating potential bottlenecks when implementing MPS by converting production plans into critical resource capacity requirements. Therefore, the capacity management function must determine the capacity needed to achieve priority plans, such as provision, supervision, and control to fulfill priority plans [7].

The objective function of obtaining optimal profit can be achieved by controlling the flow of materials following the Theory of Constraint (TOC) [8]. In an ongoing system, the constraints are interpreted as barriers to achieving higher goals [9]. In managing the constraints, scheduling and the Kanban card system have been widely used by industries [10], [11].

There are several constraints in the production system, including labor, machines, and material capacities [12]. One of the problems in the production system is the bottleneck. It is the impact of the bullwhip effect, which occurs due to fluctuated demand in a supply chain. Some cause*s of the bullwhip effect* are unpredictable demand forecasting, *order batching*, and price fluctuation [13], [14].

The planning system developed for TOC has a specific approach closely related to *lean production*, described as *Drum-Buffer-Rope* (DBR). The DBR approach combines *pull and push systems* integrated for production management. TOC includes *Capacity Constraint Resource* (CCR) as a control point of the material flow [15].

Some CCRs that must be considered in determining the production process are the waste generated, the availability of raw materials, the adequacy of costs, and the time required for the production process. This factor is closely related to production capacity, which is associated with the company's limitations in the production process [16].

P.T. X is a manufacturing company that produces building materials. The main problem that often arises in the production department is the lack of raw materials due to limited supply from suppliers and procurement regulations related to non-renewable materials. This situation results in companies failing to achieve the production target. To avoid production problems, balancing the raw materials received (supply) with the company's predetermined production target is necessary.

Considering these problems, this research aims to fulfill the company's production target by considering its capacity constraints. It applies the integration of RCCP and CCR to solve the problem. RCCP is used to identify the ability to fulfill capacity in a system, which is one of the constraints in a production system [15], while CCR is to resolve raw material constraints so that capacity planning can be balanced without the occurrence of *a bottleneck* on the system.

II. Research Methodology

The research method consists of materials, tools, and procedures for experimental / research. Materials used must be mentioned with clear specifications and the material's origin, such as jackfruit and jackfruit seeds derived from Bangkalan, Madura. Another example is the stainless steel SS316. The tools used must be given a clear specification of tools and operating conditions. The experimental procedure must be concise written in paragraph form (not a point-point-step trial, except in the form of an algorithm if needed).

The research method was carried out to determine the stages of research to solve the problems. Figure 1 shows the detailed stages of the research. The initial step is to identify problems that occur in objects and conduct literature studies to determine methods to solve the issues and data collection. Data for analysis includes production targets, demand and supply, and production time.

The data analysis consists of three steps as follow:

Step 1: RCCP analysis. It begins with determining the capacity requirement (CR) and capacity availability (CA) using equations 1 and 2.

$$CR = t_s \times material\ availability \quad (1)$$

Where t_s = standard time

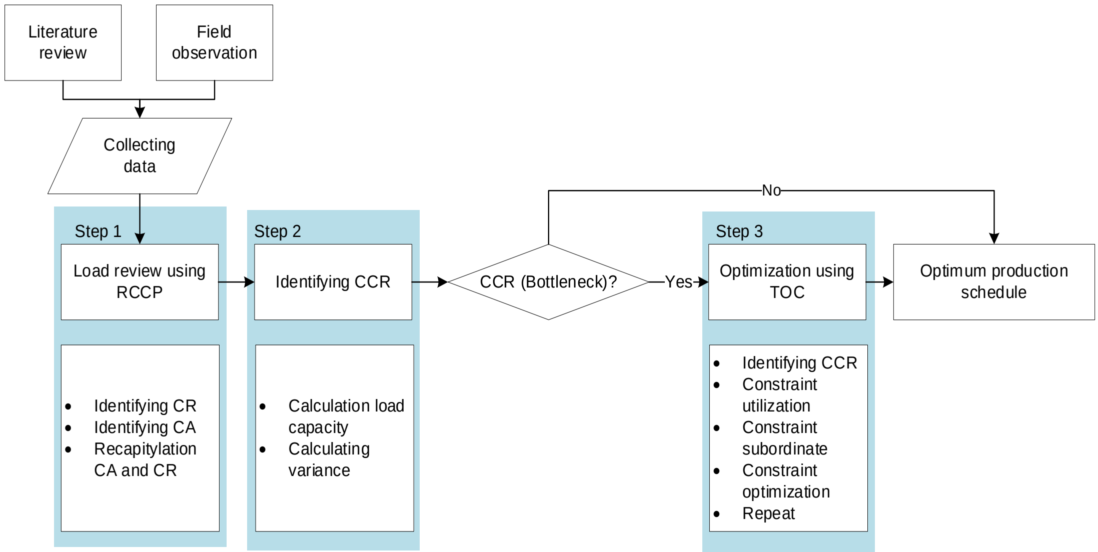

Figure 1. Research Method

CA is calculated by multiplying the machine utility (u), efficiency (ε), number of machines in operation (n), and total working hours (T) in a month.

$$CA = u \times \varepsilon \times n \times T \qquad (2)$$

Step 2: CCR identification. This process assesses the suitability of the capacity owned against the required capacity using the RCCP to identify the CCR as a bottleneck on the system and solve it using the TOC philosophy. This begins with calculating the load percentage using equation 3, as follows:

$$Load\ Percentage = \frac{CR}{CA} \times 100\% \qquad (3)$$

Next, calculate the variance by subtracting CR from CA A positive variance indicates a bottleneck in the production.

Step 3: Optimization. This step implements the TOC philosophy to optimize the production schedule by conducting the feasibility of the production target. If there are any discrepancies, then improvements can be made to production planning and scheduling.

IV. Research results and discussions

The required capacity is calculated to determine the capacity needed for each workstation according to the material supply. Based on the CR and CA Calculation results, the RCCP analysis determines the bottleneck and non-bottleneck processes. Tables 1 and 2 show the example of CR and CA measurements of the workstation Hammer Mill using Equation (1) and (2). The workstation efficiency is assumed to be 98%. The result shows that the average of CR is 635,554 seconds, while the average of CA is 657,254 seconds. This indicates that the workstation experiences a bottleneck because CA> CR.

Table 1. CR calculation

Period	t_s (s/ton)	*Supply* (ton)	CR (*s*)
January	2.63	210,150	552,695
February	2.63	18,870	49,628
March	2.63	216,440	569,237
April	2.63	322,280	847,596
May	2.63	271,810	714,860
June	2.63	352,000	925,760
July	2.63	259,030	681,249
August	2.63	294,150	773,615
September	2.63	291,060	765,488
October	2.63	189,320	497,912
November	2.63	214,950	565,319
December	2.63	259,810	683,300

Table 2. CA calculation

Period	Utilization (%)	T (hour)	CA (*s*)
January	40	399	563,069
February	46	380	616,694
March	39	399	548,992
April	39	323	444,422
May	17	399	239,304
June	20	361	254,722
July	37	380	496,037
August	45	418	663,617
September	49	399	689,759
October	46	418	678,364
November	38	418	560,388
December	43	380	576,475

CCR is identified based on a workstation experiencing a bottleneck, indicated by the load percentage value exceeding 100% and a positive variance. These workstations are categorized as bottleneck constraints. Results of the calculation of workstations experiencing bottlenecks can be seen in Table 3.

Table 3. Results of RCCP Recapitulation

Period	Load percentage	Variance	Category
Jan	98%	-10,374	Non-bottleneck
Feb	8%	-567,066	Non-bottleneck
March	104%	20,245	Bottleneck
April	191%	403,174	Bottleneck
May	299%	475,556	Bottleneck
June	363%	671,038	Bottleneck
July	137%	185,212	Bottleneck
August	117%	109,998	Bottleneck
Sep	111%	75,729	Bottleneck
Oct	73%	-180,452	Non-bottleneck
Nov	101%	4,931	Bottleneck
Dec	119%	106,825	Bottleneck

The RCCP calculation is implemented on Hammer Mill and Cutter Clay machines. The efficiency of machines is 98%. Using data from four years, with one unit of Hammer Mill and two units of Cutter Clay, the RCCP recapitulation results are displayed in Figure 2.

The next stage is applying five steps of TOC principles to optimize the constraint.

Step 1: Identifying CCR

The first stage is to identify the system boundaries. It identifies workstations with capacity constraints and fails to meet the capacity requirement. In other words, identifying workstations with a load percentage > 100%. These workstations are called bottleneck stations. Meanwhile, workstations capable of fulfilling capacity will be declared as non-bottleneck stations.

Figure 2 shows that both Hammer Mill and Cutter Clays stations experience bottlenecks for over 75% of the production period. This is mainly due to the low available capacity to meet the required capacity.

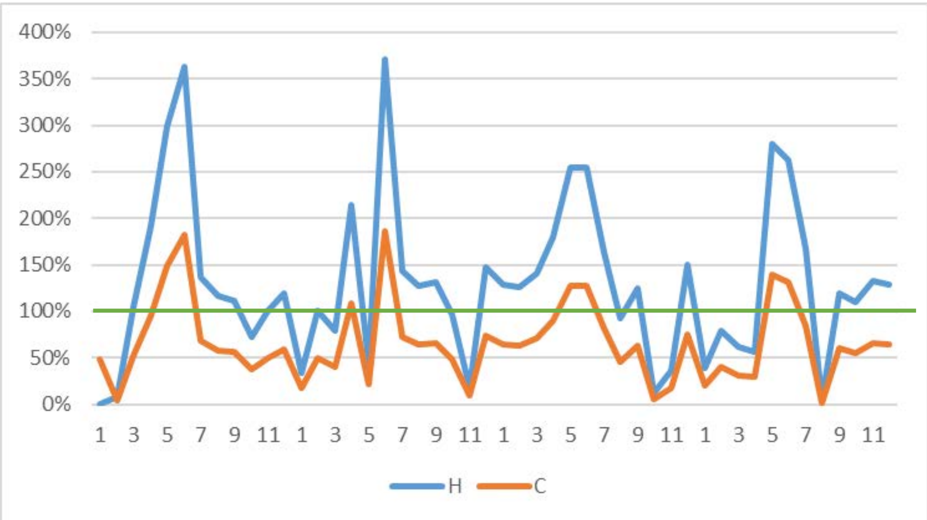

Figure 2. Recapitulation of RCCP

Table 4. Capacity Constraint Resources (CCR)

Machine	Storage	CR(*s*)	CA(*s*)	Load Percentage
Hammer mill	June	3,186,858	1,018,886	313%
	May	2,097,848	957,217	219%
	April	2,858,726	1,777,689	161%
	July	3,033,660	1,984,147	153%
	December	3,138,021	2,305,901	136%
	September	3,364,378	2,759,037	122%
Cutter clay	June	3,189,281	2,037,773	157%
	May	2,099,444	1,914,434	110%

Moreover, the workstation Hammer mill (H) experiences bottlenecks during the second quartile (April – July) and in September and December. Meanwhile, the Cutter clay workstation (C) experiences bottlenecks mainly during May and June each year.

Step 2: Constraint utilization

This activity optimizes existing resources to increase their performance by considering the constraints. It begins with optimizing the master production schedule using the Theory of Constraint (TOC) approach to spread the resources capacity load evenly. Hence, it will avoid bottlenecks. This step includes utilizing all available capacity on resources identified as CCR. It starts with solving the constraint with the most significant load sequentially down to the least significant production priority. Table 4 shows the sequence of CCR based on workstations with higher load percentages.

Step 3: Constraint subordinate

The Capacity Requirement (CR) is optimized by subtracting the Capacity Available (CA) from the Capacity Requirement (CR) for each machine based on fulfillment priority. The production priority is Storage 1, Storage 2, Storage 3, and Storage 4 sequentially.

Step 4: Constraint optimization

Problem-solving can be started from the machine on the storage with the most significant load. Table 4 indicates that the top priority solution should start from the Hammer mill workstation, followed by the Cutter clay workstation. This step should continue until no more machine has an approving load. The optimal condition is achieved when the subtraction is negative or zero. Tables 5 and 6 display the optimization of production distribution based on the priority for each workstation. By using the linear programming method, the MPS is revised by adjusting the hammer mill's capacity and cutter clay workstations.

Table 5. Constraint Optimization for Hammer Mill

Period	Storage	CR_0 (s)	CR_1 (s)
June	1	925,760	925,760
	2	944,404	93,126
	3	647,112	0
	4	669,582	0
	Total	3,186,858	1,018,886
May	1	714,860	714,860
	2	103,246	103,246
	3	610,160	139,111
	4	669,582	0
	Total	2,097,848	957,217
April	1	847,596	847,596
	2	955,050	930,092
	3	801,098	0
	4	254,981	0
	Total	2,858,726	1,777,689
July	1	681,249	681,249
	2	715,828	715,828
	3	808,199	587,070
	4	828,384	0
	Total	3,033,660	1,984,147
December	1	683,300	683,300
	2	846,847	846,847
	3	864,008	775,754
	4	743,867	0
	Total	3,138,021	2,305,901
September	1	765,488	765,488
	2	906,866	906,866
	3	863,639	863,639
	4	828,384	223,044
	Total	3,364,378	2,759,037

Table 6. Constraint Optimization for Cutter Clay

Period	Storage	CR_0 (s)	CR_1 (s)
June	1	926,464	926,464
	2	945,122	945,122
	3	647,604	166,187
	4	670,091	0
	Total	3,189,281	2,037,773
Mei	1	715,404	715,404
	2	103,324	103,324
	3	610,624	610,624
	4	670,091	485,082
	Total	2,099,444	1,914,434

Step 5: Repeat

Re-check the results of step 4. If a CCR is still identified, repeat steps 1 to 4. On the other hand, when there is no CCR found, the constraint is optimal.

Rough cut capacity planning (RCCP) revisions are carried out to see if there is still a bottleneck workstation after the revision of MPS. Improvement is carried out by reducing the capacity needed on bottleneck workstations. The optimization results show that the percentage of load on the constraints can be reduced to an optimal figure of 100% with a variance value of zero, so the constraints can be considered optimal. Constraint optimization (CCR) could be performed in the operational process by maximizing machines' performance and utilizing other resources. This is possible by improving the master production schedule so that the production process can occur optimally according to the required and actual capacity.

V. Conclusions

The Rough Cut Capacity Planning (RCCP) results provide the analysis of the condition between the actual capacity available and the required capacity. The RCCP shows the fluctuation of capacity usage in each period. The results show that 75% of the time, workstations are overloaded. This situation indicates constraints that should be optimized. The TOC philosophy enables an analysis to solve the problem and reach the optimal percentage load with a variance equal to zero. Based on these results, it is necessary to improve the master production schedule by considering the actual capabilities. It is suggested that allocated capacity should follow the actual capability by considering the load production priority. Thus, the bottleneck would be avoided, and the production target would be achieved.

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