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AGGREGATE PLANNING ANALYSIS IN PT. AKEBONO BRAKE ASTRA INDONESIA

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Abstract
Nowadays, most manufacturing companies are striving for greater profit and improvement to gain competitive advantage towards others. Such profit can be achieved by making more income or attenuate production expenses. In order to do so, manufacturers has been developing various kinds of production system in order tomaximize inventory utilization, production forecast, and production planning. Therefore,by applying certain operations management decision might lead to better result of production and inventory planning. Manufacturers around the world have been using combinations of aggregate planning models in any ways imagined to achieve best results in terms of production effectivity and cost, especially in automotive manufacturing industries which requires high planning precision with a lean inventory. PT. AAIJ is an automotive parts manufacturing company which supplies to both national and international market. PT. AAIJ however, they had been facing production shortage to its biggest client to the company, Nissan Motor UK Products since September to December 2016. Based on an ABC analysis, production shortage analysis has been focused only on Nissan Motor UK Products.

Keywords: Holding, Inventory Management, Inventory, MPS, MRP, Operations Management, Overstock, Production Management System, Production Planning, Shortage.

Introduction

The condition of manufacturing industries nowadays has changed very significantly from how it was 50 years ago. Nowadays, not only that the population of world-class manufacturers has grown into a large number but also incumbent manufacturers do not always lead the market, especially in the world of automotive industry. Clients these days have numerous choices of manufacturers or contractors to execute their production plan, which leads to higher pressure to all parties to strive for better results with cheaper input. In order to do so, an excellent operations management is a must to achieve success. Several industries even apply the Just-in-Time philosophy to achieve lean manufacturing.

Operations management has become the most substantial advantage to manufacturers in automotive industry as with such management will the manufacturer be able to be more competitive in the nowadays market, in which financial power is easily obtained even by new players, but not experience. Operational management consists of 10 important decisions, which are design of goods and services, managing quality, process and capacity design, location strategy, layout strategy, human resources and job design, supply chain management, inventory management, planning, and maintenance. Although all of those decisions are equally important to one another, inventory management and planning would be the focus of this research.

In certain industries, for example manufacturing industries, operations management accuracy is a substantial matter. Failure within operations management can result to risks occurrence, such as higher cost, longer time to market, backlogs, and shortages. Therefore, inventory management is a critical aspect to be focused on. Good inventory management will diminish excess holding related cost, which eventually will yield lower price. According to Heizer and Render (2008), the objective of inventory management is to strike a balance between inventory investment and customer service. Therefore, forecasting and planning are also very important to determine the production rate of a product to balance the customers' order. Good forecasting and planning will lead to on-time delivery, minimum waste, and minimum production cost, while having bad forecasting and planning will cause late delivery, potential loss of sales, create waste, and in some occasion will be given penalty by the clients, another additional cost to the production. Although, all these forms of management will not work at its best if it is not followed with the proper and required production capacity to keep up with all the clients' order.

PT. Akebono Brake Astra Indonesia, which was originally named PT. Tri Darma Wisesa was established in the year of 1981 and at the year of 1996, PT. Tri Darma Wisesa has signed a joint venture agreement with Akebono Brake Industry co. ltd. and changed its name into PT. Akebono Brake Astra Indonesia. PT. Akebono Brake Astra Indonesia is a manufacturer of Braking System, namely Drum Brakes and Disc Brakes for automobile, Master Cylinder and Disc Brake for motorcycle. Product capacity is divided into 2 concentrations, which are production for automobile with approximately 450,000 units per year capability and motorcycle with a 1,450,000 units per year capability. PT. Akebono Brake Astra Indonesia is the leading brake manufacturer in Indonesia, positioned at number two in terms of performance in Akebono Group International, right after Akebono Brake Industry Co., Ltd. and has been exporting goods to fellow Akebono Members around the world.

Although several accomplishments have been achieved, problems still occur in the company itself. PT. Akebono Astra Indonesia is now facing both world market and domestic market competition. Such condition forces the company to be more competitive, and it can only be achieved by applying good Production Management System. The underlying problem is that the company is currently facing shortages to clients' order and causes the company material and non-material losses, based on the production data from the last 4 months of 2016. If the company does not propose any improvement, then the company will face termination of contract. Nissan Motor UK has been the biggest and most important client for PT. Akebono Astra Indonesia. However, along September 2016 to December 2016, PT. Akebono Brake Astra Indonesia had been facing unsynchronized production for certain Nissan's products, as shown in the graph.

ABC ANALYSIS - TRISEMESTER 3 PRODUCT																
Number	Client List	Name	Month								Total Quarterly				
			Sept	Act-Sept	Oct	Act-Oct	Nov	Act-nov	Dec	Act-Dec	Ordered	Supplied	Shortage	Overstock	% of
1	Nissan Motor UK	Caliper Assy FT, **R60 Padless**	13,300	9,600	19,600	13,600	18,000	17,500	15,000	15,000	65,900	55,700	10,200	-	85.0%
2	Nissan Motor UK	Caliper Assy FT, **CMF1 N57**	55,000	50,700	44,300	47,100	42,000	44,600	41,100	38,200	182,400	180,600	1,800	-	15.0%
3	Nissan Motor UK	Caliper Assy FT, **R57 Padless**	4,000	3,000	3,200	3,800	6,100	5,900	4,500	5,300	17,800	18,000	-	200	**No shortage**

As shown in the table 1.1, there are three products that contribute to the shortages in Nissan Motor UK Production Line in PT. Akebono Brake Astra Indonesia, which are R60 Pad-less, CMF1 N57, and R57 Pad-less for Nissan Motor UK. The designated cells describe the occurrences of production shortages in several months. Shortages are indicated with orange boxes, namely on September, October, and November of R60. On September and December for CMF1 N57, and on September and November for R57 Pad-less. Although, CMF1 N57 and R57 Pad-less table of production data also indicates several overstock to complement backlogs, while R60 does not. Such conditions have caused not only potential loss of sales, but also might cause customers complaint, excess of production cost, and customer's penalty.

Literature Review

This research used literature review from several books and journal, mostly taken from the book *Operations Management* by Heizer & Render (2011).
Operation management is the science, art, and basic of goods and services assurance to customers' delivery of goods. Operations management consists of goods and services designing, creation process, and the daily planning of processes of related items, and continual improvement of related goods, services, and processes. (Collier and Evans, 2013)
The role of operation management is to transform any inputs given by the company into final goods and services with the goals of minimum inputs usage. Inputs consist of human resources, natural resources, materials, facilities, processes and method, and information. While outputs are the finished goods or services that the company offers. The transformation of inputs into outputs are as shown and explained in the graph below:

The four primary functional areas of a company are marketing, finance, operations, and human resources. Operations management is the technical core or hub of the organization, interacting with other functional areas and suppliers to produce goods and provide services for customers. Activities in operations management includes organizing work, selecting processes, arranging layouts, locating facilities, designing jobs, measuring performances, controlling quality, scheduling work, managing inventory, and planning production. (Reid and Sunders, 2007)
Aggregate planning is a process by which a company determines ideal levels of capacity, production, subcontracting, inventory, stock-outs, and pricing within a specific period of time. (Chopra and Meindl, 2007)

Aggregate planning is an attempt to balance capacity and demand in with cost minimizing. The term 'Aggregate' is used because such planning elaborates numerous of variables and resources. Aggregate planning uses all resources and existing capacity to fulfill demand. If the two are not balances, the firm then must decide in which terms should they adjust in order to fulfill the demand. Other option is to adjust the capacity higher or lower in order to meet the demand or even raise or lower the demand capacity. (Anthony, R. Inman, n.d.)
Four things that are needed for aggregate planning based on Heizer and Render (2011):

- Logical overall unit for measuring sales and output.
- Forecast of demand for a reasonable intermediate planning control period in these aggregate terms.
- Method for determining the relevant costs.
- Model that combines forecasts and costs sot that scheduling decisions can be made for the planning period.

Aggregate planners requires the following information based on Chopra and Meindl (2007):

- Demand forecast of F_t for each period t in a planning horizon that extents over T periods.
- Production costs:
  - ✓ Labor costs, regular time (IDR/Hour) and overtime cost (IDR/Hour)
  - ✓ Cost of subcontracting (IDR/Unit or IDR/Hour)
  - ✓ Cost of changing capacity, specifically cost of hiring/laying off workforce (IDR/Worker) and cost of adding of reducing machine capacity (IDR/Machine)
- Labor/Machine hours required per unit.
- Inventory holding cost (IDR/unit/period).
- Stock-out or backlog cost (IDR/unit/period)
- Constraints
  - ✓ Limits in overtime
  - ✓ Limits on layoffs
  - ✓ Limits on capital available
  - ✓ Limits on stock-outs and backlogs

- ✓ Constraints from suppliers to the enterprise

Using this information, companies are able to determine an aggregate planning thoroughly and adjust:

- Production quantity from regular time, overtime, and subcontracts
- Inventory held
- Backlog or stock-out quantity
- Workforce hired or laid off
- Machine capacity increase or decrease

The quality of an aggregate planning has significant impact towards the profitability of a company. A good aggregate planning can result to increase of sales and profits while a poor aggregate planning can result otherwise.

According to Pan, Lin; Kleiner, H., (1995), there are few strategies of aggregate planning that can be applied, in which some of the prominent are to:

- Maintain workforce level.
- Maintain a steady output rate.
- Match demand by period.
- Use combination of decision variables.

Therefore, an aggregate planner has to make trade-offs among capacity, inventory, and backlog costs in order to achieve the perfect level of the aspects mentioned above. An aggregate plan that increase one of these costs will typically result to the decrease of the other two, which then results to the most profitable combination of trade-offs as the main goal of an aggregate planning, given that the demand may varies over time. The usual condition of these three costs that might occur according to Chopra and Meindl (2007) are as followed:

- If the cost of varying capacity is low, then a company may not need build an inventory or carry backlogs.
- If the cost of varying capacity is high, then a company might have to compensate by building an inventory or carry backlogs.

Therefore in general, a company should attempt to use the combination of the three costs to best match with the demand, in which the three most fundamental trade-offs are:

- Capacity (regular time, overtime, and subcontracts),
- Inventory, and
- Backlog or loss of sales caused by delay.

In order to achieve or find the best combination of trade-offs, there are two methods that can be applied, linear programming and graphical method can be used. Linear Programming is an optimization technique that allows the user to find a maximum profit or minimum cost based on the available resources and certain limitation. A special type of linear programming called Transportation Model can be used to obtain an aggregated plan that would allow balanced capacity and demand within a minimum level of cost usage. However, only a few of actual aggregate planning decision are compatible with the linear assumptions of linear programming as few variables are hard to measure or defined as a non exact (R. Anthony Inman, n.d.), while graphical technique is a very popular method of balancing amongst aggregate planners, as they are easy to use and understand. These plan works with only few variables at a time to allow planners to compare projected demand with existing capacity.

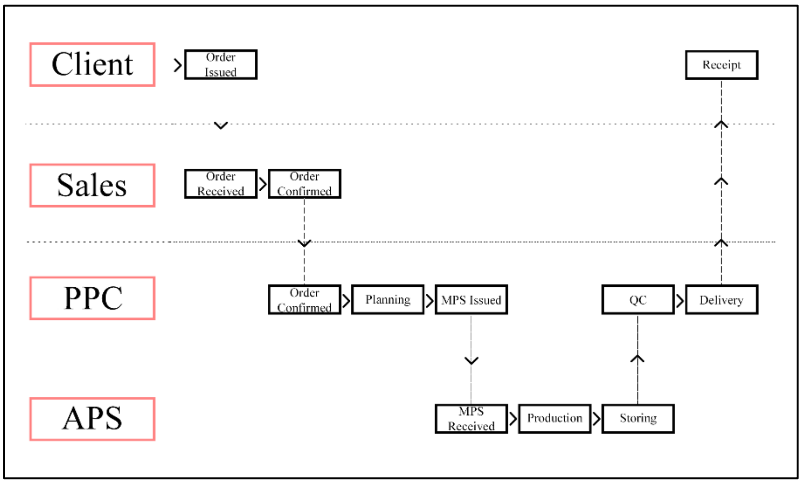
Methodology

The flow of the research begins in problem discovery in which PT. Akebono Brake Astra Indonesia has recently been facing unsynchronized demand and supply which leads to shortage and cause the company material and non-material losses. Therefore, the necessary action to solve this is to evaluate the Production Management System through an observation to discover the root cause by reviewing current workloads, cost, overstock, and shortage number. After the root cause has been identified, only then the author will analyze by creating the current condition mapping of business process, production planning, related cost, and cause &e effect of certain decision. Such analysis will yield conclusion and also propose a recommendation which is workloads balancing through several lines.

Data for the thesis are gathered from field observation within the company, interview, and historical data. Field observation is done through an internship program that is given to the author. Therefore, author can best identify the underlying problems and symptoms that exist in the process of production. Interview are conducted to key players of the production plan, of which few of them are Pak Tyo (Head of Production 1), Pak Ali (Production 1 Foremen), Pak Yasser (Head of Production 2), Pak Ismail (Production 2 Foremen). While historical data are collected from company's historical data to identify any needed pattern or detailed information that cannot be achieved or best identified through Field Observation. Data that will most likely to be used are Master Production Schedule data, Order and Actual Production data, Manufacturing Information Flowchart, and Production Capacity Sheet.

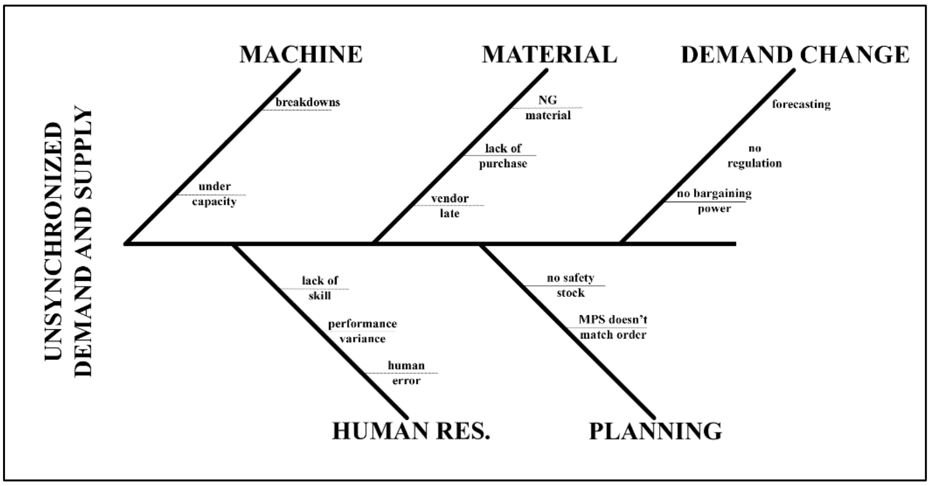
Result and Discussion

PT. Akebono Brake Astra Indonesia is a company that operates under Astra Otoparts Group Indonesia, and is partially owned by Akebono Brake Industry Co., Ltd. Japan, thus Akebono Japan can directly control the production. PT. AAIJ, which stand for Akebono Astra Indonesia Jakarta, supplies braking components namely disk brakes caliper, drum brakes, and friction materials for four-wheel industry and disk brakes caliper, master cylinder, and also friction materials for two-wheel industries, although author only focus on four-wheel production line.
There are various lines of product that are manufactured by PT. AAIJ for different companies in all over the world which leads to unlimited possibility of error and problems due to its complexity. Through the field observation and data, business process can be identified as follows:



The first process of production comes from client orders as PT. AAIJ is using pull system for their production, meanings that they only produce what clients order. Orders then received by sales division in precise number, then relayed to PPC division. PPC division transforms the order number into monthly MPS or Master Production Schedule. Finished MPS will be submitted to the APS division, or Astra Production system to execute the plan. Production performance lies in this division, as the division is responsible in every operational matter within the plant (Production related only). After the products are manufactured, then it is stored in the delivery area near PPC division and QC by PPC team shortly before delivery. PT. AAIJ can do the delivery by them or comply with clients' special requests. The final process of the business is goods delivery to the clients.

The problem analysis data is obtained from a combination of field observation, historical data, and interview with key player. The existing problems are, as described using fishbone analysis below:



As seen in the graph, the problem that exists within the company is an unsynchronized condition between demand and supply. Such problem is caused by several variables that the author has identified within the company, starting from machine, material, order, forecast, human resources, and planning. Although, from conducted interview, it can conclude that the most common and substantial to the shortage condition is machine capacity and planning. Order or demand is as substantial as forecasting and planning, but because PT. AAIJ has little bargaining power against its client, therefore author could not propose any improvements towards the regulation nor the contract.

Machine Capacity

The current machine capacity in Line DB XI could not accommodate production requirements of Nissan UK products, especially for R60. Such condition is caused by high and fluctuated number of demand, which the production rate cannot keep up with. Production rate of items itself, based on an interview, is not solely defined by the machine capacity, but also by other aspects, such as human operators speed, material movements speed, and the process time itself. Therefore, production capacity has been set into certain number, in which the production rate of Nissan UK is 60-unit/hour for product R60, R60 SA, R57, and CMF1 N57. CMF1 N57 has a significantly lower shortage than R60, it is known because CMF1 N57 is given its own dedicated line as their main production line IN DB I, while R60 still has to share workloads with other products in the current LINE DB XI, according to MPS data from September to December. PT. AAIJ however, has released a revised production rate since October 2016 into 50-unit/hour due to internal research about ideal production rate. The production rate changed from an initial 60-unit/hour rate into 50-unit/hour since such rate had caused higher stress to machines and operators, which in the end leads to decrease of machine effectiveness when errors occur, and also the ideal production rate, therefore results to lower production efficiency. Such production rate is only applicable if it is assumed that all 14-hours available workloads are allocated for single-product-use. Therefore, it now depends on how the PPC plans the production workloads allocation on each line and day, as there are several idle conditions in other line.

Production Planning

There are several problems that occurred in the production process, which are planning inaccuracy, lack of safety stock, and breakdowns that results to shortage of production. In PT. AAIJ, safety stock determination and production planning cause shortage of production. Production planning in PT. AAIJ is set into daily production, whereas work hours is divided into 2 shifts with total of 14 effective working hours. Each production line in PT. AAIJ are predetermined for certain products and even made into dedicated line for certain clients. Although such decision can offer value to clients, it often makes production activities inflexible and leads to certain product's shortage due to its wasteful idle condition.

As far as planning concerns, PT. AAIJ has always set every production plan according to clients' order, although there are several planning and production inaccuracy within actuation of planning. Overtime, PT. AAIJ has failed to execute production planning as it is. Product **R60** has always slack of production, as on September it was 26% under the planned number, 31% on October, and 3% on November, while on December PT. AAIJ was barely producing it as there are several unfulfilled backlogs. However, **CMF1 N57** performed slightly well with 8% under the planned number on September, 6% overproduction on October and November, and 7% under planned production on December. PT. AAIJ also did not put any safety stock, as the planned number of production is equal or even less than the order. Not only that the determination of safety stock is absent, planning of workloads distribution is also not in its best configurations, as there are several other lines that were idle for several hours in a month. The workloads are as shown below:

Line	Month	Theoretical workloads (in Hours)			Actual Workloads (in Hours)			Workloads Available (in Hours)		
		RT	OT	WE	RT	OT	WE	RT	OT	WE
DB I	September	294	126	180	294	126	68	0	0	112
	October	294	126	180	294	91	90	0	35	90
	November	308	132	160	308	88	111	0	44	49
	December	266	114	240	266	82	44	0	32	196
DB II	September	294	126	180	234	7	16	60	119	164
	October	294	126	180	228	0	0	66	126	180
	November	308	132	160	271	1	0	37	131	160
	December	266	114	240	228	3	0	38	111	240
DB III	September	294	126	180	284	90	31	10	36	149
	October	294	126	180	294	126	125	0	0	55
	November	308	132	160	308	111	74	0	21	86
	December	266	114	240	224	95	96	42	19	144
DB IV	September	294	126	180	280	21	13	14	105	167
	October	294	126	180	294	31	17	0	95	163
	November	308	132	160	306	24	21	2	108	139
	December	266	114	240	237	34	34	29	80	206
DB XI	September	294	126	180	294	126	68	0	0	112
	October	294	126	180	294	126	105	0	0	75
	November	308	132	160	308	132	100	0	0	60
	December	266	114	240	266	114	110	0	0	130

Workloads are distributed differently as shown in table above and the level of stress are also significantly different. **DB XI** that handles all Nissan MUK products, namely **R60**, **R57 Pad-less**, **R60 Pad-less**, and **CMF1 N57** shows the highest level of stress indicated from the total workloads-hours left in the 'Workloads Available'. On other hand, **DB II** that handles Nissan Indonesia product **K2**, and Astra Daihatsu Product **D18D**, **D80 12"**, and **D18 13"** shows a relatively lower stress level as seen from the total workloads available.

It can be concluded based on tables above that production activities in PT. AAIJ is not caused by under capacity as it is clearly shown from these table that several line of production still have idle work-time and available workloads. Therefore the problem might lie in the planning itself.

Aggregate Planning

As stated before, a balanced aggregated planning is required in order to balance workloads and minimize shortage that is caused by certain line under-capacity. According to Heizer (2008), there are several aggregated planning models that can be applied into companies' operation management, which are:

- Model 1: Vary Workforce
- Model 2: Constant Workforce, Vary Inventory and Stock-out.
- Model 3: Constant Low Workforce, Subcontract.
- Model 4: Constant Workforce, Overtime.

However, based on an interview, PT. AAIJ has specifically prohibited any form of subcontracts to maintain their quality, whether workforce or products, and prefers not to easily hire or lay-off, as not only that the cost of hiring and lay-off is high, but also the form of training that needs to be given to workers are rather time-wasting if done to constantly different operators, which might results to different production performance as stated in chapter 4.2.1.. Thus, the possible models that are left are:

- Model 2: Constant Workforce, Vary Inventory and stock-out.
- Model 4: Constant Workforce, Overtime.

The simulation of aggregate planning models will be divided into two models, which are theoretical models, which the workloads are not distributed within line availability, and actual models, which the workloads hour will be divided within line's workloads availability. The simulation of theoretical Models are as shown below:

Constant Workforce, Vary inventory and Stock-outs

Aggregate Planning	Sept	Oct	Nov	Dec
Beginning Inventory	-	4,340	- 560	- 3,160
Working Days	21	21	22	19
Regular Hours Available (7hrs/day * 2 shifts * Working days)	294	294	308	266
Demand Forecast	13,300	19,600	18,000	15,000
Actual Production	17,640	14,700	15,400	13,300
Ending Inventory	4,340	- 560	- 3,160	- 4,860
Shortage Cost (IDR 119,000/unit)	IDR -	IDR 66,640,000	IDR 376,040,000	IDR 578,340,000
Safety Stock (25%)	3,325	4,900	4,500	3,750
Units Excess (W/O Safety Stock)	IDR 2,030,000	IDR -	IDR -	IDR -
Straight time cost (IDR 23,480/Hr) * 2 workers	IDR 13,806,240	IDR 13,806,240	IDR 14,463,680	IDR 12,491,360
Total Cost	IDR 15,836,240	IDR 80,446,240	IDR 390,503,680	IDR 590,831,360
Accumulated Cost	IDR 15,836,240	IDR 96,282,480	IDR 486,786,160	IDR 1,077,617,520

According to model above, theoretically with a 14 work-hours worth of workloads everyday, PT. AAIJ will still experience stock-outs on October, September, and December. Although on September inventory excess occurs, but it could not accommodate the needs of next month's order. The accumulated cost that occurs in model 2-1 is approximately IDR 1,077,617,520, which was the highest cost on the last production month of 2016 reaches IDR 590,831,360. On the other hand, aggregate planning model with overtime policy applied, successfully decreases number of shortages and its total cost to as much as 94% lower. Theoretically they can still manage to accommodate all order with the accumulated cost of IDR 65,327.384 and IDR 0 for shortage cost. As shown in the model below:

Constant Workforce, Overtime

Aggregate Planning	Sept	Oct	Nov	Dec
Beginning Inventory	-	4,340	-	-
Working Days	21	21	22	19
Regular Hours Available (7hrs/day * 2 shifts * Working days * 2 workers)	294	294	308	266
Demand Forecast	13,300	19,600	18,000	15,000
Actual Production	17,640	14,700	15,400	13,300
Units available before OT	4,340	- 560	- 2,600	- 1,700
Units Overtime	-	560	2,600	1,700
First Overtime Workhours (IDR 35,220/Hr)	-	2	9	6
Next Overtime Workhours (IDR 46,690/Hr)	-	9	43	28
Total Overtime Cost	IDR -	IDR 1,004,944	IDR 4,672,520	IDR 3,052,400
Ending Inventory	4,340	-	-	-
Shortage Cost (IDR 119,000/unit)	IDR -	IDR -	IDR -	IDR -
Safety Stock (25%)	3,325	4,900	4,500	3,750
Units Excess (W/O Safety Stock)	IDR 2,030,000	IDR -	IDR -	IDR -
Straight time cost (IDR 23,480/Hr) * 2 workers	IDR 13,806,240	IDR 13,806,240	IDR 14,463,680	IDR 12,491,360
Total Cost	IDR 15,836,240	IDR 14,811,184	IDR 19,136,200	IDR 15,543,760
Accumulated Cost	IDR 15,836,240	IDR 30,647,424	IDR 49,783,624	IDR 65,327,384

Be as it is, both models are only applicable if all workloads are allocated for one product, in which in reality the production of **R60** did not. Therefore models should be modified into real-time condition and apply existing overtime policy, which are as shown in the model below:

Constant Workforce, Overtime (Existed)				
Aggregate Planning	**Sept**	**Oct**	**Nov**	**Dec**
Beginning Inventory	-	- 3,700	- 9,700	- 10,200
Working Days	21	21	22	19
Regular Hours Available on DB XI Based on MPS	57	86	160	146
Demand Forecast	13,300	19,600	18,000	15,000
Actual Production	9,600	13,600	17,500	15,000
Overtime Workhours Used Based on MPS	64	76	96	86
First Overtime Workhours (IDR 35,220/Hr)	11	13	16	15
Next Overtime Workhours (IDR 46,690/Hr)	53	63	80	71
Total Overtime Cost	IDR 5,723,980	IDR 6,798,660	IDR 8,597,440	IDR 7,686,580
Ending Inventory	- 3,700	- 9,700	- 10,200	- 10,200
Shortage Cost (IDR 119,000/unit)	IDR 440,300,000	IDR 1,154,300,000	IDR 1,213,800,000	IDR 1,213,800,000
Safety Stock (25%)	3,325	4,900	4,500	3,750
Units Excess (W/O Safety Stock)	IDR -	IDR -	IDR -	IDR -
Straight time cost (IDR 23,480/Hr) * 2 workers	IDR 2,690,808	IDR 4,038,560	IDR 7,513,600	IDR 6,856,160
Total Cost	IDR 448,714,788	IDR 1,165,137,220	IDR 1,229,911,040	IDR 1,228,342,740
Accumulated Cost	IDR 448,714,788	IDR 1,613,852,008	IDR 2,843,763,048	IDR 4,072,105,788

Constant workforce with overtime model clearly shows that the shortage is getting out of control when using existing aggregate planning configuration, and causing so much material and non-material loss to PT. AAIJ. The cost of shortages contributes the most to total cost, in which reaches IDR 4,072,105,788 accumulated, and IDR 1.229,911,040 as the highest cost occurrence on November. If we see the production number and production hours more carefully, they even had to over-perform to achieve such production numbers. In September, they had to perform a 79-unit/hour while the production rate was designed precisely at 60-unit/hour performances. Having a better performance in terms of production might seem good, but in the scope of PT. AAIJ is not quite. PT. AAIJ uses Just-in-time philosophy as their production bows and parameters, therefore having an accurate performance are even more important. Therefore, such incidents might leads to other inconsistency and further and more serious problems. The existing work hours could not handle the workloads of the product. However, by adding certain work hours to the existing aggregate planning, the shortage problem can be overwhelmed. Although the production rate has been deduced into 60-unit/hour on September and 50-unit/hour as designed, overtime work hours could still accommodate the orders on the remaining production months.

Constant Workforce, Overtime (Actual)				
Aggregate Planning	**Sept**	**Oct**	**Nov**	**Dec**
Beginning Inventory	-	-	-	-
Regular Hours Available on DB XI Based on MPS	57	86	160	146
Demand Forecast	13,300	19,600	18,000	15,000
Actual Production	3,438	4,300	8,000	7,300
Units available before OT	- 9,862	- 15,300	- 10,000	- 7,700
Units Overtime	9,862	15,300	10,000	7,700
First Overtime Workhours (IDR 35,220/Hr)	23	30	26	21
Next Overtime Workhours (IDR 46,690/Hr)	141	276	174	133
Total Overtime Cost	IDR 14,897,277	IDR 28,035,120	IDR 18,173,520	IDR 13,970,600
Ending Inventory	-	-	-	-
Shortage Cost (IDR 119,000/unit)	IDR -	IDR -	IDR -	IDR -
Safety Stock (25%)	3,325	4,900	4,500	3,750
Units Excess (W/O Safety Stock)	IDR -	IDR -	IDR -	IDR -
Straight time cost (Rp 23.480/Hr) * 2 workers	IDR 2,690,808	IDR 4,038,560	IDR 7,513,600	IDR 6,856,160
Total Cost	IDR 17,588,085	IDR 32,073,680	IDR 25,687,120	IDR 20,826,760
Accumulated Cost	IDR 17,588,085	IDR 49,661,765	IDR 75,348,885	IDR 96,175,645

Constant workforce and overtime with actual available workloads model has successfully lowered the total cost from an initial of IDR 4,072,105,788 to an accumulated cost of IDR 96,175,645 simply by adding several hours of overtime work hours into Model 4-2 with the highest cost occurrence on October as little as IDR 32,073,680. Model 4-3 transforms the cost from shortage cost as the previous highest contributors of total cost into additional overtime cost from an initial sum of IDR 28,806,660 to a total of IDR 75,076,517. However, with an additional overtime cost of approximately IDR 46,269,857, Model 4-3 has successfully decrease IDR 4,022,200,000 worth of shortages.

Therefore has created a tradeoff ratio of 1:87, meanings that every IDR 1 increase of overtime cost has decreased IDR 87 of shortage cost. Such tradeoff is relatively good, especially when the amount of shortage itself is as staggering as IDR 4,022,200,000. Unfortunately, the desired overtime work hours are not available within the existing Production Line DB XI; therefore it should be distributed to other idle line.

Distribution of workloads from Line DB XI into Line DB II could be done into two ways, which are distributing workloads only into overtime work hours while neglecting available regular hours on Line DB II as shown in Model 4-1 which results to total cost of IDR 65,327.384, and by distributing excess workloads into available or idle regular work hours in Production Line DB II as shown in Model 4-4 which results to a total cost of IDR 84,894,147, another increase number of budget spent on workforce. Model 4-4 has an additional amount of IDR 25,594,399 worth of man-hours, which results to a 1:157 trade-off ratio compared to Model 4-2, meanings that every IDR 1 spent on workforce, has led to a deduced IDR 157 of shortage cost.

Such model is IDR 42 better then the previous Model 4-3. By doing so, not only the shortage number can be decreased and desired overtime work hours are fulfilled, but also can save a total of IDR 11,281,498 by shifting the overtime workloads in Model 4-3 into regular hours as shown in Model 4-4, rather than just executing it in overtime work hours. The model is as shown below:

Constant Workforce, DB XI & DB II, Overtime (Actual)

Aggregate Planning	Sept	Oct	Nov	Dec
Beginning Inventory	-	-	-	-
Regular Hours Available on DB XI Based on MPS	57	86	160	146
Demand Forecast	13,300	19,600	18,000	15,000
Regular Hours Available on DB II Based on MPS	38	37	66	60
Actual Production	5,718	6,150	11,300	10,300
Units available before OT	- 7,582	- 13,450	- 6,700	- 4,700
Units Overtime on DB II & DB XI	7,582	13,450	6,700	4,700
Overtime Workhours used	126	269	134	94
First Overtime Workhours (IDR 35,220/Hr)	42	42	42	42
Next Overtime Workhours (IDR 46,690/Hr)	84	227	92	52
Total Overtime Cost	IDR 10,836,639	IDR 24,155,740	IDR 11,549,440	IDR 7,814,240
Ending Inventory	-	-	-	-
Shortage Cost (IDR 119,000/unit)	IDR -	IDR -	IDR -	IDR -
Safety Stock (25%)	3,325	4,900	4,500	3,750
Units Excess (W/O Safety Stock)	IDR -	IDR -	IDR -	IDR -
Straight time cost (IDR 23,480/Hr) * 2 workers	IDR 4,475,288	IDR 5,776,080	IDR 10,612,960	IDR 9,673,760
Total Cost	IDR 15,311,927	IDR 29,931,820	IDR 22,162,400	IDR 17,488,000
Accumulated Cost	IDR 15,311,927	IDR 45,243,747	IDR 67,406,147	IDR 84,894,147

Conclusion

	Model 2-1	Model 4-1	Model 4-2	Model 4-3	Model 4-4
Total Straight-time Cost	IDR 54,567,520	IDR 54,567,520	IDR 21,099,128	IDR 21,099,128	IDR 30,538,088
Total Overtime Cost	IDR -	IDR 8,729,864	IDR 28,806,660	IDR 75,076,517	IDR 54,356,059
Units Excess Cost (IDR 2,000/unit)	IDR 2,030,000	IDR 2,030,000	IDR -	IDR -	IDR -
Shortage Cost (IDR 119,000/unit)	IDR 1,021,020,000	IDR -	IDR 4,022,200,000	IDR -	IDR -
R57 and N57 Sales Loss	IDR 4,522,000,000	IDR 4,522,000,000	IDR -	IDR -	IDR -
Total Cost	IDR 1,077,617,520	IDR 65,327,384	IDR 4,072,105,788	IDR 96,175,645	IDR 84,894,147

it can beconcluded in accordance with financial concerns that there are two best options to overcome production shortage of Nissan Motor UK‟s product code R60 Pad-less, which are production Model 4-1 and Production Model 4-4. Model 4-1, which excels with the total cost of IDR 65,327,384, is deemed the most suitable model to be used as an improvement as it is capable of achieving IDR 0 of shortage cost. However, Model 4-1 will result to an additional sales loss of IDR 4,552,000,000 from the Nissan Motor UK‟s product code R57 and CMF1 N57 as it utilizes all work hours only for Nissan Motor UK‟s product code R60 Pad-less while sacrificing other production. On the technical point of view, Model 4-2 is also only applicable when PT. AAIJ allocates all workloads capability of Production Line DB XI solely for the production of R60, but in other word making Production Line DB XI a dedicated production line, therefore making it impractical and does not fulfill the technical norms. On the other hand, Model 4-4 is able to reduce the cost to merely IDR 84,894,147, an IDR 19,566,763 more expensive than the Model 4-2.

Be as it may, Model 4-2 also fulfills all financial and technical characteristics of PT. AAIJ aggregate planning, in which desires no spontaneous and constant lay-offs and hiring, no activities of any form of sub-contracting, no additional production line investment, no current product line workloads diminishing, and no certain product sacrifices. Therefore, Model 4-4 is the most suitable and realistic improvement towards aggregate production planning.

Recommendation

Based on the observation and analysis conducted through a comparison of existing and simulated production models, PT. AAIJ should utilize more workforce and work hours resources on Production Line DB II at its best capability. Model 4-4, as the most recommended model, with a total cost of approximately IDR 84,894,147, can be applied on the current aggregate production planning as an improvement towards the current aggregate planning. According to such situation, author has also provided the optimization strategy in terms of work-hours of DB II and DB XI in a form of Master Production Schedule. The proposed MPS is configured with the current available workloads based on historical data, and also distributed in accordance with PT. AAIJ preferences, in which are no week end work hours, balance workloads, and no new investment. As seen in the appendix, in the Master Production Schedule Alteration Recommendation tables, planned production in September is equal to the order number of 13,300, which is divided into 6,051 units in DB II and 7,249 units in DB XI.

In October, total production number fulfills the order number of 19,600, and divided into 8,582 units in DB II and 11,018in DB XI. In November, total production number is equal with the total order of 18,000 with configuration of 6,668 units in DB II and 11,332 in DB XI. In December, production number also fulfill order quantity, the same as the current MPS, although workloads are distributed evenly between workdays with the total of 5,353 units produced in DB II with a daily production number of 281-282 units in 19 effective working days, and total of 9,647 unit in DB XI with a daily production number of 507-508 units per day in 19 effective working days. The proposed MPS, which can be found in the appendix column, can be used either as a reference to future MPS planning, or used merely as a spectrum of possible improvement within the production planning. Other minor recommendations that can be done to improve production management system are to design an alternative forecasting method to anticipate fluctuated orders, create a strict working environment to minimize any production plan alterations, and consider a new investment to a new production line to accommodate future growing orders.

References

Heizer, J. H., & Render, B. (2008). *Operations Management* (Vol. 2). Pearson Prentice Hall.

Reid, R. D., & Sanders, N. R. (2007). *Operations Management* (Vol. 3). Reid and Sanders.

Chase, C. W. (2013). *Demand-Driven Forecasting: A Structured Approach to Forecasting* (Vol. 2). Charles W. Chase.

Sunil Chopra, P. M. (2007). *Supply Chain Management: Strategy, Planning, and Operation.* Pearson Prentice Hall.

Colliers, & Evans. (2013). *Operations Management* (Vol. 4). Colliers and Evans.

Nahmias, S. (2005). *Production and Operation Analysis* (Vol. 1). London: McGraw-Hill Education.

Anthony, R. I. (2015). *Aggregate PLanning.* Retrieved 2016, from References for Business: http://www.referencesforbusiness.com/management.A-Bud/Aggregate-Planning.html#ixzz41kaLfotJ

Heizer, J. H., & Render, B. (2011). *Operations Management* (Vol. 10). Prentice Hall.

Lin Pan, B. H. (1995). *Aggregate Planning Today* (Vol. 1).

Slacks, N., Chamber, S., & Johnson, R. (2007). *Operations Management.* Prentice Hall.

Damodaran, A. (n.d.). Retrieved from NYU Stern University: http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/margin.html

Fatihah, N. (2015). *Improving Inventory Management System at Ilthofb Fashion Store.* Institut Teknologi Bandung. Bandung: SBM ITB.

Chasiwan. (2016). *Aggregate Planning Strategies at CV. Saswco Perdana.* Institut Teknologi Bandung. SBM ITB.