CHAPTER 4
ANALYSIS AND DISCUSSION

4.1 The 6 Sigma Methodology

The final report methodology using 6 Sigma lean concept to improve with the existing process – DMAIC (Define, Measure, Analyze, Improve and Control), with the step focuses as follow:

- Define: Mapping Current State of processes and gathering data collection.
- Measure: Total Lead Time, Cycle Time and Cycle Efficiency, Investment required.
- Analyze: Identify Wastes, Issues, Discounted Cash Flow analysis.
- Improve: Capacity Increase, Cost Reduction, Mapping Future State.
- Control: Set appropriate production metrics to maintain future state performance.

4.2 The Production Capability Analysis

The information of fabrication production capabilities are based on as follows:

a. The analysis focus to all major fabricated component level such as Stick As, Frame As – Upper, Boom As, Frame As – Under, Counterweight, and Bucket components is out of scope since produces under other department at PT ABC.

b. The information related with customer requirement, current customer demand for hydraulic excavator components is 2,75 units per day (Based on 660 machines per year or 55 machines per month with 20 working days per month).The future demand is 4 units per day, 5 units per day and 7.1 units per day.

c. Gather all production information related with the production cycle time, resources, and inventory. The data needed such as:
    - Number of operator.
    - Number of stations per operation.

- Number of parts per cycle process.
- Cycle time operation.
- Change over time.
- Number of shift at product line.
- Available time.
- Baseline production daily demand with other scenarios.
- Takt time scenarios.
- Work in process in the work station.

d. Available Time at the fabrication production line is 7.16 hours on first shift, 6 hours on second shift and 6 hours on third shift.

Table 4.1 The Detail of Available Time

												Baseline Daily Demand	"What-if" Demand Level		
Day of Week Index =>		1	2	3	4	5	6	7				2.75	4.00	5.00	7.10
Demand	Shift#	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total	Days/ Week	Min/ Shift	Takt = 149.1 @ 2.8 Per Day	Takt = 102.5 @ 4.0 Per Day	Takt = 82.0 @ 5.0 Per Day	Takt = 57.7 @ 7.1 Per Day
Demand 1st Shift	1	2.75	2.75	2.75	2.75	2.75	0	0	14						
Demand 2nd Shift	2	0	0	0	0	0	0	0	-						
Demand 3rd Shift	3	0	0	0	0	0	0	0	-						
Total Demand		2.75	2.75	2.75	2.75	2.75	0	0	13.75			14	20	25	36
Available Min 1st Shift	1	410	410	410	410	410	-	-	2,050	5	410				
Available Min 2nd Shift	2	-	-	-	-	-	-	-	-	0	360				
Available Min 3rd Shift	3	-	-	-	-	-	-	-	-	0	360				
Total Minutes		410	410	410	410	410	-	-	2,050	5	1130	2,050	2,050	2,050	2,050
										Minutes	Takt Time	149.09	102.50	82.00	57.75

Source: Research data at PT ABC

e. The production processes covers all fabrication steps from tack welding, full welding, cleaning, painting and machining. Illustrated at Table 4.2.

f. The future production capacity planning is 1200 machines on 2011 and 1700 machines on 2012.

g. The Request For Investment (RFI) for PT ABC provided by Hydraulic Excavator product group with maximum spent < US$ 4,25 Millions.

h. Interpretation on Internal Rate Return on the investments with an IRR less than the cost of debt (currently 5%) do not allow for the repayment of debt and would always be unacceptable from a strict economic viewpoint. Investments with an IRR between 5% and 10% would exceed our cost of debt, but would not support our WACC.

Tabel 4.2 >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

i. Thus, shareholder value would deteriorate, which would be unacceptable from a strict economic point view. Investments with an IRR between 10% and 16% would exceed our WACC and increase shareholder value, but not provide the overall return needed to meet our enterprise financial targets. Investments with an IRR of 16% (and above) achieve the minimum desired return to support our enterprise financial targets. Appropriate quantification of risk should be included in the discounted cash flows, as the 16% hurdle rate is to be met under the most realistic business case.

j. PT ABC product will allocated to ASEAN market when they have the surplus supply on Indonesia demand.

4.3 Current State Value Stream Mapping Analysis

Based on the customer requirement on the fabrication components and the takt time calculation or time allocated to produce one parts or component based on the rate of sales, found the constrains processes at fabrication process to meet higher demand in year 2011 and after.

And based to the current data the management assumption indicated that some areas need to be expanded and replicated in order the production capacity increased by supporting the investment on the tooling and space, by eliminated wastes on the process flow that mapped on current value stream.

After gathered all the information to support the current stream mapping such as defined customer requirements, identified process steps, separated by inventory, gathered process data, gathered inventory data, determined external material flow and determined information driving flow and internal material flow and finally calculate and map total cycle time in order could be reviewed and analyzed for future improvements, the developed map shown on the figure 4.3.

Figure 4.1>>

Figure 4.2>>

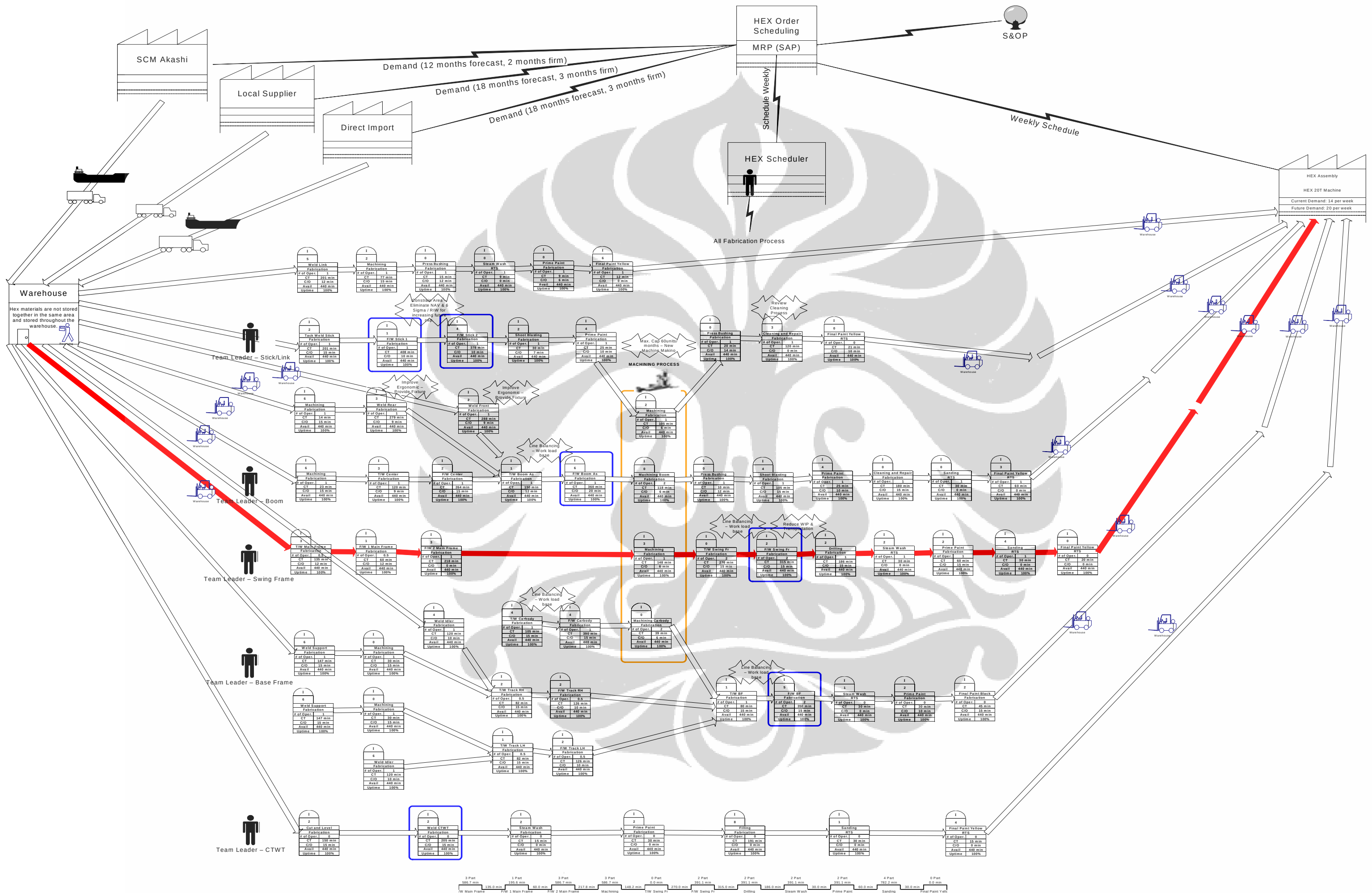

Figure 4.3 PT ABC Fabrication Value Stream Mapping

Source: Current State Analysis at Fabrication Process PT ABC

From the observation in the production line and review on the current value stream mapping could be identified wastes on the value stream and process waste.

Table 4.3 Levels of Waste

LEVELS OF WASTE	
Value Stream Waste	**Process Waste**
▪ Easy to spot ▪ Big Impact on Value Stream ▪ High potential for improvement	▪ Involves waste within the process or microwastes within a process
Examples ▪ Work-in-progress ▪ Poor plant layout – transporting material ▪ Rejects ▪ Returns ▪ Rework ▪ Material not delivered to point of use ▪ Batch size ▪ Lax equipment maintenance	**Examples** ▪ Poor cell design ▪ Unsafe workplace or process ▪ Bending and reaching ▪ Double handling ▪ Temporary storage ▪ Paperwork ▪ Speed and feed of the equipment

Source: Project Review at PT ABC

The analysis focused on the opportunity to achieve value stream improvement that focused on People, Quality, Velocity and Cost on the value stream level.

On the people will focus on the eliminated safety hazard to support zero accident during the production process and also encourage production team members to create improvement ideas to support productivity, from the observation found the 5S improvement opportunities in each components work centers. Quality focus on developing the quality system and layout to support components with zero defects and the Velocity focus on the creating one piece flow process and made stable process. And the last related with effective cost to support with production activities.

Figure 4.4 Wastes Finding at Operation Processes

Source: Observation at Production Line PT ABC.

The detailed observation from the major components hydraulic excavator as follows:

Boom Current Work Processes:

- F/W Boom process 5,8hr and add with repair process 3hr for weld and surfaces.
- Over production for each backing plates for butt weld grind before tacking to boom – 25 minutes.
- Workspace Clutter because rework processes – Unused creativity/Capability.
- Boom after blasting and primer paint back to work center for cleaning.
- Part defects from First Operation Supplier.
- All Booms have pitted defect because lifted by chain.
- Front and Rear Boom welded without positioner since technical and safety issue on positioner.

- Final Weld quality focused at final process.
- Cleaning Level unclear for welder – No standard for cleaning level.

Base Frame Current Work Processes:

- F/W Carbody and Base Frame consuming high time – 6.5hr
- Carbody after machining storage at front of Full Weld Base frame, need crane and waste time when delivered to Tack Weld area.
- Parts packaging position need improve from suppliers, in order eliminate hazards and reduce time for rotation process.
- Excessive motion and setup when carbody welded on positioner because welder should climb and setting weld positions.
- Part defects from First Operation Supplier.
- Lamps over Tack Weld area out of order – Safety and Quality.

Swing Frame Current Work Processes:

- Swing Frame (S/F) is critical path on HEX Fabrication.
- The longest CT is Full Weld S/F with total time 5.25hr.
- Before drilling process, S/F need burning process to balance skirt RH and LH. Burning time around 15-25 minutes.
- Wet floor condition
- Part defects from First Operation Supplier.

Stick and Link Current Work Processes:

- Full Weld Stick Reinforce is the longest CT at HEX Fabrication, 6.8hr.
- Every parts need repair and cleaning process – 2hr with one dedicated person.
- Stick back to welding area after primer paint – Transportation waste.
- Over Processing on bracket grinding process.
- Waiting for External Weld Inspection (UT Test) if Quality Auditor not available.

Based on the current conditions and analysis on current value stream map of hydraulic excavator fabrication found the longest lead time process at the

Swing Frame line and the fabrication production capability depend on the production flow on the critical path, at the current state value stream map the critical path illustrated with the red line.

The summary of the production ability to meet a customer demand shown on table below:

Table 4.4 Current State Map Statistic

Part - VSM Critical Path Statistics					
Takt Time =	410.91	min			
Exit Rate =	1.00	Unit	per	378.00	min
WIP =	22.00	Units	=	9040.0	min
TCT =	9040.00	min	=	150.7	hrs
VA =	1452.00	min	=	24.2	hrs
CE =	16.1%				
# Operators =	11.00				

Source: Current State Value Stream Statistic Results at PT ABC

The Cycle Efficiency (CE) for the fabrication is 16.1% with Work In Process (WIP) 22 units in the processes, with this performance the opportunity for improvements to increase cycle efficiency by reducing the level of inventory and eliminating the non value added activities.

4.4 Future State Value Stream Mapping Analysis

Based on the customer requirement on the fabrication components and the calculating takt time or time allocated to produce one parts or product, based on the rate of sales, to meet customer requirements, found the constrains processes for the future demand.

The major constrain that should be reviewed before decided for expansion investment in order eliminated the cost and create profitable growth on PT ABC operation processes. The cycle time constrain should be reduced in order achieved with the future takt time.

For the short term planning management need to cover demand rate 4 units machines per day or 80 machines per month or 960 machines per month with low capital investment.

From the observation on the work centers of constrain components such as Stick As, Main Frame, Boom As and Base Frame some improvement to reduce cycle time could be implemented and had the opportunities improve the continuous flow at fabrication areas.

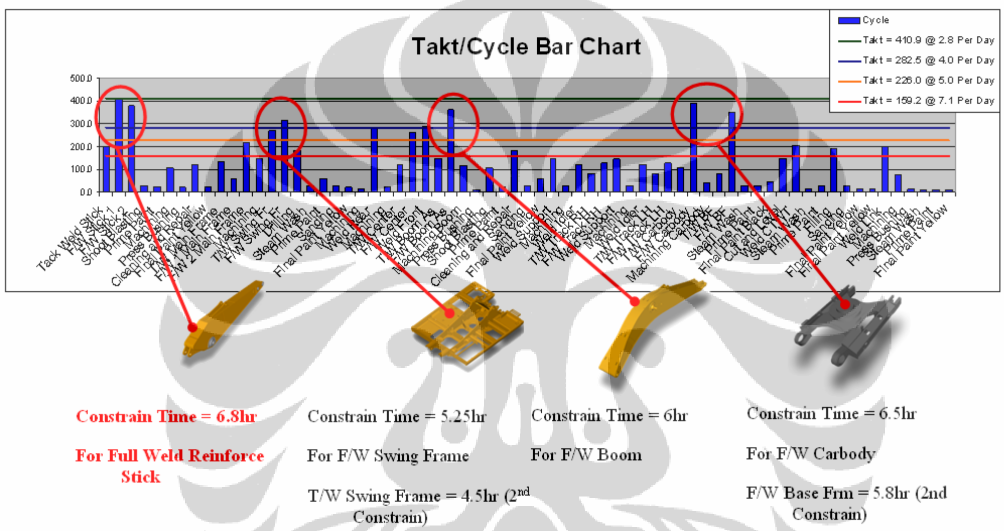

Figure 4.5 The Major Constrain at Fabrication Line

Source: Current State Value Stream Results at PT ABC

To address with the 2010 production demand gap with the current capability the pilot project for rapid improvement launched with supported by all production team and all related support functions such as safety, maintenance, engineering, quality and human resources. The detail agenda for the improvement as follows:

- Review with safety hazard at all production line then scoring to measure with the impact on current and future process, the focus on safety included 5S, Safety risk assessment and training all member with safety programs.
- Review with all current standard process including review with current state map to formulate future improvement.

- Refine future demand and process and made the simulation for next processes.
- Evaluate and verify the current processes, the established the new process including the new standard process and improvement on the safety and quality.
- Review with the result and benefit from the improvements.

Follow with the steps at above, the new improvement process for fabrication area implemented with the goal for reducing the non value added activities. The key point for the improvement is line balancing for the high cycle time by distributed the task to other areas or by added new work centers if the constrain process could not allocated to other process.

The summary below is the rapid improvement results in order increase the production capacity with short time and low capital investment.

4.4.1 Boom Improvement Processes

The key points of the improvement processes at the Boom fabrication such as: eliminating safety hazard in the work center by reinforcing 5S and standard work, improve the quality by introduced clear standard for the inspection criteria and implemented quality gates, reducing the cycle time by eliminating over processing in the cleaning and grinding by 2 hrs, leverage the highest process time to previous processes or line balancing at full weld, reduce WIP in the line.

4.4.2 Base Frame Improvement Processes

The key points of the improvement processes at the Base Frame fabrication such as: eliminating safety hazard in the work center by reinforcing 5S and standard work, re-layout of work center, improve the quality by introduced clear standard for the inspection criteria and implemented quality gates, leverage the highest process time to previous processes or line balancing at full weld from 5,8 hrs to be 2.5hrs, reduce set up time for big raw material, reduce WIP in the line.

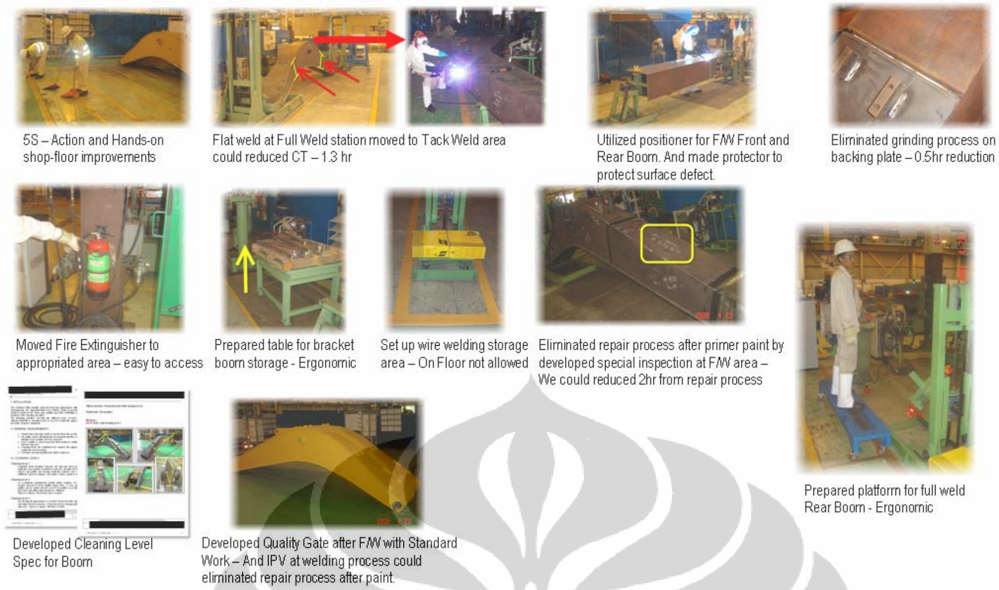

Figure 4.6 Boom Line Process Improvements

Source: Improvement Project at PT ABC.

Figure 4.7 Base Frame Line Process Improvements

Source: Improvement Project at PT ABC.

4.4.3 Swing Frame Improvement Processes

The key points of the improvement processes at the Swing Frame fabrication such as: eliminating safety hazard in the work center by reinforcing 5S and standard work, re-layout of work center, improve the quality by introduced clear standard for the inspection criteria and implemented quality gates, reducing the cycle time by eliminating over processing in the cleaning and grinding, leverage the highest process time to previous processes or line balancing at full weld from 5,25 hrs to be 4.65 hrs, reduce WIP in the line.

4.4.4 Stick and Link Improvement Processes

The key points of the improvement processes at the Stick and Link fabrication such as: eliminating safety hazard in the work center by reinforcing 5S and standard work, re-layout of work center and add the stand to improve the velocity at full weld from 6.8 hrs to be 3.4 hrs, improve the quality by introduced clear standard for the inspection criteria and implemented quality gates, reducing the cycle time by eliminating over processing in the cleaning and grinding, reducing WIP in the line.

Figure 4.8 Swing Frame Line Process Improvements

Source: Improvement Project at PT ABC.

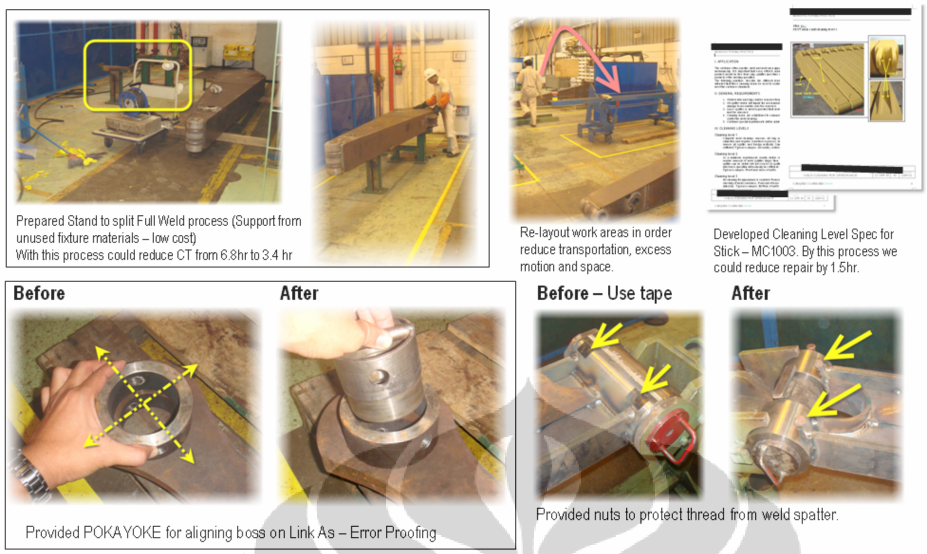

Figure 4.9 Stick and Link Line Process Improvements

Source: Improvement Project at PT ABC.

All improvement processed illustrated above done in the one week with full time support and gave the evident that production capacity could increase to 80 units per month or 1080 units per year, Figure 4.10.

And to support with the improvement on the process flow and reducing inventory, the supermarket and pull system should be introduced to the future value stream map, and make all cycle time process lower than takt time.

The summary of the production ability to meet a customer demand after the improvement shown on table below:

Table 4.5 Future State Map Statistic

Part - VSM Critical Path Statistics					
Takt Time =	410.91	min			
Exit Rate =	1.00	Unit	per	279.00	min
WIP =	17.00	Units	=	6985.5	min
TCT =	6985.45	min	=	116.4	hrs
VA =	1379.00	min	=	23.0	hrs
CE =	19.7%				
# Operators =	12.00				

Source: Future State Value Stream Statistic Results at PT ABC

Table 4.10>>

The Cycle Efficiency (CE) for the fabrication improved by 22,36% from 16.1% to 19.7 % with reduced Work In Process (WIP) by 29,41% from 22 units to 17 units in the processes, with this performance the fabrication line could increase the production from 55 hydraulic excavator per month to be 80 per month.

For future development some improvement on the process flows developed in order reduced the inventory by implementation the pull system to trigger the replenishment process for production materials.

The pull implementation should introduce on the supply based area from the order of raw materials to facility from the suppliers especially for the local suppliers, the other pull concept should introduce in the central service process in the fabrication process such as machining process and painting process since all more than one type of components should be processed in on machine or one work center.

4.5 Common Effective Preferential Tariff (CEPT) Scheme Implementation

Hydraulic excavator type 20 ton produced by PT ABC in the CEPT scheme categorized as not wholly obtained or produced and should content at least 40 percent of ASEAN Value Content or Regional Value Content (RVC) originates from that member states or it has undergone a change in tariff classification at four-digit level (change in tariff heading) of the Harmonized System (HS). Based on the BTBMI 2009 list, hydraulic excavator 20 ton had HS Code 8429.52.00.00 and categorized under zero percent of tariff duty on CEPT scheme, see to the Table 4.7. If the local content less than 40 percent the tariff duty when the machine exported the ASEAN country would be applied as Most Favorable Country (MFN) tariff for 10 percent, this condition made the product would not competitive if the other competitor already applied tariff 0 percent.

To fulfill the 40 percent RVC for hydraulic excavator 20 ton from PT ABC, only two quick win localized products program applied to the machines in order increase the content value:

1. Attachment bucket as standard configuration for export and capable to produce in house or local suppliers.

2. Localize Cabin As from Japan to Indonesia, Komatsu and Hitachi makes their cabin in local supplier and opportunities to be replicated.

Table 4.6 Harmonized Codes for Hydraulic Excavator

Subdirectorate of Classification

HS CODE	URAIAN BARANG	DESCRIPTION OF GOODS	MFN	CEPT	PPN*	PPnBM*	LARTAS*
84.29	**Buldoser, angledoser, mesin perata, leveller mesin pengikis, sekop mekanik, eskavator, shovel loader, mesin pemadat dan mesin giling jalan, berdaya gerak sendiri.**	**Self-propelled bulldozers, angledozers, graders, levellers, scrapers, mechanical shovels, excavators, shovel loaders, tamping machines and road rollers.**					
	-Buldoser dan angledoser :	-Bulldozers and angledozers :					
8429.11.00.00	--Track laying	--Track laying	10	0	10	-	
8429.19.00.00	--Lain-lain	--Other	10	0	10	-	
8429.20.00.00	-Grader dan mesin perata	-Graders and levellers	10	0	10	-	
8429.30.00.00	-Mesin pengikis	-Scrapers	0	0	10	-	
8429.40	-Mesin pemadat dan mesin giling jalan :	-Tamping machines and road rollers :					
8429.40.10.00	--Mesin giling jalan	--Road rollers	10	0	10	-	
8429.40.30.00	--Mesin pemadat	--Tamping machines	0	0	10	-	
	-Sekop mekanik, ekskavator dan shovel loader :	-Mechanical shovels, excavators and shovel loaders :					
8429.51.00.00	--Front-end shovel loader	--Front-end shovel loaders	10	0	10	-	
8429.52.00.00	--Mesin yang berputar 360° diatas bangunan dasarnya	--Machinery with a 360° revolving super structure	10	0	10	-	
8429.59.00.00	--Lain-lain	--Other	10	0	10	-	

Source: Buku Tariff Bea Masuk Indoneis (BTBMI 2009).

Table 4.7 Regional Value Content Plan

RVC - Direct Method	Hydraulic Excavator with Bucket	Hydraulic Excavator with Local Cabin
Non ASEAN content		
Material Cost	66.5%	59.2%
ASEAN content		
Material Cost	20.4%	27.5%
Freight	5.3%	5.2%
Process Costs:	12.4%	12.7%
- Variable Logistic		
- Variable Labor		
- Variable Machines		
- Period Machine		
- Period Logistic		
- General Overhead		
- Margin		
Total ASEAN Content	**38.1%**	**45.4%**

Source: Project Analysis at PT ABC