Suesca Rozo, Kathya Alexandra; Santos Hernández, Andrés Felipe

Conference Paper

Design of an added plan with social responsibility

Proceedings of the Hamburg International Conference of Logistics (HICL) – 25

Kathya Alexandra Suesca, Andrés Felipe Santos

Design of an Added Plan with Social Responsibility

HICL

Published in: The Road to a Digitalized Supply Chain Management
Wolfgang Kersten, Thorsten Blecker and Christian M. Ringle (Eds.)
ISBN 9783746765358, September 2018, epubli

Design of an Added Plan with Social Responsibility

Kathya Alexandra Suesca Rozo[1], Andrés Felipe Santos Hernández[1]

1 – Escuela Colombiana de Ingeniería ”Julio Garavito”

For decades and worldwide, steel has been one of the most important commodity in the development of the industry due to its multiple uses. At present, the offer of steel in Colombia is too low compared to the sector's demand. This has caused market speculation and a low added value regarding all products made with steel. In such a competitive market, the organizations involved have been developing strategies to improve their incomes, some of these are developed in the operations area, where the planning is the most important part regarding the cost reduction, minimize the rate of rotation of the personal in the operations area and increment in the effectivity of the supplies chain. Having this need and tendency created, the investigation group designed an added planning model, based on the case of an enterprise that transforms steel in cloves. Using this model in the enterprise will guarantee decrease the shortage in posterior periods and as consequence lower the costs and wastes caused by shortfalls, the costs of keeping an inventory and costs due to high lead time to market. Furthermore, the model will minimize the rate of rotation of the personal in the operations area, this will result encouraging social responsibility which contribute to the organization's productivity.

Keywords: Steel transformation; Added planning; Optimization; Social responsibility

First recieved: 30.May.2018 *Revised:* 09.Jul.2018 *Accepted:* 16.Jul.2018

1 Introduction

Since the start of the 50's, steel in Colombia has become a resource quite relevant regarding development of the industry and the country's infrastructure. 500.000 tons of steel are expected to be the demand in the projects of infrastructure, such as the routes 4G (El Espectador, 2017). Nowadays, according to Camacero (Cámara Colombiana del Acero), Colombia produces 1.2 million tons of steel and consumes 3.6 million tons, this shows a shortfall in the primary supply chain of the sector. Therefore, the producers and marketers must import around 2.4 million tons per year, so the demand can be satisfied (Portafolio, 2017).

Production of this sector represents 7% of the national industrial GDP and even though it creates more than 40.000 jobs, it still shows problems in reducing the production and logistics costs. This is a consequence of the lack of knowledge regarding the practices in the supply chain and exterior facts, such as the increment of imports in lower prices (Dinero, 2017).

Keeping in mind the late technological and industrial tendencies in the world, China has shown to be the asiatic country with the highest production of steel, with around 800 tons per year, provides about 50% of the global demand (El nuevo siglo, 2016). Their companies are owned by the state, so they are highly subsidized and are not governed by market rules (Alacero, 2017). For this reason, their prices are lower than the market, which is known as dumping (El español, 2016).

This has generated an oversupply of this product and a drop in international prices (Portafolio, 2017). Not to mention the technical stoppages and closures of steel plants that the overproduction of this asiatic giant has generated (Alacero, 2017).

Consequently, the Chinese government has hardworking to close those companies that produce low quality steel made of scrap. Same, with the objective to reduce its production capacity by more than 50 million tons, increment their prices and minimize environmental impacts (Infoacero, 2018). In addition, these decisions are part of the government's goal of changing its economic model, with less dependence of the industry and more focalized on new technologies (Angencia EFE, 2018).

Regarding this inconvenient, the sector must know that it will continue to fight with the price against this rival, since the asiatic country will continue to produce steel at very competitive prices. For this reason, the national companies of sector should implement best practices throughout the supply chain, specifically in the primary chain and the planning of its production, to guarantee the supply of this product at a competitive cost.

Given the fact that this product is a commodity, the enterprises involved with this supply chains have had to deal with the prices, and therefore the organizations are concerned and have worked slowly in reducing the operational costs with the purpose of improving their opportunities and therefore their oncomes.

Even though detecting the wasting and overspends along the process is relevant (Nave, 2002), this practice does not reduce the costs significantly in comparison to an adequate planning in its supply chain. As Chopra (2008) says, an adequate plan will guarantee the focalization of the resources along the chain so that an emerging market can be handled, even more if there are high lead time to market, uncontrolled product portfolios, over-stock, low service quality, lost sales, and unsatisfied customers.

However, the arrival of enterprises such as Gerdau, Votorantim and Techint has improved the sectors know how and its technology level. This, marked by the demand of competitiveness, requires that the customer service and the attention to the market demand an expansion in the investments of the information systems and adequate planning in the supply chain (Munar, 2008).

By identifying this need in the sector, the research group has built a model of added planning, through the application of linear programming, for an enterprise located in Bogotá (Colombia) that works in the transformation of steel in construction products, such as rod, mesh, cloves, picks, and other products. The model's aim is to lower the costs of the planning in the supply chain, the costs are the inversions made with the expectations of getting benefits in the future, but also in the present. How we try to impact in the enterprise is to generate benefits along the whole chain so that we can accomplish a balance between the demand and the offer of cloves.

To meet this end, a model has been developed so that the effectivity and the productivity of the resources is improved. A model like this is a representation of reality using linear mathematic expressions, in which we can know with certainty the parameters and by giving it a solution, the model proposes which should be the decisions to make in one or more time periods (Bohórquez Quiroga , Sarmiento Lepesqueur, & Jaimes Suárez, 2013).

2 Added Planning Models

There are many methods of added planning which can be divided in three groups according to Boiteux, these are: comparative alternatives, use of decision rules and based in models of linear programming (Boiteux, 2007). The linear programming models are the most used nowadays.

There are some authors that have developed applications, in this sector, there is Cañas (2013), who planned the production of an industry that belong at the metallurgical industry so that he could maximize utilities by introducing multiphase, multi period, multiproduct models of linear programming and by the development of a constructive heuristic based on the principles of the restrictions theory. Chavez (2014), designed a model of linear programing with the purpose of resolving a problem of added planning in production for Huachipato metallurgical company, considering the restrictions concerning inventory, demand, and capacity. Zurito (2010), made a model of linear programming to minimize the lacks in the inventory and therefore the associated costs. Gholamian & Tavakkoli & Nezam (2015), developed an entire mixed model of linear programming with a multi objective approach, to minimize the total production cost, improve the service quality, minimize fluctuations in the rates of change of the work force and maximize sales.

3 Case Study

3.1 Company and Process Background

The enterprise to be analyzed is part of the labor union Camacero (Cámara colombiana del acero), which was created in 2014 with the objective of gathering more than 40 national enterprises dedicated to the production, transformation, and commercializing of steel. This with the purpose of generating solutions in the value chain (El Espectador, 2014). Nowadays, the labor union counts with more than 400 producers registered.

In Latin-American, Colombia is stablished as the fourth steel producer after Brazil, México, and Argentina (Alacero, 2017). Nevertheless, Colombia must work to increase its production and improve its competitiveness.

According to the ANDI (Asociación nacional de empresarios de Colombia) between 2007 and 2016 the sector grew 13% (Andi, 2018), despite the hard situation that it has been facing.

Given this need and considering the shortage of raw material, the strong competence with foreign enterprises, a model of added planning is proposed so that it determines the ideal production, capacity inventory, stock-out and out-sourcing levels required to satisfy the cloves demand, the product that was chosen to this case of study (Sunil Chopra, 2008). Nevertheless, if the organizations in addition to making a correct planning would add practices of social responsibility, they would assure not only the decrease of costs, but also will assure an improve in their competitiveness.

It is also necessary to identify the stage in which the workers are about the learning curve, this means to know if they are beginners, medium or advanced. If enterprises reduce the rotation of their advanced personnel, they could assure not only quality but also the flux in production. We know this because the workers with more experience have a more efficient handling of the resources and guarantee the improvement of the production.

3.2 The Process

The fabrication process of the 3”x 24 -kilogram galvanized clove has 5 steps. The raw material for this product is 5-milligram SAE 1023[1] steel which comes in approximately 2-metric ton rolls. The supplying of this material is made with forklifts, leaving 2 rolls per round in two reelings. These feed two drawing machines, the koch 1 and koch 2. These machines are automatic, the operator handling is needed during the time of charge and discharge. The drawing is the plastic conformation of a material through tensile continuous stresses, through rows, it is possible it’s thinning (Boca, 2017). In this case, a diameter of 5.5-milligram was thinned to a diameter of 3.8-milligram. This wire is deposited in coils of up to 900-kilogram., which are transported by the forklift to the area of hot galvanizing. On each route, the vehicle can carry up to four coils. In the hot galvanizing line, usually 2 lines are programmed for this type of product.

[1] It is a quality of low carbon steel that can be used in cold. It has high tenacity and low mechanical resistance.

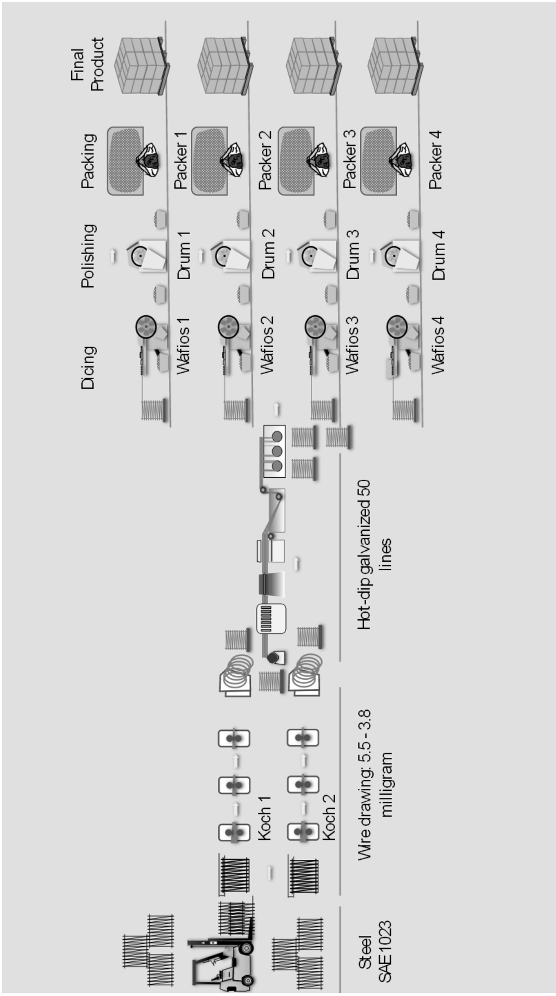

Figure 1: Galvanized 3”x 24-kilogram clove process

The entire line has 50 threads, but only two lines are programmed for this type of clove; these coils are unrolled at a slow pace, going through a process of hot galvanizing, which is a surface treatment in a zinc vat at high temperatures that allows the wire to be protected from corrosion, so that later, the galvanized wire is winded at the end of the line, also, with up to 900-kilogram (Berto, 2017). This material is taken by the forklift to the cloves ship, where 4 wafios equipment are programmed. These machines turn the wire into cloves, temporarily storing them in baskets of up to 300-kilogram. Using a bridge crane, in the same ship, the baskets are taken to the polishing area, where 4 drums that turn with sawdust, clean, and polish the clove. These polished cloves are deposited again in the same baskets and loaded by the bridge crane to the packing section. Generally, 4 packers are scheduled for the packing of this material. Each packer manually weighs about 600-grams with a tolerance of 10-grams. In each pack, and each one of these, the packer deposits the clove in a cardboard box of 24-kilogram. As they finish each carton they stack it in a stowage, until completing 54 cartons. The operator that is completing the stacking, packs the stowage with stretch film[2].

[2]Vinipel, translucid plastic film with a high resistence.

Table 1: Statistics of the process of the 3”x 24-kilogram galvanized clove. May 2017.

Operation	Equipment	Production speed (ton/hour)	Efficiency (%)	Real production (ton/hour)
Drawing	Koch 1	2.1	65	1.4
	Koch 2	2.5	57	1.4
Galvanizing	2 lines	3.5	63	2.2
Dicing	Wafios 1	1.7	72	1.2
	Wafios 2	1.3	67	0.9
	Wafios 3	1.5	70	1
	Wafios 4	1.2	55	0.7
Polishing	drum 1	0.7	85	0.6
	drum 2	0.8	92	0.7
	drum 3	0.7	80	0.6
	drum 4	0.6	89	0.5
Packing	packer 1	0.024	78	0.008
	packer 2	0.024	82	0.008
	packer 3	0.024	72	0.007
	packer 4	0.024	86	0.009

4 Methodology

4.1 Data Gathering

The product that was chosen to carry out this research was the galvanized 3”x 24-kilogram clove, which was selected through an ABC analysis, which is a tool used to classify products into, high, medium and low turnover categories, also known as pareto’s 80:20 law, which indicates that 80% of the money from the sales of a company is generated by 20% of the existing products in its portfolio, so that this product has an A classification (Bravo, 1996).

4.2 Model Formulation

In order to develop the added planning model, the planning horizon of six months and the demand to be supplied are identified. Based on Table 2, the demand of the 3”x 24-kilogram clove is shown based on a historical data given by the organization. Furthermore, Table 3 shows the costs associated with the aggregated plan.

In order to calculate the kilograms per standard hour produced by each of the drawing, galvanizing, dicing and polishing machines, the speed of production and efficiency for each machine are considered.

Then, to calculate the kilograms per standard hour produced by each of the drawing, galvanizing, dicing and polishing machines, the speed of production and efficiency for each machine are considered.

Table 2: 3” x 24- kilogram cloves demand

Months	Demand unit (kilogram)
June	16500
July	13800
August	13100
September	18450
October	18465
November	22350

Table 3: Costs associated with the added plan. May 2017.

Item	Price	Unit
Material	11	€ /kilogram
Inventory maintenance cost	1.4	€ /kilogram/month
Stock-out cost	1.8	€ /kilogram/month
Hiring cost	225	€ /worker
Dismissal cost	315	€ /worker
Packing MOD cost	8.3	€ /hour
Extra hours cost	14.3	€ /hour
Drawing cost	19.5	€ /hour
Galvanizing cost	75	€ /hour
Dicing cost	33	€ /hour
Polish cost	12.6	€ /hour
Outsourcing cost	60	€ /kilogram

Drawing operation: It has two drawing equipment, the koch1 and the koch 2.

$$Drawing\,machine = \left(2100\frac{kilogram}{hour} * 65\%\right) + \left(2500\frac{kilogram}{hour} * 57\%\right) = 2790\frac{kilogram}{hour} \tag{1}$$

Galvanizing operation: It has one machine

$$Galvanizing\,machine = \left(3500\frac{kilogram}{hour} * 63\%\right) = 2205\frac{kilogram}{hour} \tag{2}$$

Dicing operation: It has four machines (Wafios).

$$Dicing\,machine = \left(1700\frac{kilogram}{hour}*72\%\right) + \left(1300\frac{kilogram}{hour}*67\%\right) + \left(1500\frac{kilogram}{hour}*70\%\right) + \left(1200\frac{kilogram}{hour}*55\%\right) = 3805\frac{kilogram}{hour} \tag{3}$$

Polish operation: It has four machines

$$Polish\,operation = \left(700\frac{kilogram}{hour}*85\%\right) + \left(800\frac{kilogram}{hour}*92\%\right) + \left(700\frac{kilogram}{hour}*80\%\right) + \left(600\frac{kilogram}{hour}*89\%\right) = 2425\frac{kilogram}{hour} \tag{4}$$

Based on the kilogram per standard hour of each machine, the cost per hour is calculated. Table 4 shows the costs associated with the drawing, galvanizing, dicing and polishing operations. The kilogram per hour produced by the packing operation depends on the efficiency of each worker, because this operation, unlike the drawing, galvanizing, dicing and polishing operations, uses labor for its operation. The efficiency of each packer is determined by the seniority. The classification is shown in Table 5.

In order to calculate the labor of packing, the following assumptions are considered: 1 shift has 7.5 hours a day and 1 month has 25 days.

Beginner packer labor per hour

$$Beginner = \frac{\left(54\frac{boxes}{turn}*\frac{24}{1}\frac{kilogram}{box}*\frac{1}{7.5}\frac{turn}{hours}*55\%\right)}{4} = 24\frac{kilogram}{hour} \tag{5}$$

Table 4: $ per-kilogram costs. Source: the authors

Operation cost	Price	Unit
Drawing cost	0.01	€ /kilogram
Galvanizing cost	0.03	€ /kilogram
Dicing cost	0.01	€ /kilogram
Polish cost	0.01	€ /kilogram

Table 5: Personal classification in the Packing operation

Type	Efficiency	Seniority
Beginner	55%	Less than 3 months
Medium	65%	Between 3 and 4
Advanced	85%	More than 4 months

Medium packer labor per hour

$$Medium = \frac{\left(54 \frac{boxes}{turn} * \frac{24}{1} \frac{kilogram}{box} * \frac{1}{7.5} \frac{turn}{hours} * 65\%\right)}{4} = 28 \frac{kilogram}{hour} \tag{6}$$

Advanced packer labor per hour

$$Advanced = \frac{\left(54 \frac{boxes}{turn} * \frac{24}{1} \frac{kilogram}{box} * \frac{1}{7.5} \frac{turn}{hours} * 85\%\right)}{4} = 37 \frac{kilogram}{hour} \tag{7}$$

Furthermore, based on the amount of days we can have an inventory of the product in the process of drawing, dicing, and polishing. The used inventory policies are shown in Table 6.

The first step to build a model of added planning is to identify the decision that the enterprise can make (Sunil Chopra, 2008).

Table 6: Inventory policy

Drawing (Kilogram)	Galvanizing (Kilogram)	Dicing (Kilogram)	Polish (Kilogram)	Final Product Inventory (Kilogram)	Stockout (Kilogram)
10 days	4 days	6 days	8 days	15 days	Policy
5500	2200	3300	4400	8250	250
4600	1840	2760	3680	6900	250
4367	1747	2620	3493	6550	250
6150	2460	3690	4920	9225	250
6155	2462	3693	4924	9233	250
6548	2619	3929	5239	9823	250
6856	2742	4114	5485	10284	250

4.2.1 Decision Variables

Be t= 1, ... ,6 the horizon time to analyze, Where 1=June, 2= July, ..., 6 = November.

The next step in the construction of the model is establishing the objective functions.

Table 7: Decisions can be taken

Variable	Description
B_t	Number of employee’s beginner for packing at the beginning of month t.
Md_t	Number of employee’s medium for packing at the beginning of month t.
A_t	Number of employee’s advanced for packing at the beginning of month t.
D_t	Number of employees dismissed for packing at the beginning of month t.
C_t	Number of employees hired for packing at the beginning of month t.
F_t	Amount of kilogram produced in drawing in month t.
P_t	Amount of kilogram produced in dicing in month t.
G_t	Amount of kilogram produced in galvanizing in month t.
U_t	Amount of kilogram produced in polishing in month t.
M_t	Amount of kilogram of finished product in packing in month t.
EB_t	Number of extra hours of beginner hired for packing at the beginning of month t.
EMd_t	Number of extra hours of medium hired for packing at the beginning of month t.
EA_t	Number of extra hours of advanced hired for packing at the beginning of month t.
IF_t	Inventory of drawing at the end of month t.
IG_t	Inventory of galvanizing at the end of month t.
IP_t	Inventory of dicing at the end of month t.
IU_t	Inventory of polishing at the end of month t.
IM_t	Inventory of finish product at the end of month t.
S_t	Number of pending units in month t.
SC_t	Number of subcontracted units in month t.

4.3 Objective function:

Minimize the total cost of the organization during the time of the planning, in this case its 6 months.

$$\text{Min Z} = \sum_{t=1}^{6} 225 * C_t + \sum_{t=1}^{6} 315 * D_t + \sum_{t=1}^{6} 1532 * B_t + \sum_{t=1}^{6} 1532 * M_t + \sum_{t=1}^{6} 1532 * A_t + \sum_{t=1}^{6} 14.3 * (EB_t + EM_t + EA_t) + \sum_{t=1}^{6} 0.01 * F_t + \sum_{t=1}^{6} 0.03 * G_t + \sum_{t=1}^{6} 0.01 * P_t + \sum_{t=1}^{6} 0.01 * U_t + \sum_{t=1}^{6} 1.4 * IM_t + \sum_{t=1}^{6} 1.8 * S_t + \sum_{t=1}^{6} 60 * SC_t + \sum_{t=1}^{6} 11 * F_t \tag{8}$$

4.4 Subject a:

The size of the work force: the size of the work force, which is the total of the hired workers in the month t, considering the actual workers (beginner, medium and advanced), but not the dismissed ones.

$$B_t + Md_t + A_t = B_{t-1} + Md_{t-1} + A_{t-1} + C_t - D_t \tag{9}$$

Extra hour: a worker (beginner, medium and advanced) can work until 10 extra hours in the month t (Gerencie, 2017).

$$EB_t \leq 10 * B_t \tag{10}$$

$$EMd_t \leq 10 * Md_t \tag{11}$$

$$EA_t \leq 10 * A_t \tag{12}$$

Packing capacity: the amount of kilogram cloves produced should not be above the available capacity of the packer (beginner, medium and advanced).

$$\left(1\,turn * \frac{7.5\,hours}{1\,turn} * \frac{25\,days}{1\,month} * \frac{24-kilogram}{hour}\right) * B_t + \left(\frac{24-kilogram}{hour}\right) * EB_t \geq M_t \tag{13}$$

$$\left(1\,turn * \frac{7.5\,hours}{1\,turn} * \frac{25\,days}{1\,month} * \frac{28-kilogram}{hour}\right) * Md_t + \left(\frac{28-kilogram}{hour}\right) * EMd_t \geq M_t \tag{14}$$

$$\left(1\,turn * \frac{7.5\,hours}{1\,turn} * \frac{25\,days}{1\,month} * \frac{37-kilogram}{hour}\right) * A_t + \left(\frac{37-kilogram}{hour}\right) * EA_t \geq M_t \tag{15}$$

Machine capacity: the production capacity of the machines must be greater than the production required in the drawing, galvanizing, dicing and polishing operations.

$$\left(1\,turn * \frac{7.5\,hours}{1\,turn} * \frac{25\,days}{1\,month} * \frac{2790-kilogram}{hour}\right) \geq F_t \tag{16}$$

$$\left(1\,turn * \frac{7.5\,hours}{1\,turn} * \frac{25\,days}{1\,month} * \frac{2205-kilogram}{hour}\right) \geq G_t \tag{17}$$

$$\left(1\,turn * \frac{7.5\,hours}{1\,turn} * \frac{25\,days}{1\,month} * \frac{3805-kilogram}{hour}\right) \geq P_t \tag{18}$$

$$\left(1\,turn * \frac{7.5\,hours}{1\,turn} * \frac{25\,days}{1\,month} * \frac{2425-kilogram}{hour}\right) \geq U_t \tag{19}$$

Inventory: the inventory in each operation must be equal to the inventory in the immediately previous period, plus the production carried out in that period, minus the production required in the next season, minus the inventory that should remain in the operation; to guarantee the flow of production.

$$IM_t = IM_{t-1} + M_t + SC_t - S_{t+1} + S_t - demand(t) \tag{20}$$

$$IF_t = IF_{t-1} + F_t - G_t \tag{21}$$

$$IG_t = IG_{t-1} + G_t - P_t \tag{22}$$

$$IP_t = IP_{t-1} + P_t - U_t \tag{23}$$

$$IU_t = IU_{t-1} + U_t - M_t \tag{24}$$

Constrain positive: ensure that the variables take positive values.

$$\begin{aligned} B_t, Md_t, A_t, C_t, D_t, EB_t, EMd_t, EA_t, F_t, G_t, \\ P_t, U_t, M_t, IF_t, IG_t, IP_t, IU_t, IM_t, S_t, SC_t \geq 0 \end{aligned} \tag{25}$$

On the other hand, it must be guaranteed that the out-sourced units do not exceed 250 units and that the inventory policies established are equal to the inventory of each operation in each month.

5 Results

The total cost with the proposed model is 1.51 M €. The Tables 8, 9, 10, 11, 12, and13 shown the results. This Table shows the production that is required in each operation, drawing, galvanizing, dicing, polishing and final product to satisfy the demand of claves.

These tables show the inventory that each operation should have according to the corresponding inventory policies. As can be observed, the only month with shortage in units is November.

Table 8: Production during the planning horizon (2017)

Month	Production drawing (kilogram)	Production galvanizing (kilogram)	Production dicing (kilogram)	Production polishing (kilogram)	Final product (kilogram)
June	38600	32000	33100	29800	25400
July	10290	11370	11190	11730	12450
August	12190	12470	12423	12563	12750
September	25405	23265	23622	22552	21125
October	18485	18479	18480	18477	18473
November	20929	20457	20536	20300	19985

Table 9: Inventory WIP (2017)

Month	Drawing inventory (kilogram)	Galvanizing inventory (kilogram)	Dicing inventory (kilogram)	Polishing inventory (kilogram)	Final product inventory (kilogram)
June	5500	2200	3300	4400	8250
July	4600	1840	2760	3680	6900
August	4367	1747	2620	3493	6550
September	6150	2460	3690	4920	9225
October	6155	2462	3693	4924	9233
November	6548	2619	3929	5239	9823

Table 10: Policies of Stock-out and Outsourcing

Month	Stock-out (kilogram)
November	250

Table 11: Work force required for each period

Month	Worker Force
June	15
July	8
August	8
September	12
October	11
November	12

The number of workers after the month of August is regular. The distribution according to the time horizon is shown in Table 12.

Table 12: Distribution of work force

Month	Hiring cost	Dismissal cost	Beginner	Medium	Advanced
December					4
June	11		6	5	4
July		7	3	3	2
August			3	3	2
September	4		5	4	3
October		1	4	4	3
November	1		5	4	3

Table 13 shows distribution of costs according to the type and time period such as the total costs of hiring, dismissal and extra hours.

Table 13: Total costs

Month	June	July	August	September	October	November
Hiring cost	2475			900		225
Dismissal cost		2205			315	
Beginner	9281	4641	4641	7734	6187	7734
Medium	7734	4641	4641	6187	6187	6187
Advanced	6187	3094	3094	4641	4641	4641
Extra hours cost				215	391	
Drawing cost	270	72	85	178	129	146
Galvanizing cost	1088	387	424	791	629	696
Dicing cost	287	97	108	205	160	178
Polish cost	155	61	65	117	96	105
Inventory cost	11137	9315	8842	12453	12464	13260
Stock-out cost						450
Outsourcing cost						
Material cost	405300	108045	127995	266753	194087	219755

The kilograms of the final product that the organization should produce to satisfy the demand are 110183 kilograms with the raw material unit cost estimated as 11 €, which gives a total cost of 1.2 M€ and a total cost of planning of 1.5 M€. The cost of buying raw material represents 77 % of this cost. This shows a shortage in the supply chain of this sector.

6 Improvements

Aggregate planning plays a fundamental role in the supply chain, because it allows any organization to determine the quantity of production, inventory, outsourced units, minimum of inventory shortage and capacity that it must have in a given period, to satisfy the demand. In turn, it will guarantee the reduction of costs and improve the level of service.

On the other hand, performing an aggregate planning model, considering the level of learning of workers, i.e., if the worker is beginner, medium or advanced, allows the organization to classify workers according to their efficiency in each period. In this way, a fair wage could be guaranteed for them.

Whit the proposed model, the organization may:

- Determine the optimal level of inventory that this should have, to ensure a good level of service and incur a low cost to maintain inventory.
- Identify the cost in which the organization incurs to keep the three kinds of workers. (beginners, medium and advanced)
- Verify if it complies whit the established inventory policies of the organization.
- Include social responsibility issues to ensure a fair wage for their employees which will depends on their efficiency.
- Reduce the inventory shortage and their associated costs.
- Minimize the operations personnel turnover.

— Manage the variability of delivery time and demand.

7 Relevance in the Sector

The combination of aggregate planning with social responsibility is essential if organizations seek to increase their productivity and consequently their competitiveness. Each one fulfills a fundamental role, in the first case it seeks to make the best decisions at the aggregate level, and in the second case, to ensure a focus on the organization's human capital, so that a fair payment is made.

One of the decisions that any organization should take when planning is to decide how many workers to hire and how many to dismiss, if the organization considers the efficiency of its workers and plans based on this, it will be able to reduce the rotation of the Operations personnel, because their workforce will be enough to supply all the demand. Consequently, their workforce would be motivated, and the organization would not have to incur costs for fired.

On the other hand, being steel is one of the scarcest raw materials at the national level and with greater use, its cost of acquisition is high compared to international prices, for this reason the organizations immersed in the sector must contend at price level.

8 Conclusions

The aggregate planning being more than a mathematical model, is a tactic tool that enables the determination of the inventory, production, stock-out levels as well as the workers that the organization needs to satisfy the demand in the corresponding period of time. In addition, it guarantees the optimization of cost, time and resources.

The planning guarantees an organization a high level of service, reduced costs and controls the variability of demand. However, the planning should consider the social responsibility in order to ensure fair wages and level of workforce in all working periods.

Finally, the organization should considers its operations within the whole supply chain. This includes the added value from the side of raw material to the final product in order to decrease the lead time to market along with the associated costs and waste caused by shortages and inventory.

References

Alacero (2017a). *Latin America in figures 2017*.

Alacero (2017b). *Steel subsidized from China puts at risk the employment of thousands of Latin Americans. We call on our governments to act urgently and ensure fair competition.*

Alacero (2017c). *Uses of Steel*.

Andi (2018). *Colombian Committee of steel producers*.

Berto, R. and M. Ayatollai (2017). “Mechanical behavior of hot-dip galvanized welded steel under”.

Bohorquez Quiroga C., S. L. A. J̃. S. (2013). *Mathematical model*.

Boiteux, O. D. (n.d.). “State of the art on aggregate production planning”. PhD thesis.

Bravo, J. (1996). *Purchases and inventories*.

Camacero (2014). “The guild of steel is born, Camacero”. In:

Camacero (2017). “Economic information”. In:

Cañas Catañeda, J. S. (2013). “Planning of the production applying linear programming models and theory of restrictions for an industry in the metalworking sector”.

Chase, R., R. Jacobs, and N. Aquilano (2009). *Production operations management and supply chain*.

Chopra, S. (2008). *Management of the supply chain Strategy, Planning and Operation*.

Clifford, F. A. and H. Reinoso (2014). “Formulation of a programming problem for the aggregate planning of steel company Huachipato”.

Dinero (2017a). *Despite dumping and low demand, the steel industry does not stop investing*.

Dinero (2017b). *Improve prospects for the steel industry How is it and where is it going?*

Donald J. Bowersox, David J. Closs, and M. Bixby Cooper (2007). *Administracion y logistica en la cadena de suministros*, p. 426.

El español (2016). *Why China is a growing threat to European steel*.

El Espectador (2017). *An industry that stomps*.

El Nuevo Siglo (2016). *China threatens steel sector in Colombia*.

F, A. (2018). *China will continue to cut capacity for steel and coal production in 2018*.

Gerencie (2017). *It is not legal to work more than 10 hours a day*.

Gestión (2017). *China, the world leader in steel and aluminum accused of ”dumping” by its partners*.

Herrera, M. (2018). *Another year of high prices*.

Infoacero (2017a). *How is the panorama of the steel industry going?*

Infoacero (2017b). *The Academy and its Importance to Promote the Use of Steel*.

Mahdavi-Amiri, N. G. I. M. R., M. Tavakkoli, and M.-A. Nezam (n.d.). “A Comprehensive fuzzy multi-objective multi-product multi-site aggregate production planning decisions in a supply chain under uncertainty”.

Munar, X. V. (2008). *Strategic direction for the steel industry in Colombia for the year 2020*.

pais, E. (2016). *China, the great steel super producer*.

Portafolio (2008). *Why does China sell so cheap?*

Portafolio (2014). *In Colombia, production is much lower than demand*.

Portafolio (2017). *Colombian steel, between China and local demand*.

Quality, A. S. for (2002). “How To Compare Six Sigma, Lean and the Theory of Constraints”. In: *American Society for Quality*.
República, L. (2017). *Contraband and low prices in China, the main problems of the steel industry*.
Sas-Boca, I. M., M. Tintelecan, M. Pop, D.-A. Iluţiu-Varvara, and A. M. Mihu (2017). “The wire drawing process simulation and the optimization of geometry dies”. In: *Procedia Engineering* 181, pp. 187–192.
Vargas, L. D. (2016). *Steel and metalworking: a sector of importance for the Colombian industry*.
Zurito Olea, C. A. (n.d.). “Production planning at the Gerdau Aza steel company. S.A”.