PRODUCTION FLOW OPTIMIZATION AT SIDOR WITH AIS [1]

Freddy Hormiga[2]
Ronald Perez[2]
Gustavo Alvarez[3]
Danny Nuñez[3]
Pierre Beghin[4]

Abstract

The project goal is to optimize the production flow of SIDOR (Siderúrgica del Orinoco), through the implementation of a model of the production plant (31 production lines) and a solver to calculate the daily volume to be produced by production line, dealing with production campaigns, available capacity, the plan stops, and the restrictions of inventories, and meeting the required demand. The methodology of the project consisted in a first stage in preparing the data to model the supply chain: the characteristics of the production lines and inventories, productivity, yields, transport times, cooling times, lead times, defining data interfaces with production systems. In a second phase the AIS planning system that supports the model, the solver and the user interface was configured. In the third phase were performed testing and validation of the model and the tuning of the solver, and the definition of reports. The optimization of flow production allows better management of production resources, optimizing the load distribution of production between nominal and alternative lines optimize the evolution of stocks across the line and providing a safety stock but also an effective rotation inventories. The simulation of different scenarios to assess changes in plans or in campaigns sequences, check the customer orders shipment on time, the distribution of the order by market segment and validation of the goals of the monthly production plan.

Key words: Production planning; Flow balancing; Optimization.

OTIMIZAÇÃO DO FLUXO DE PRODUÇÃO NA SIDOR COM A AIS

Resumo

O objetivo do projeto é a otimização do fluxo de produção da SIDOR (Siderúrgica del Orinoco) , a traves da implantação de um modelo da cadeia de produção da fábrica (32 líneas de produção) e um solver para calcular o volume diário a ser produzido por línea, resolver as campanhas de produção, respeitando a capacidade disponível, o plano de paradas, e as restrições de inventários, e atendendo a demanda de pedidos requerida. A metodologia do projeto consistiu em uma primeira fase em preparar o levantamento dos dados para alimentar o modelo da cadeia de produção: características das líneas e inventários, produtividades, rendimentos, tempos de transporte, tempos de resfriamento, lead times; Definições das interfaces de dados com os sistemas de produção. Em uma segunda fase foi configurado o módulo de planejamento da AIS que suporta o modelo, solver de resolução e interface gráfica. Na terceira fase foram executados testes e validações do modelo assim como o tuning do solver, e a definição dos relatórios. A otimização do Fluxo de produção permite um melhor gerenciamento dos recursos de produção, otimizando a distribuição da carga de produção entre líneas nominais e líneas alternativas, otimizar a evolução dos estoques em frente à línea, assegurando um estoque de segurança, mas também uma rotação efetiva dos estoques. A simulação de diferentes cenários permite avaliar mudanças nos planos de paradas ou na sequencia de campanhas de produção, verificar o atendimento a pedidos e navios em devido tempo, a distribuição do despacho por segmento de mercado e a validação dos objetivos do plano mensal de produção.

Palavras-chave: Planejamento de produção; Balanço de fluxo; Otimização.

[1] *Technical Contribution to the 29th Logistic Seminar, June, 17th-18h 2009, 2010, Joinville SC, Brazil.*
[2] *Sidor, Planning*
[3] *Sidor, IT models*
[4] *AIS / PSI, Consultant*

ISSN 1982 - 985X

1 INTRODUCTION

Sidor, C.A. is an integrated steel complex located in Venezuela, manufacturer of flat and long steel products. It produces steel through the direct reduction of iron ore and AC electric arc furnaces.

Its wide product mix enables the company to serve an important range of industries and activities such as oil & gas, construction, automotive, home appliances, packaging and canning, hot dip galvanizing lines, distributors and service centers.

AIS (member of the PSI group) is specialized in the development and the implementation of software for decision support in the areas of production planning and supply chain logistics in process industries.

The planning component is a powerful production planning solution, developed by AIS, which optimizes the performance of a metallurgical plant in terms of product output, quality, order-to-delivery time and cost.

2 GENERAL OVERVIEW

The production chain that has been modeled involves 31 production lines. The main lines have the following characteristics:
1 wide hot strip mill (1 rougher and six finishing stands)
2.4 M T/year
2 Pickling and Tandem mills (5 stand 4-high)
1.5 M T/year
2 Batch annealing units and1 continuous annealing line.
3 Temper mills (two 2 stand 4-high and one 1-stand 4-high)
0.9 M T/year
1 Electrolytic tinning line & 1 tinning and tin-free line
0.3 M T/year
Skin pass, cutting lines, slitters, re-coilers, and packing lines are also modeled.
The detailed description of the production lines and the material flow is described in the following diagram:

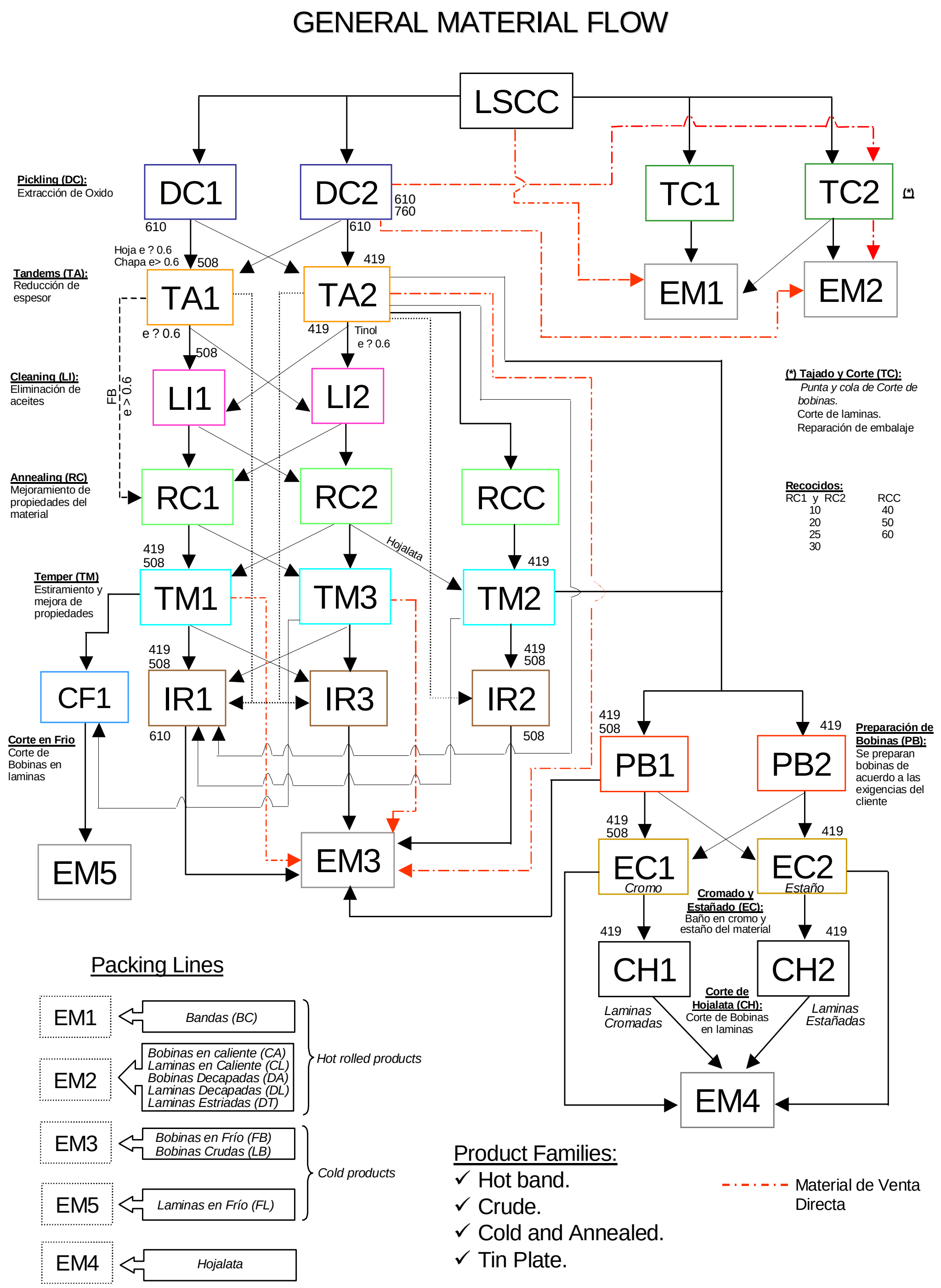


Figure 1 – General Material Flow Diagram.

Table 1 – Production Lines modelled

It	Name	Description	Description (English)
1	LSCC	Laminador semi-continuo	Hot strip mill
2	TC1	Tajado, Corte	Slitting and Cutting line
3	TC2	Tajado, Corte	Slitting and Cutting line
4	DC1	Decapado	Pickling line
5	DC2	Decapado	Pickling line
6	TA1	Tándem	Tandem mill
7	TA2	Tándem	Tandem mill
8	LI1	Limpieza	Cleaning line
9	LI2	Limpieza	Cleaning line
10	RC1	Recocido	Batch annealing
11	RC2	Recocido	Batch annealing
12	RCC	Recocido continuo	Continuous annealing
13	TM1	Temper	Temper mill
14	TM2	Temper	Temper mill
15	TM3	Temper	Temper mill
16	CF1	Corte en Frio	Cold cutting
17	IR1	Rebobinadora	Coiler and conditioning
18	IR2	Rebobinadora	Coiler and conditioning
19	IR3	Rebobinadora	Coiler and conditioning
20	PB1	Preparación Bobina	Coil Preparation
21	PB2	Preparación Bobina	Coil Preparation
22	EC1	Estañado Cromado	Stain and Chrome
23	EC2	Estañado Cromado	Stain and Chrome
24	CH1	Corte Hojalata	Tin plate cut to length
25	CH2	Corte Hojalata	Tin plate cut to length
26	EM1	Embalaje	Packing line
27	EM2	Embalaje	Packing line
28	EM3	Embalaje	Packing line
29	EM4	Embalaje	Packing line
30	EM5	Embalaje	Packing line
31	SKP	Skin Pass Line	Skin Pass Line

The project scope covers the supply of a Flow Plan solution for the production lines of SIDOR, relative to the production lines described in Table 1. The resolution horizon is a rolling window of 30-45 days, with a time resolution of 1 day.

3 OBJECTIVES

The objectives pursued by this project are:

- Better definition of the flow constraints for the HSM scheduling balance;
- Better control over slabs stock level evolution by product family;
- Simulation of the impact of maintenance plans changes;
- Graphical tools to visualize the stock evolution.
- Minimize work in progress stocks with adequate flow planning and control.
- Decrease the number of unplanned delays resulting from a lack of material or space, especially on bottleneck lines.
- Increase lines utilization rate.
- Decrease response time to unexpected situations.
- Gaining increased confidence, repetitiveness and efficiency in the planning process.

ISSN 1982 - 985X

4 METHODOLOGY

The team organization for the project involved jointly:

- the IT model's department
- the production planning project leader and planning responsible.
- the AIS consultants.

The methodology of the project consisted in a first stage in the preparation of the factory model of the production chain:

- the characteristics of the production lines and inventories,
- productivity,
- yields,
- transport times, cooling times, lead times,
- defining data interfaces with production systems.

In a second phase the planning component that supports the model, the user interface and the solver was configured.
An important point consists in defining the appropriate product families' aggregation level or detail according to the requirements of the planning business process requirement.
Product families have been defined as a combination of routes (as a sequence of production steps) and production patterns, such as campaigns on the tandem mills ("Chapa" or "Hojafina") and campaigns on the coating lines ("Cromo" or "Estaño").
In total, the flow plan is modeled through 120 product families to represent the main fulfillment streams of the production chain. Of course, these are simplified routes for the orders. As orders may have material on service lines or on exceptional reworks, a pre-processing of these materials pushes them artificially to the next process on the standard routes in their product family so that simplified routings can be used. This reduces complexity, simplifies the edition of the plan for simulations purposes and reduces computer process time for the solver and is enough detail for the planning purpose.
In a third phase were performed testing and validation of the model and the tuning of the solver, as well as the definition of reports. In this phase, data problems are corrected, and a fine tuning of the configuration is performed.

5 PROPOSED SOLUTION

The Flow Plan is an aggregated plan in product families and time buckets that manages the load balancing of the plant: the production flows for every day, the campaigns of products, the stock constraints, and the maintenances plans.
The Flow Plan takes care of appropriate stock evolutions in front of the production lines in order to build up inventory before campaigns for example, or manage maximum residence time of products in inventory.
The Flow Plan is used to generate the appropriate flow constraints as objective product flows for the hot strip mill scheduling.
The purpose of solving the load balancing by product family is to avoid having to decide which is the exact orders sequence, leaving freedom to the hot strip mill to decide which is the most appropriate combination of orders, avoiding arbitrary decisions that could result in excessive and useless constraints.
The result of the Flow Plan is an aggregated production plan used as common objective for the production people, for each production line, in tons and hours, for each day of the current month. It is also a tool that allows simulating the impact of

ISSN 1982 - 985X

changes in maintenance dates, in shift policies, in campaigns sequence or size or other simulations.

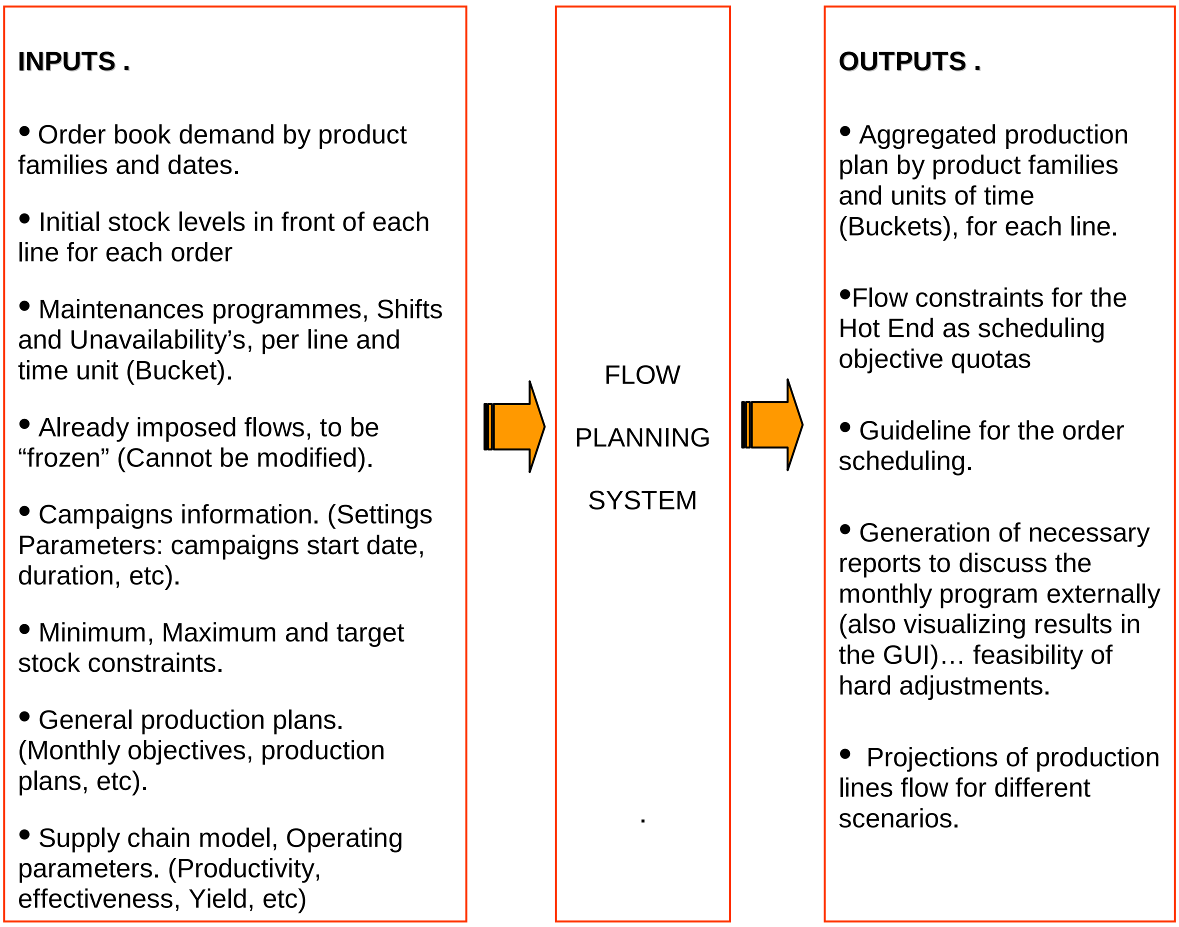
The result is also used to feed the AIS Hot Strip Mill scheduling optimizer system with flow constraints (already implemented in the hot end, see reference 1), in order to generate hot strip mill schedules that are balanced in product routing.

The inputs of the systems are:

- The factory model containing the lines, inventories, production routes, lead times, yields and productivities.
- The order book with the demand, weight balance in tons, due dates, material type, product family.
- The work in process, piece by piece, assigned or not to the orders.
- The maintenance and stops plan, with possible alternatives to make what if scenarios.
- The imposed campaigns plan horizon on the coating lines.

On top of these inputs, the user can impose flow constraints on particular lines (minimum or maximum cumulated constraints for example) for a tonnage, for the whole line or by group of products.

The user can also set target stock levels for the end of the month, to generate a plan in accordance to the expected inventory levels for the commercial industrial plan.



The outputs of the systems are:

- The production flow by product family on each line.

ISSN 1982 - 985X

- The stock evolution on each inventory, reaching the objectives stocks of the business plan and respecting the maximum warehouse constraints.
- The expected order due date satisfaction according to the capacity capabilities and the resulting calculated fulfillment streams.
- The generation and validation of the campaign plan on the coating lines.

6 RESULTS

The data extraction from the legacy system is done automatically three times per day to prepare the data situation for each shift (at 23h, 7h and 15h).
It is also possible to extract a data set with a snapshot of the situation on demand. Thanks to a fine tuning of the database and extraction code, in incremental mode, the extraction of the data for all orders (+/- 3000 in average), material units and frozen schedules, the generation of the order routes, takes all in all less than 6 minutes. A full extraction from scratch runs in less than 12 minutes.
Running the Flow Planner solver by the user takes 9 to 10 minutes, allowing the possibility of easily analyzing alternative scenarios.
The solver takes care about aiming about final order due date and weight balance satisfaction on the dispatching line. The solver aims at satisfying the demand by using the available capacity, respecting minimum residence times before lines (technical cooling times for example), logistics minimal times, but also maximum residence (stock perishing times) ensuring an appropriate stock rotation of products.
The simulation of the Flow plan allow to validate whether the campaigns defined on the coating lines are appropriate in time and duration, and whether the fulfillment streams of the different campaign products can be supplied in time.
The simulation of the Flow plan also allows checking appropriate load balancing of the different lines, evaluation of the usage of alternative lines and global stock levels evolution through the whole production chain. In particular, in the packing and dispatch lines where little room is available, a special attention is required to maximum inventory levels.
The user can change constraints or campaign duration to simulate what-if situations.
With the alarms on demand satisfaction and stock evolution the planner can react and simulate alternative scenarios of campaign planning, line stops or shifts assignments.
A follow-up of the results and key performance indicators during the year of 2010 will allow to measure on real numbers the expected stock reduction due to a better optimization of the production flow.
The following snapshots show some examples of the user interfaces that the user can see when operating the system: the lines and routes model, showing the order routings, the flow plan by bucket and lines and the demand matrix displaying the order book tonnage by characteristics.

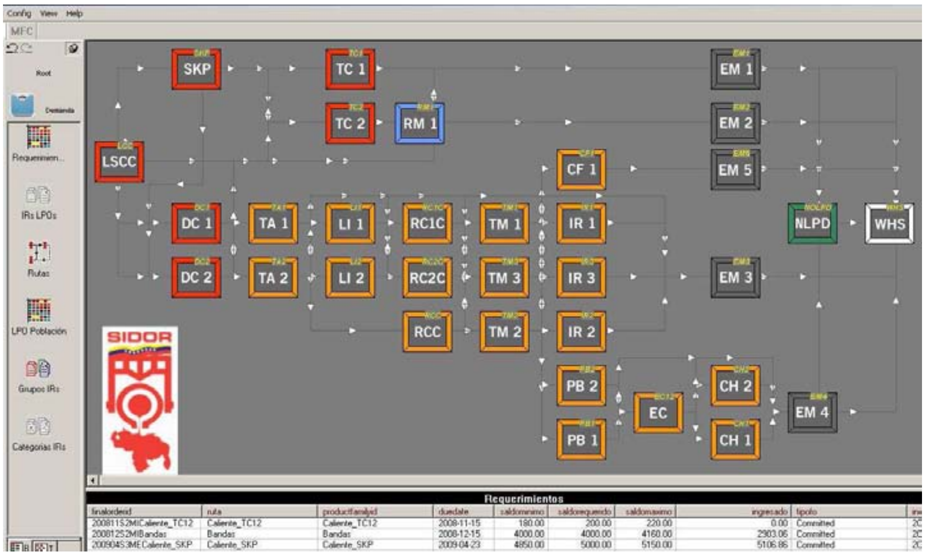


Figure 2 – Lines and routes model.

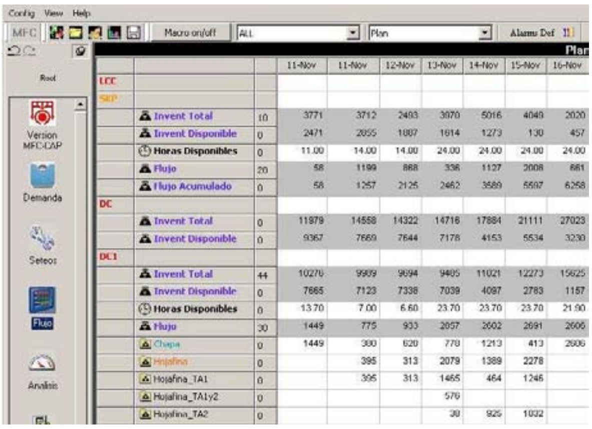


Figure 3 – Flows.

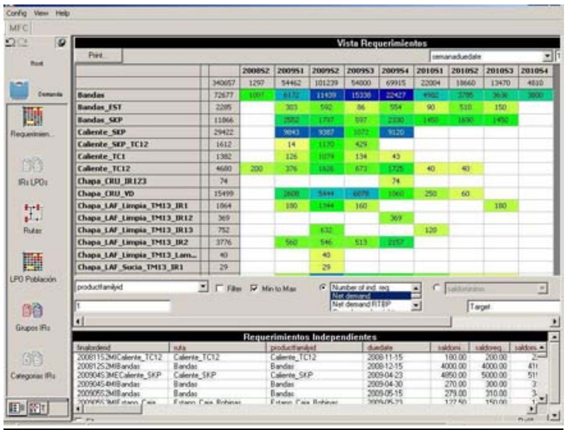


Figure 4 – Demand matrix.

The next steps are the workflow integration with the Hot Strip Mill scheduling system implemented in a previous phase (as described in an article of ABM automation seminar.[(1)]) and the master scheduling of the orders on the cold end lines.

REFERENCES

1 Ostos, 0;Hormiga, F.;Perez , R.;Alvarez.G; Beghin P., sidor’s steel making plant and hot strip mill production scheduling integration and optimization, ‘a steelplanner solution’ at Sidor. In: SEMINÁRIO DE AUTOMAÇÃO DE PROCESSOS, 9., 2005,