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ETI GIDA Chocolate Factory Production Planning Optimization Project

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INTRODUCTION

Eti Gıda was founded in Eskişehir in 1962 by Firuz Kanatlı.

The company produces biscuits, cookies, cakes, pies, chocolate, wafers, baby food and ready-made food products.

The project is carried out at Eskişehir Eti Chocolate Factory.

CURRENT SYSTEM

Production continues 24 hours a day in 3 shifts. Weekly and daily schedules are created to plan the production of products. There are 28 production lines in the factory. The capacities and speeds of lines different. The chocolate groups that can be produced on these lines may differ from each other. Set-up time between product groups are different. Sales of products are divided into three categories: international, export and local market. Products have different delivery priorities. A maximum stock period of 6-7 days is expected for the local market. Stock is not required for export and international products. Deliveries are made weekly.

PROBLEM DEFINITION

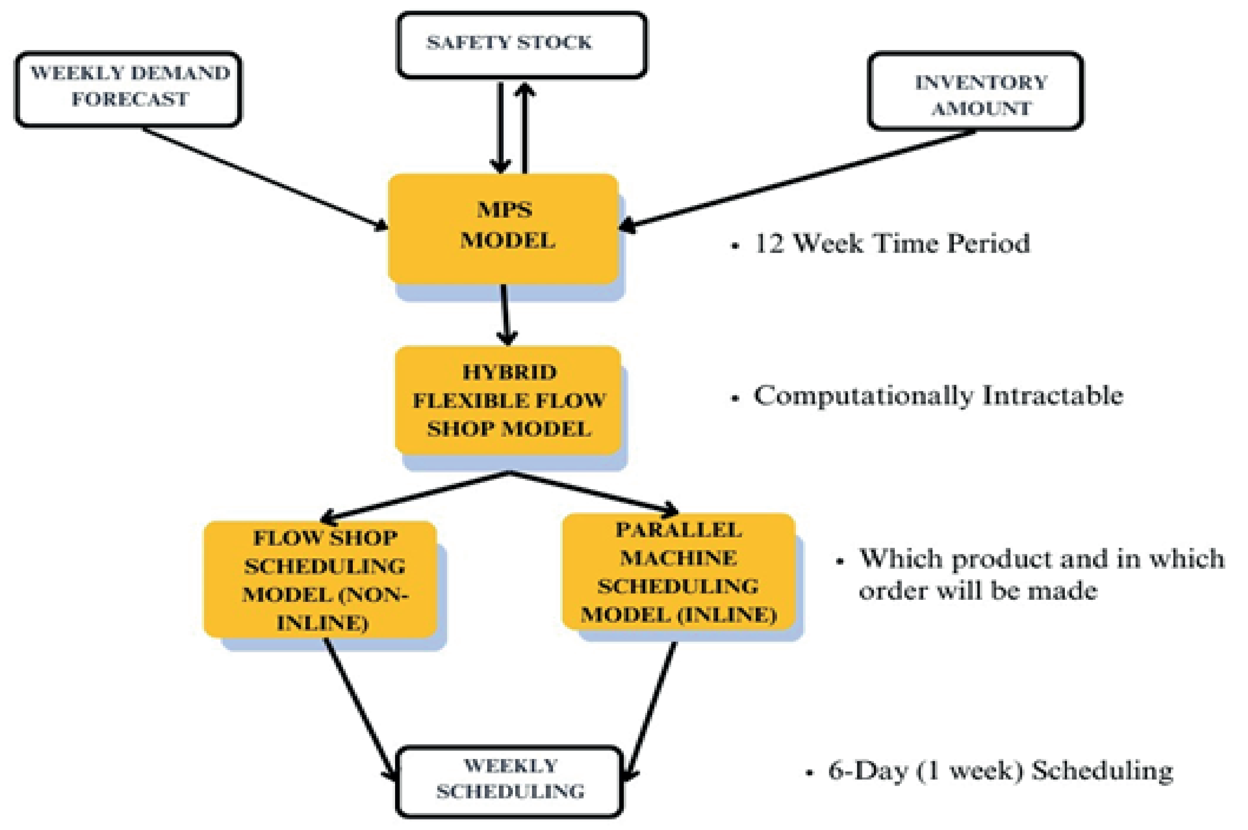
The main problem of the project is non-optimized production planning. The main reason for this is manual planning.

Since there is demand for finished products, a production plan is made according to the finished product. Therefore, the plan of semi-finished products is ignored. For this reason, problems such as overstocking, out-of-stock or shortage are occurring.

The firm needs a system that provides optimized planning by eliminating human-related planning errors to meet incoming demands.

Main Aim: Minimizing the cost and completion time

METHODOLOGY



1. MPS Model

Sets

i = product

k = semi-product

j = line

t = week

Parameters

c_{it} = penalty unit shortage cost of product i in week t

h_{it} = penalty unit holding cost of product i in week t

D_{it} = demand of product i in week t

b_i = beginning inventory of product i

v_{ij} = velocity of product i in line j

vs_{kj} = velocity of semi-product k in line j

$setup_{ij}$ = setup of product i in line j

$setups_{kj}$ = setup of semi-product k in line j

$minenv_i$ = minimum inventory of product i

MPQ_i = minimum production quantity of product i

w_{ij} = if product i can produce in line j 1, otherwise 0

ws_{kj} = if semi-product k can produce in line j 1, otherwise 0

$maxi_{jt}$ = maximum available hour of line j at week t

r_{ki} = if semi-product k is a semi-product of product i 1, otherwise 0

α = importance weight for shortage cost

γ = importance weight for holding cost

M = very large number

$worker_{ij}$ = number of workers required in line j to produce product i

$worker_{kj}$ = number of workers required in line j to produce semi-product k

Decision Variables

a_{ijt} = if product i was assigned to line j at week t 1, otherwise 0

as_{kjt} = if semi-product k was assigned to line j at week t 1, otherwise 0

$zresult_{it}$ = production quantity of product i week t

z_{ijt} = production quantity of product i in line j at week t

$zsresult_{kt}$ = production quantity of semi-product k at week t

zs_{kjt} = production quantity of semi-product k in line j at week t

I_{it}^{+} = amount of on hand inventory of product i in week t

I_{it}^{-} = amount of shortage of product i in week t

Formulation

Objective Function

Minimization of the cost is the objective of this model. The cost is the summation of total holding cost and total holding cost in equation 1.

$$Min\ TC = \alpha SC + \gamma HC \quad (1)$$

Objective Function Elements

$$SC = \sum_{it} c_{it} I_{it}^{-} \quad (2)$$

Shortage cost is a multiplication of the unit penalty shortage cost of product i in week t and the amount of shortage of product i at week t.

$$HC = \sum_{it} h_{it} I_{it}^{+} \quad (3)$$

Holding cost is a multiplication of the unit penalty holding cost of product i in week t and the amount of on hand inventory of product i at week t.

Constraints

Constraint	Domain	No.
$I_{it}^{-} = \sum_j z_{ijt} + I_{it}^{+} - D_{it}$	$\forall i,t$	(4)
$I_{i1}^{+} = b_i$	$\forall i,t$	(5)
$I_{it+1}^{+} = I_{it}^{+} + \sum_j z_{ijt} - D_{it}$	$\forall i,t>1$	(6)
$\sum_i z_{ijt} v_{ij} + \sum_i a_{ijt} setup_{ij} \le maxi_{jt}$	$\forall j,t$	(7)
$\sum_k zs_{kjt} vs_{kj} + \sum_k as_{kjt} setups_{kj} \le maxi_{jt}$	$\forall j,t$	(8)
$z_{ijkt} \le M a_{ijt}$	$\forall i,j,t$	(9)
$a_{ijt} \le w_{ij}$	$\forall i,j,t$	(10)
$as_{kjt} \le ws_{kj}$	$\forall k,j,t$	(11)
$z_{ijt} \ge MPQ_i a_{ijt}$	$\forall i,j,t$	(12)
$minenv_i \le I_{it}^{+}$	$\forall i,t>1$	(13)
$\sum_j zs_{kjt} \ge \sum_{ij} z_{ijt} r_{ki}$	$\forall k,t$	(14)
$\sum_{i,j} a_{ijt} worker_{ij} \le 6145$	$\forall t$	(15)
$\sum_{i,j} a_{ijt} workers_{kj} \le 950$	$\forall t$	(16)
$\sum_j z_{ijt} = zresult_{it}$	$\forall i,t$	(17)
$\sum_j zs_{ijt} = zsresult_{kt}$	$\forall k,t$	(18)
$a_{ijt}, as_{kjt} \in \{0,1\}$		(19)
$z_{ijt}, zs_{kjt}, HC, I_{it}^{+} \ge 0$		(20)

2. Flow Shop Scheduling (Non-Inline)

Sets

i, k = product

s = stage

j = line

n = order

Parameters

z_i = production amount of product i

v_{ij} = velocity of product i in line j

w_{sj} = if product i can produce on stage s in line j 1, otherwise 0

$setup_{ij}$ = setup time of product i in line j

sp_{ij} = waiting time of product i in line j

M = Big M (a sufficiently large number)

Decision Variables

C_{isj} = completion time of product i at stage s in line j

$Cmaxi$ = maximum completion time

x_{isjn} = if product is assigned to stage s line j at order n 1, otherwise 0

Formulation

Objective Function

$Min\ Z = Cmaxi$

Constraints

Constraint	Domain	No.
$\sum_{jn} x_{isjn} = 1$	$\forall i,s$	(1)
$x_{isjn} \le w_{sj}$	$\forall i,s,j,n$	(2)
$\sum_i x_{isjn} \le 1$	$\forall s,j,n$	(3)
$c_{i1j} + M(1 - x_{i1j1}) \ge c_{ij} + v_{ij} z_i + sp_{ij}$	$\forall i,j$	(4)
$c_{isj} - c_{ksj} + M(2 - x_{isj(n-1)} - x_{ksjn}) \ge (v_{ij} z_i + setup_{ij}) + sp_{ij}$	$\forall j, i \neq k, n>1, s$	(5)
$c_{i2j} \ge c_{i1j} + v_{ij} z_i + sp_{ij}$	$\forall i,j$	(6)
$Cmaxi \ge c_{isj}$	$\forall i,s,j$	(7)
$\sum_i x_{isjn} - \sum_i x_{isj(n-1)} \le 0$	$\forall s,j,n>1$	(8)
$x_{isjn} \in \{0,1\}$		(9)
$c_{isj}, Cmaxi \ge 0$		(10)

3. Parallel Machine Scheduling

Sets

i, k = product

j = line

n = order

Parameters

$time_{ij}$ = processing time of product i line j

$setup_{ij}$ = setup time of product i in line j

w_{ij} = if product i can produce in line j 1, otherwise 0

M = Big M (a sufficiently large number)

Decision Variables

C_{ij} = completion time of product i

$Cmaxi$ = maximum completion time

x_{ijn} = if product i is assigned to line j in order n 1, otherwise 0

a_i = starting time of product i

Formulation

Objective Function

$Min\ Z = Cmaxi$

Constraints

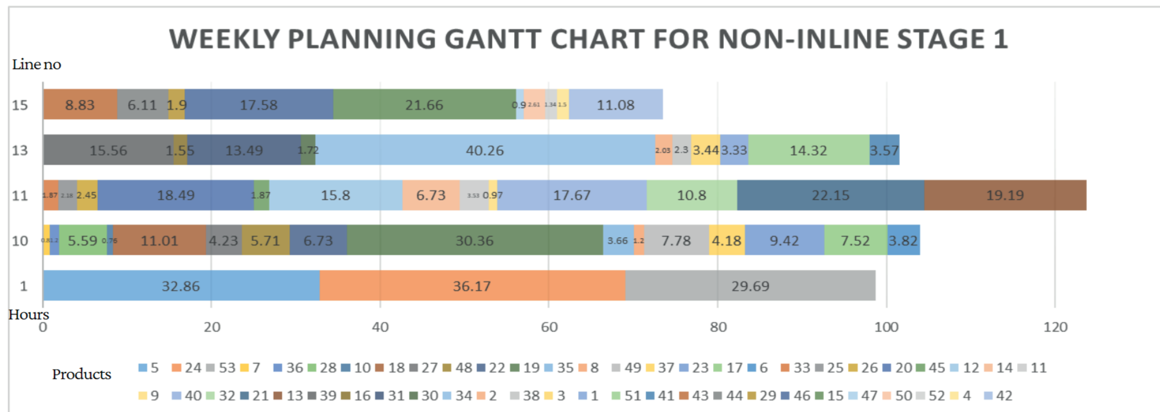
Constraint	Domain	No.
$\sum_i x_{ijn} \le 1$	$\forall j,n$	(1)
$\sum_{nj} x_{ijn} = 1$	$\forall i$	(2)
$\sum_i x_{ijn} - \sum_k x_{kj(n-1)} \le 0$	$\forall j, n>1$	(3)
$c_{ij} + M(1 - x_{ij1}) \ge setup_{ij} + time_{ij}$	$\forall i,n,j$	(4)
$c_{ij} + M(2 - x_{ijn} - x_{kjn-1}) \ge c_{kj} + setup_{ij} + time_{ij}$	$\forall j, i \neq k, n>1$	(5)
$Cmaxi \ge c_{ij}$	$\forall i$	(6)
$w_{ij} \ge x_{ijn}$	$\forall i,j,n$	(7)
$a_i \ge c_{ij} - M(2 - x_{ijn} - x_{ijn-1})$	$\forall i \neq k,j,n>1$	(8)
$a_i \le M(1 - x_{ij1})$	$\forall i \neq k,j,n>1$	(9)
$x_{ijn} \in \{0,1\}$		(10)
$c_i, Cmaxi \ge 0$		(11)

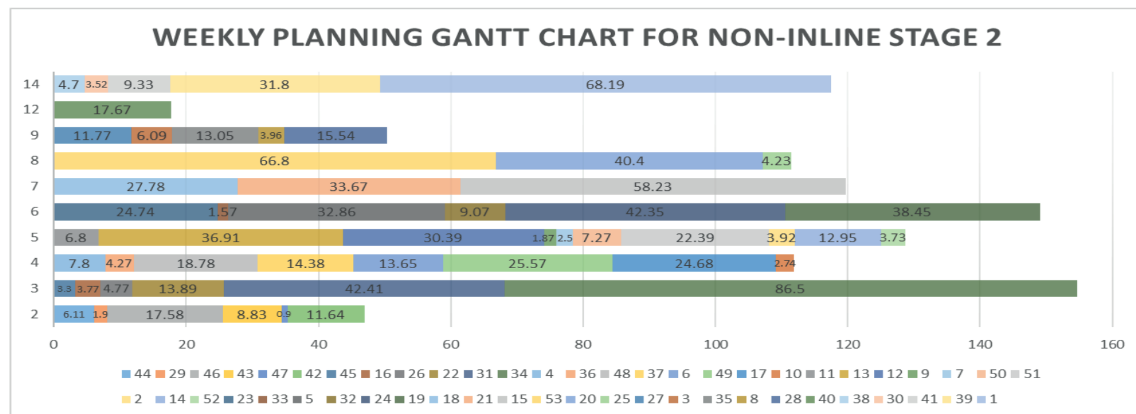
RESULT

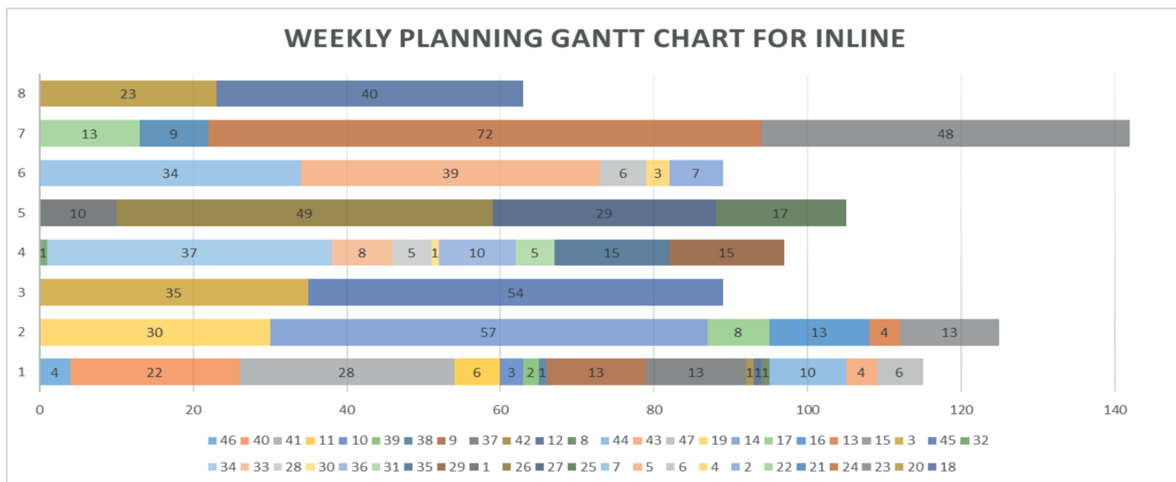
The outputs of the MPS Model show how many kg of products should be produced in which week.

Flow Shop Scheduling Model shows the products to be produced in non-inline production should be produced on which line, in which order and for how long.

Parallel Machine Scheduling Model shows the products produced in inline production should be produced on which line in which order and for how long.







Product No	Minimum Production Required	ETI	Project
2	1451	1451	1451
5	1222	750	1568
6	2651	2651	2651
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407	4320	4320	4320
408	457	750	750
411	0	0	0
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582	10604	10604	10604
584	0	0	0
604	0	0	0

Cost of ETI	Cost of Project	Improvement
86350	75315.2439	12.78%

INTERFACE

CONCLUSION

MPS and Scheduling models were developed using GAMS for weekly plans.

A detailed 12-week production plan was developed, taking into account product priorities and changeover times.

Shortage and inventory costs are minimized by using restrictions on production lines and raw material stocks.

The interface has been developed for the company's use.

A 13% improvement in planning efficiency was achieved.

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