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SCHEDULING & SETUP MINIMIZATION IN PANEL LINE PRODUCTION

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1 COMPANY DESCRIPTION

ARKOPA has been serving the furniture, decoration, and construction industries since 2003. The company specializes in decorative foil-coated MDF and chipboard panels, deep-textured melamine-coated panels, and custom profiles. ARKOPA also produces wall paneling, drawer boxes, door panels, skirting boards, and other products, all meeting international quality standards.

2 PROBLEM DEFINITION

The process involves two identical machines applying coatings, which require different glues and bobbins. Setup times are longer when changing glue types. Panels are fed into the machine after glue and bobbin changes so that setup time are appeared. Currently, production planning is based on incoming orders and managed by a supervisor who sequences jobs based on experience. This lack of structured planning causes job delays, extended lead times, missed deadlines, customer dissatisfaction, and production bottlenecks.

3 OBJECTIVE OF THE FUNCTION

The main objective is to minimize setup times for bobbin and glue changes during production.

4 METHODOLOGY

• DATA DESCRIPTION

To set model parameters, product names were analyzed for a data structure. Reel changes took 7 minutes when switching products. The glue setup matrix showed "HG" products used Durante glue, while "RM," "PP," "PVC," and "MAT" used Fuller glue. "SM" products required a 15-minute setup regardless of glue type. Double-sided products ("ÇY" or "CY") needed rescheduling after one day. These parameters were added to the model to improve production accuracy and optimization.

• MATHEMATICAL MODEL

In this study, a mathematical model was developed for the identical parallel machine scheduling problem in which sequence-dependent setup times are minimized and there is a common resource.

Indices:

i, j: orders {1,2,3,4,5,6,7,8,9...n}

l: panel line {1,2}

k: shift {1, 2,3,4,5, 6...}

$N1_i$ = single-faced orders

$N2_i$ = double-faced orders

$N3_i$ = Those who are not dummy

$N4_k$ = Night Shift {2,4, 6..}

$N5_k$ = Day Shift {1,3,5,7...}

Parameters:

P_j = processing time for orders j

V_k = working time shift for k

S_{ij} = bobbin setup time required to start producing product j immediately after order i

B_{ij} = glue setup time required to start producing product j immediately after order i

Decision Variables:

$$Y_{jlk} = \begin{cases} 1, if\ order\ j\ is\ assigned\ to\ production\ line\ l\ in\ shift\ k \\ 0, otherwise \end{cases}$$

$$X_{kijl} = \begin{cases} 1, if\ order\ j\ was\ assigned\ to\ production\ line\ l\ in\ shift\ k\ after\ order\ i \\ 0, otherwise \end{cases}$$

u_{ikl}= It represent the order of processing

Objective Function:

$$Z = \min \sum_{i,j,l,k} (S_{ij} + B_{ij}) * X_{kijl} \quad (1)$$

Constraints:

$$\sum_{i,k} Y_{ilk} = 1 \ \forall i \in N1_i \quad (2)$$

$$\sum_{i,k} Y_{ilk} = 2 \ \forall i \in N2_i \quad (3)$$

$$Y_{00k} = 1 \ \forall k \in N5_k, l \quad (4)$$

$$Y_{88lk} = 1 \ \forall k \in N5_k, l \quad (5)$$

$$Y_{01k} = 1 \ \forall k \in N4_k \quad (6)$$

$$Y_{881k} = 1 \ \forall k \in N4_k \quad (7)$$

$$Y_{j0k} = 0 \ \forall k \in N4_k, j \quad (8)$$

$$\sum_i Y_{i,l,(k+1)} * Y_{i,l,(k+2)} \leq 1 - \sum_i Y_{i,l,k}$$

$$\forall i \in N2_i, k \in N5_k \quad (9)$$

$$Y_{i1(k-1)} + Y_{i1(k-2)} \leq 1 - Y_{i1K}$$

$$\forall i \in N2_i, k \in N4_k \quad (10)$$

$$\sum_{i,j} (S_{ij} + B_{ij}) * X_{kijl} + \sum_j p_j * y_{jlk} \leq V_k \quad \forall k,l \quad (11)$$

$$\sum_j X_{kijl} = Y_{ilk} \quad \forall l,k, \forall i \in N3_i \quad (12)$$

$$\sum_j X_{kjil} = Y_{ilk} \quad \forall l,k, \forall i \in N3_i \quad (13)$$

$$X_{kiil} = 0 \quad \forall l,k,i \quad (14)$$

$$\sum_j X_{kj0l} = 0 \quad \forall l,k \quad (15)$$

$$\sum_j X_{k88jl} = 0 \quad \forall l,k \quad (16)$$

$$\sum_j X_{ko0jl} = 1 \quad \forall l,k \quad (17)$$

$$\sum_j X_{kj88l} = 1 \quad \forall l,k \quad (18)$$

$$\sum_j Y_{i,l,k} \leq \sum_j X_{kijl} + X_{kjil} \quad \forall i,l,k \quad (19)$$

$$u_{ikl} - u_{jkl} + n * X_{kijl} \leq (n-1) \ \forall i,j,k,l \quad (20)$$

$$X_{kiil} + X_{kjil} \leq 1, \forall i,j,k,l \quad (21)$$

$$X_{ijkl} \in \{0,1\} \quad (22)$$

$$Y_{jkl} \in \{0,1\} \quad (23)$$

$$u_{ikl} \geq 0 \quad (24)$$

5 RESULTS

The mathematical model was run in GAMS, and outputs were evaluated using different company data sets. Table 1 shows that all three scenarios achieved high accuracy within reasonable time frames. The low relative gap, including a 0.00 gap in scenarios i=74 and i=88, indicates successful optimization of all constraints and parameters by the solver.

GAMS RESULTS				
i	Objective Value	Relative Gap	Solver	Execution Time (Seconds)
74	462.00	0.00	CPLEX	80
88	644.00	0.00	CPLEX	110
100	686.00	0.0102	CPLEX	148

Table 1. GAMS Result Table

PYTHON RESULTS				
i	Objective Value	Relative Gap	Solver	Execution Time (Seconds)
74	462.00	0.00	CPLEX	390
88	644.00	0.00	CPLEX	2055
100	700.00	0.03	CPLEX	2308

Table 2. Python Result Table

PYTHON RESULTS				
i	Objective Value	Relative Gap	Solver	Execution Time (Seconds)
74	462.00	0.00	GUROBI	123
88	644.00	0.00	GUROBI	40
100	679.00	0.0102	GUROBI	843

Table 3. Python Result Table

In the current system with 10 shifts, the model tested reducing shifts and found that demands initially requiring 10 shifts could be met with 8 shifts.

• GANTT CHARTS

A Python-generated Gantt chart displays the four-day production schedule for 74 products on two lines with two shifts each, showing product sequence, processing times, and setup times for reel and glue changes.

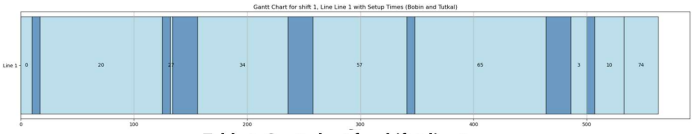
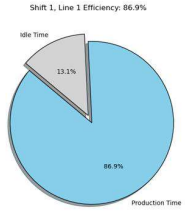


Table 4. Gantt chart for shift 1 line 1

The chart starts with job 0, followed by jobs 20, 27, 34, 57, 65, 3, 10, and 74. Light blue bars represent jobs, with dark blue sections indicating setup times for bobbins and glue.



The chart shows Line 1's efficiency at 86.9% during Shift 1. The blue slice indicates production time, while the gray slice represents 13.1% idle time.

Figure 1. Efficiency representation of shift 1 line 1

Production decreased from 10 to 8 shifts, resulting in a one-day improvement, with setup times improving by about 37%.

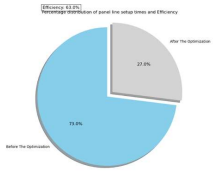
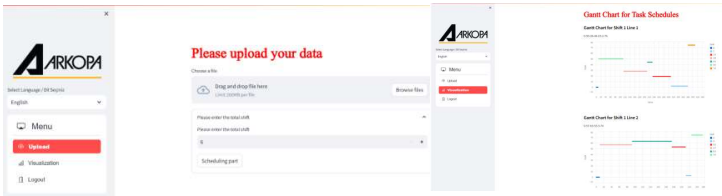


Figure 2. Set up comparison before and after optimization

6 INTERFACE



7 CONCLUSION

The project aimed to enhance efficiency and reduce setup times in Arkopa's panel production line. Using a mathematical model with the GUROBI solver, demand was met with 8 shifts instead of 10, improving by 20%, and setup times were reduced by 37%. Gantt charts and a user-friendly interface improved production planning and data visualization, boosting efficiency and timely delivery. Future plans include adapting the model for complex scenarios and integrating real-time data.

8 STAKEHOLDERS

The optimization model at Arkopa benefits all stakeholders. Employees face less stress and enjoy better workflows. Managers see improved resource allocation and productivity. Customers get more reliable deliveries. The project team gains satisfaction from successful outcomes and enhanced processes. Each stakeholder contributes to and benefits from the project's success.

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