Maximizing Efficiency and Profit in Screen-Printing Operations Using Mixed-Integer Programming

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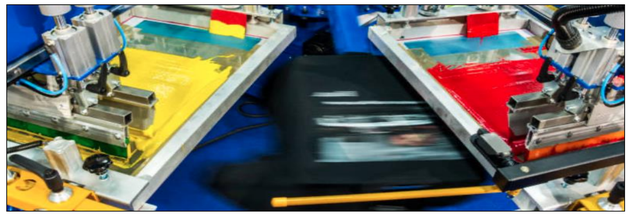
Abstract

Why Optimize?
- The rising demand for customized production requires efficiency while focusing on profitability.

Manufacturing Challenges:
- Time, machine, and labor constraints demand smart solutions.

Power of MIP:
- Maximizes efficiency, cuts costs, and improves decision-making.

Case Study:
- **Optimize the production of 1 million of screen print pieces across 25 designs on 9 production machines.**



Describing the Manufacturing Problem

Client Order
- 1 million pieces across 25 unique designs (3–18 colors each).

Machine Capabilities
- Varying color capacities, speeds, and shared fixed costs.

Objective
- Efficiently assign designs to machines, meeting constraints to maximize profitability.

Mixed Integer Programming

Mixed Integer Programming (MIP) extends linear programming by requiring some variables to be integers, making it ideal for real-world decision modeling.

Variables

Objective Function

Constraints

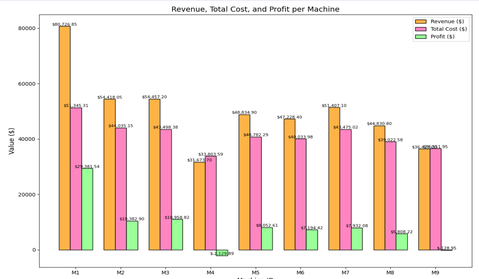
Model Purpose	To allocate designs to machines, considering constraints and costs, and achieve **maximum profitability.**
Decision Variables	Assignment of designs to machines.
Objective Function	Maximize profit = Revenue – Costs.
Constraints	1. Each design is assigned to only one machine.
	2. Machines can only handle designs within their color capacity.
	3. Balance workload across machines (no machine can work more than 25% than another machine).

BEFORE | Manual - Design to Machine Assignment

Manual Assignment
- Production planners assigned designs to machines manually.

Profit Achieved
- **Total model profit: $77,451.75.**

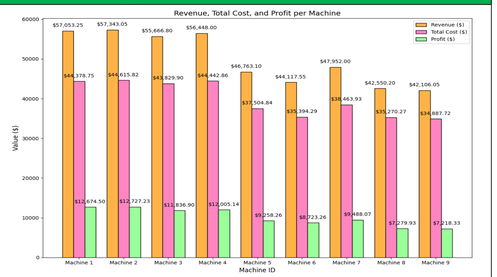
Constraints Maintained
- Design quantities, color requirements, and machine
- capacities were identical to the MIP model.



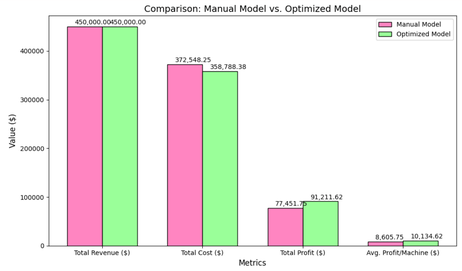
AFTER | MIP - Design to Machine Assignment

Tool
- **Pyomo in Python** created and implemented the **Mixed Integer Programming model.**

Impact
- Efficiently assigned designs, reducing execution time.
- Adhered to all constraints while **maximizing profit to $91,211.62.**



Comparing the Two Models



- The optimization model **boosted profit by $13,759.87** over the manual assignment.
- **Scalable & Adaptable** Model can handle more machines, designs, and orders.
- Easily integrates new constraints like resource limits.

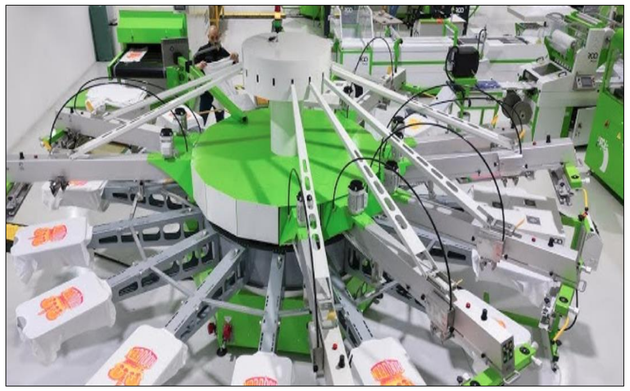
Four Ideas

Challenges: Balancing workloads across machines and efficiently managing variable costs, such as setup time and ink usage.

Solutions: The MIP model addressed these challenges by ensuring fair workload distribution across machines and providing accurate cost calculations, which guided optimal design assignments.

Next Steps: Future efforts will include sensitivity analysis to evaluate how changes in machine costs impact overall profit and scenario analysis to adapt the model to different client orders.

Extensions: The next phase of development involves building a user-friendly interface will enable real-time visualization and allocation of orders, further improving operational decision-making.



Insights

- **Profit increased by 18%.**
- **Task allocation time reduced by 95%.**
- **Faster decision-making.**
- **Accurate task allocation.**

Contact

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