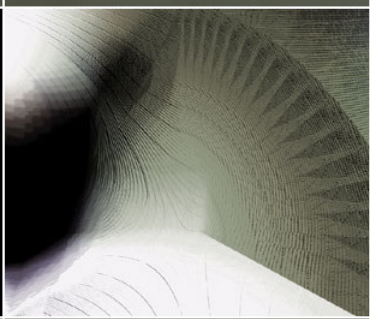
ETM

ENGINEERING & TECHNOLOGY MANAGEMENT

Aluminum Extrusion: Make Scrap Pay



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Make Scrap Pay

- Analyze and Maximize profits from aluminum scrap
- Built an OR model to determine most profitable method to manage scrap
- Determine the best option to deal with excess material

Aluminum Extrusion

- **A process used to produce elongated components of variable lengths and uniform cross-sections**

Aluminum Extrusion (Cont.)

- **Extrusion can be performed through two processes:**
  - **Indirect- billet remains stationary and die is forced along its length**
  - **Direct-hold the die stationary and forces the billet through die**

Target Plant

- Metropolitan Metal Co. Ltd
- Based in Thailand
- Founded in 1979
- Uses a Direct extrusion process
- Offer three types of aluminum alloy: 6060, 6061 and 6063

Target Plant (Cont.)

- Has three direct extrusion machines on site
- Runs three shifts 20hrs/day 6days/week
- Uses the same sized billets for machines 1 & 2
- Uses a larger and more expensive billet for machine 3

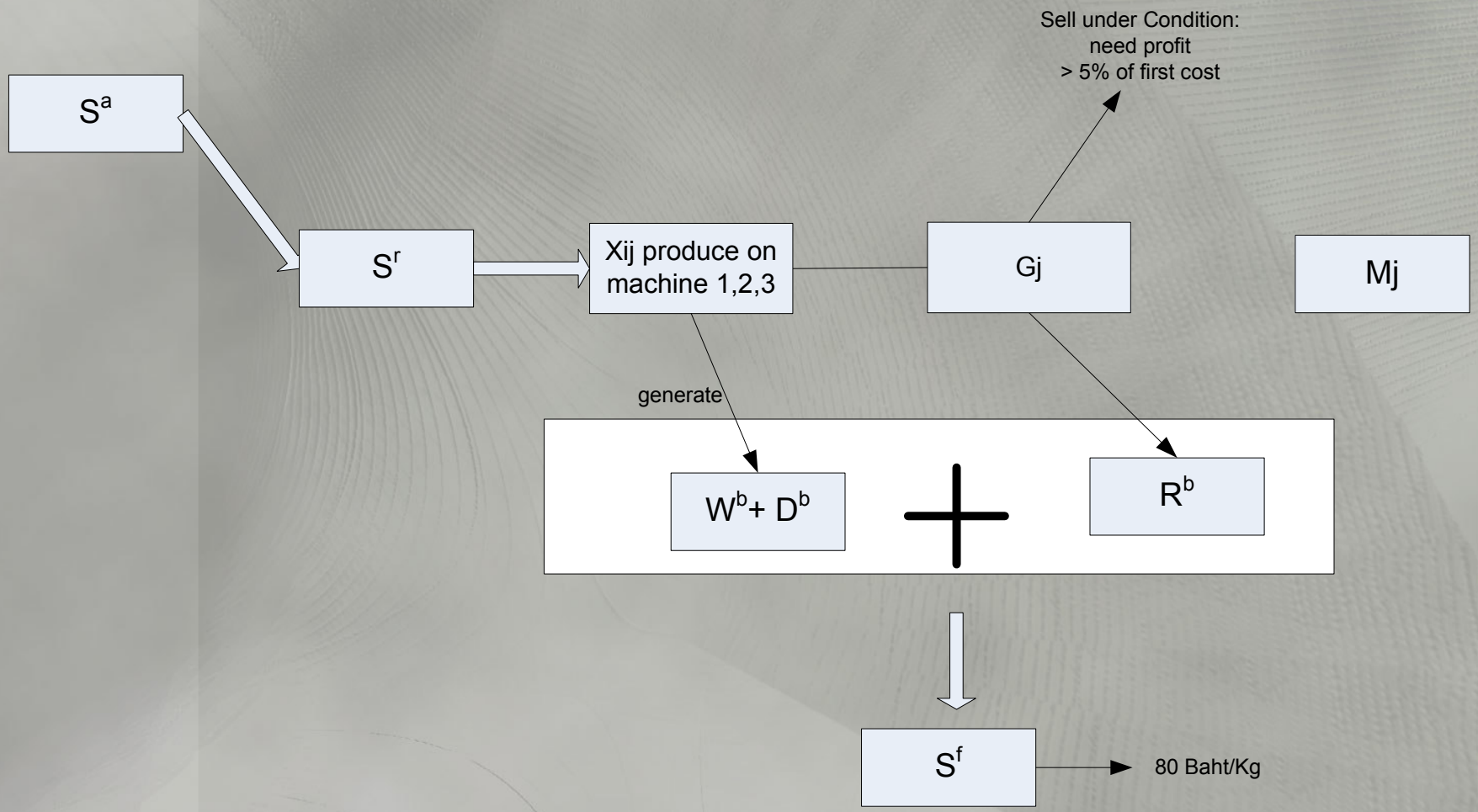
Problem Definition

- **Two challenges face extrusion today extrusion plants:**
  - **Downtime**
  - **Scrap Management**

Model Definition

- **Using Multiple Objective analysis to maximize profit, which is generated from scrap**
- **Assumptions**

Model Flow Diagram



Model Definition (Cont.)

G_j = Good Product in month j

S_j^f = Final Scrap in month j

S_j^r = Scrap Required in month j

S_j^a = Scrap Available in month j

M_j = Demand in month j

R_j^b = Returns from recycled product

D_j^b = Defects from reprocess

W_j^b = Waste fron reprocess

P = Profit

P_j^u = Price per ton (1 ton = 1000 kg) = first cost * 1.05 (need > 0.5% of first cost)

P^o = Production Output

P^r = Hours operating

C_{ij} = Capacity machine i to month j = $0.6(P^o / P^r) * 24 * 30$

A_{ij} = Cost of reprocessing machine i to month j

X_{ij} = Amount Produce from machine i to month j

$$Y_{ij} = \begin{cases} 1 & \text{, if machine i is selected in month j} \\ 0 & \text{, otherwise} \end{cases}$$

Model Definition (Cont.)

Multiple Objective Function

MAX: $$\text{Profit} = \sum_{j=1}^{12} G_j * P_j^u + \sum_{j=1}^{12} S_j^f * 219.78$$

MIN: $$\text{Cost} = \sum_{i=1}^{3} \sum_{j=1}^{12} X_{ij} * A_{ij}$$

MIN: $$\text{Final scrap} = \sum_{j=1}^{12} S_j^f$$

Model Definition (Cont.)

Constraints:

$$S_j^f = \sum_{i=1}^{3} W^b + \sum_{i=1}^{3} W^b - R^b \Big\} \text{Final Scrap constraint}$$

$$G_j = X_{ij} - \sum_{i=1}^{3} W^b - \sum_{i=1}^{3} W^b = S_j^r - \sum_{i=1}^{3} W^b - \sum_{i=1}^{3} W^b \Big\} \text{Good Product constraint}$$

$$\sum_{i=1}^{3} X_{ij} = S_j^r = S_j^a \quad , \forall j \Big\} \text{Amount produce constraint}$$

$$\left.\begin{array}{l} X_{ij} \le C_{ij} * Y_{ij} \\ X_{ij} \le C_{ij} \end{array}\right\} \text{Capacity constraint}$$

$$X_{ij} \ge 0.3 * Y_{ij} \Big\} \text{Minimum order constraint}$$

$$Y_{ij} = \text{binary} \Big\} \text{Binary}$$

Goal Programming (GP)

MIN: the maximum of

$$w_1\left(\sum_{i=1}^{3}\sum_{j=1}^{12} X_{ij} * A_{ij} - 1{,}922{,}730.48\right) / 1{,}922{,}730.48$$

$$\text{and } w_2\left(\sum_{j=1}^{12} S_j^f - 294.27\right) / 294.27$$

MIN: Q

Goal Programming (GP) (Cont.)

Constraints:

$$w_1\left(\sum_{i=1}^{3}\sum_{j=1}^{12} X_{ij} * A_{ij} - 1{,}922{,}730.48\right) / 1{,}922{,}730.48 \le Q \Big\} \text{ goal 1 MINIMAX constraint}$$

$$w_2\left(\sum_{j=1}^{12} S_j^f - 294.27\right) / 294.27 \le Q \Big\} \text{ goal 2 MINIMAX constraint}$$

Lessons Learned

- Determine the problem to solve early.
- Let the model drive the data rather than the data drive the model.
- More granular data was required.

Future Research

- Energy and environmental impacts of recycling should be considered.
- Research how different companies value scrap for analysis.
- Further research required on the chemical breakdown of the material.

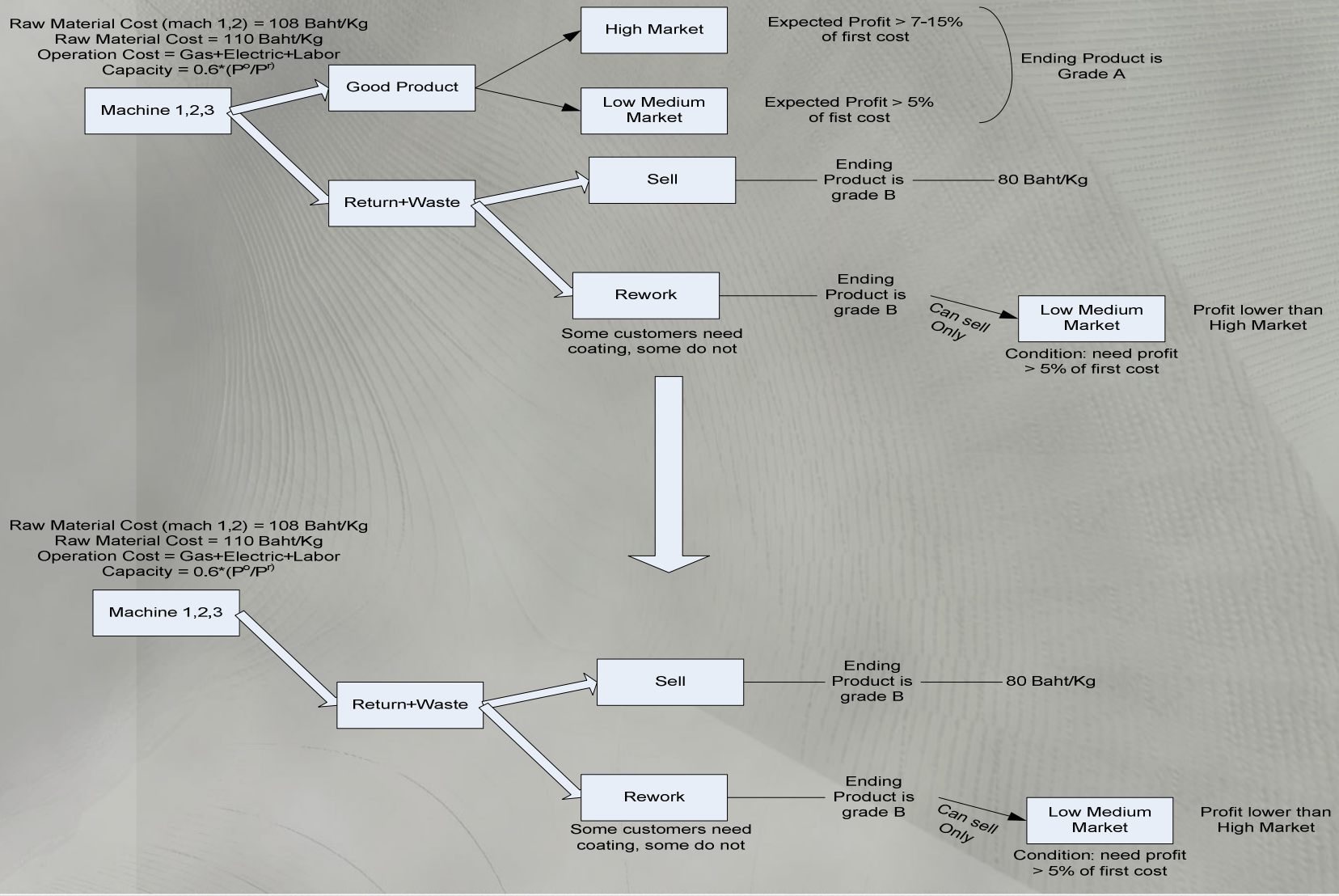
Conclusion

- Scrap can be reprocessed to fill a large percentage of orders at a fraction of the cost
- Scrap is used first to fill orders and is sold directly as a second option.
- Results support assumed solution rather than an unanticipated approach
- Model could be applied in other factories or in different fields with related variables

Make Scrap Pay

Questions/Comments

Back up


Raw Material Cost (mach 1,2) = 108 Baht/Kg
Raw Material Cost = 110 Baht/Kg
Operation Cost = Gas+Electric+Labor
Capacity = 0.6*(P^o/P^r)
Machine 1,2,3
Good Product
High Market
Low Medium Market
Expected Profit > 7-15% of first cost
Expected Profit > 5% of fist cost
Ending Product is Grade A
Return+Waste
Sell
Ending Product is grade B
80 Baht/Kg
Rework
Ending Product is grade B
Some customers need coating, some do not
Can sell Only
Low Medium Market
Profit lower than High Market
Condition: need profit > 5% of first cost
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