Performance Lawn Equipment (PLE) Production Optimization Report

Executive Summary

This report presents the findings of a production optimization analysis for Performance Lawn Equipment (PLE). The analysis aimed to maximize the profit from producing mower and tractor housings, given constraints in departmental hours, material availability, and production rates. The use of Excel Solver allowed for a detailed examination of the optimal production strategy, revealing actionable insights and potential areas for operational improvements.

Problem Statement

PLE operates manufacturing facilities producing engine housings for mowers and tractors. Each product undergoes five stages: Stamping, Drilling, Assembly, Painting, and Packaging. With constraints on available work hours in each department, as well as limited resources of sheet metal and paint, PLE seeks to maximize profit from their production line. The profit margins are €190 per mower housing and €260 per tractor housing.

Constraints:

- **Departmental Hours Available:**
  - Stamping: 200 hours
  - Drilling: 300 hours
  - Assembly: 225 hours
  - Painting: 220 hours
  - Packaging: 100 hours
- **Resource Availability:**
  - Sheet Metal: 1440 square feet
  - Paint: 400 liters

Production Requirements:

- Mower housing requires 1.6 square feet of sheet metal and 100 milliliters of paint per unit.
- Tractor housing requires 1.7 square feet of sheet metal and 320 milliliters of paint per unit.

Methodology

Step 1: Determining the Objective

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From the problem statement, our result variable is **total profit,** and the objective is to maximize the total profit.
The objective function is total profit = $190X_1 + 260X_2$ where 190 and 260 are the coefficient of objective function which is profit per unit of X_1 and X_2 (i.e. Mower and Tractor) respectively.

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Step 2: Determining the decision variables.
As per the problem statement, Decision variables are X_1 - units of mowers housing to be produced and X_2 - units of tractors housing to be produced.

Step 3: Determining the uncontrollable variables (constraints).
Time constraints are as follows:

- Stamping: $0.2 X_1 + 0.3 X_2 <= 200$ (In hours)
- Drilling: $0.3 X_1 + 0.4 X_2 <= 300$ (In hours)
- Assembly: $0.25 X_1 + 0.35 X_2 <= 225$ (In hours)
- Painting: $0.17 X_1 + 0.25 X_2 <= 220$ (In hours)
- Packaging: $0.05 X_1 + 0.1 X_2 <= 100$ (In hours)

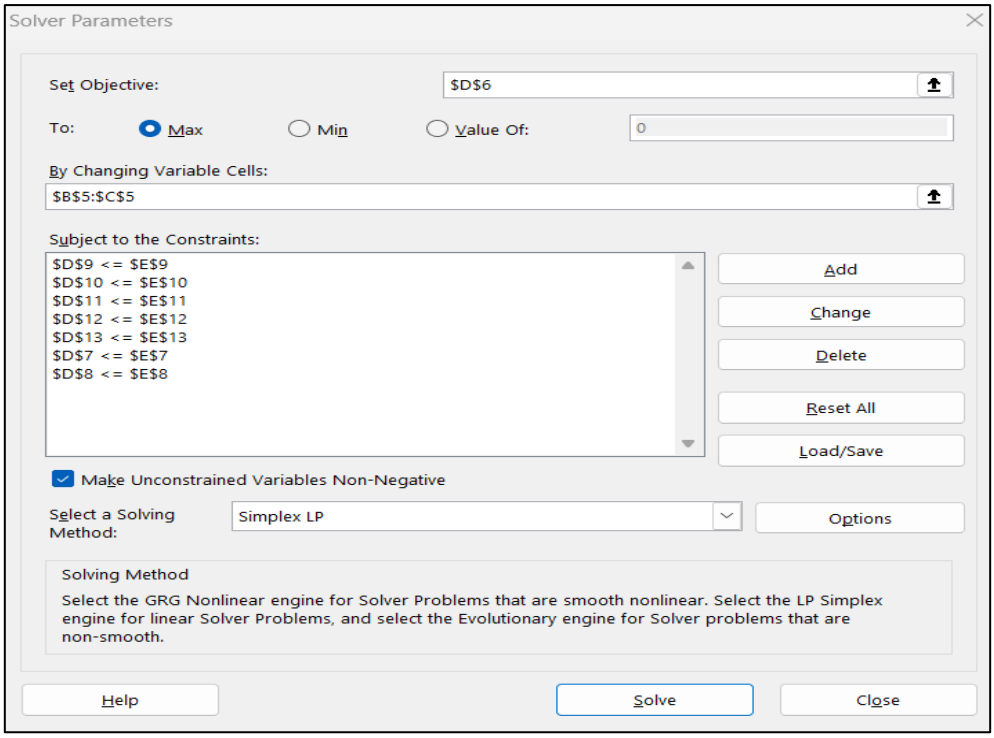
Resources constraints are as follows:

- Sheet metal available: $1.6 X_1 + 1.7 X_2 <= 1440$ (In Square Feet)
- Paint availability: $0.1 X_1 + 0.32 X_2 <= 400$ (In Litre)

D6 =$B$5*B6+$C$5*C6

	A	B	C	D	E
1				Decision Variable	
2				Objective variable	
3	Model formulation & solution				
4		Mower (X1)	Tractor (X2)	Total	Limit
5	Decision Variable	900	0		
6	Total Profit	190	260	€ 171,000.00	
7	Stamping	0.2	0.3	180	200
8	Drilling	0.3	0.4	270	300
9	Assembly	0.25	0.35	225	225
10	Painting	0.17	0.25	153	220
11	Packaging	0.05	0.1	45	100
12	Sheet Metal	1.6	1.7	1440	1440
13	Paint	0.1	0.32	90	400

Model Formulation & Solution



Solver dialog box

Answer Report:

Microsoft Excel 16.0 Answer Report
Worksheet: [23105446_MS5107_A1.xlsx]Sheet1
Report Created: 10/12/23 12:04:04 AM
Result: Solver found a solution. All Constraints and optimality conditions are satisfied.
Solver Engine
Engine: Simplex LP
Solution Time: 0.015 Seconds.
Iterations: 2 Subproblems: 0
Solver Options
Max Time Unlimited, Iterations Unlimited, Precision 0.000001, Use Automatic Scaling
Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$D$6	Total Profit Total	€ 171,000.00	€ 171,000.00

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$B$5	Decision Variable Mower (X1	900	900	Contin
$C$5	Decision Variable Tractor (X2	0	0	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$D$9	Assembly	225	$D$9<=$E$9	Binding	0
$D$10	Painting	153	$D$10<=$E$10	Not Binding	67
$D$11	Packaging	45	$D$11<=$E$11	Not Binding	55
$D$12	Sheet Metal	1440	$D$12<=$E$12	Binding	0
$D$13	Paint	90	$D$13<=$E$13	Not Binding	310
$D$7	Stamping	180	$D$7<=$E$7	Not Binding	20
$D$8	Drilling	270	$D$8<=$E$8	Not Binding	30

The report summarises that the optimize model can achieve €171,000 of maximum total profit with the given resources and constraints.
The decision variables i.e., the final production plan for Mower (X_1) and Tractor (X_2) are to produce 900 mower housings and 0 tractor housing, to achieve maximum profit.

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The Assembly department and the Sheet metal constraints are shown as binding which means they have reached to its limiting value with no slack. In contrast, Painting, Packaging, Stamping and Drilling department have not hit their limits and have slack of 67 hours, 55 hours, 20hours, and 30 hours respectively, indicating potential for increasing the production in these departments. Also, Company has 310 litres of slack in paint which could be use without breaching the constraint.

Sensitivity Report:

Microsoft Excel 16.0 Sensitivity Report
Worksheet: [BI Assignment.xlsx]Sheet1
Report Created: 10/04/23 12:17:20 AM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$C$8	Decision Variable X1	900	0	190	1E+30	4.285714286
$D$8	Decision Variable X2	0	-6	260	6	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$E$10	Stamping	180	0	200	1E+30	20
$E$11	Drilling	270	0	300	1E+30	30
$E$12	Assembly	225	760	225	8.88178E-15	225
$E$13	Painting	153	0	220	1E+30	67
$E$14	Packaging	45	0	100	1E+30	55
$E$15	Sheet Metal	1440	0	1440	1E+30	5.68434E-14
$E$16	Paint	90	0	4000	1E+30	3910

The sensitivity report elucidates that the company should produce 900 units of mowers and 0 unit of tractor to achieve optimal profitability within the current binding constraint. The reduced cost of 0 units for mowers indicates that there is no further improvement is possible. However, there is room for improvement in profit by producing more tractor. The reduced cost of tractor, which is -6 suggests that **a unit increase in tractor production will increase total profit by 6 units** with current resources available. **The allowable increase and decrease have very high range which indicates that the solution is robust and will remain optimal even there is significant changes in objective coefficients i.e.., profit margin per unit of mowers or tractor**.

In the constraints table, Shadow price for assembly department is 760, suggesting **a unit increase in available hour in assembly department would increase total profit by €760**. The optimal solution is not very sensitive to small changes in constraints as suggested by large allowable increase and decrease range.

Limit Report:

Report shows that the maximum profit of €171,000 could be achieved with the current resources after optimization. Also, decision variable's lower limits are 0, which indicates that they cannot be negative, while upper limits for mower and tractor are 900 and 0, respectively based on the objective result.

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Microsoft Excel 16.0 Limits Report
Worksheet: [23105446_MS5107_A1.xlsx]Sheet1
Report Created: 10/12/23 12:04:05 AM

Cell	Objective Name	Value
$D$6	Total Profit Total	€ 171,000.00

Cell	Variable Name	Value	Lower Limit	Objective Result	Upper Limit	Objective Result
$B$5	Decision Variable Mower (X1)	900	0	0	900	171000
$C$5	Decision Variable Tractor (X2)	0	0	171000	0	171000

Improved Model

		Decision Variable			
		Objective variable			
Model formulation & solution					
	Mower (X1)	Tractor (X2)	Total	Limit	Actual Limit	Difference
Decision Variable	200	600				
Total Profit	190	260	€ 194,000.00			
Stamping	0.2	0.3	220	225	200	25
Drilling	0.3	0.4	300	300	300	0
Assembly	0.25	0.35	260	260	225	35
Painting	0.17	0.25	184	190	220	-30
Packaging	0.05	0.1	70	70	100	-30
Sheet Metal	1.6	1.7	1340	1440	1440	0
Paint	0.1	0.32	212	400	400	0

Improved Model

An improved model was developed to enhance total profit further by reallocating work hours:

- **Adjusted Hours:**
  - Reduced Painting and Packaging by 30 hours each.
  - Added 25 hours to Stamping and 35 hours to Assembly.

This adjustment increased the total profit by €23,000, demonstrating more effective utilization of available resources.

Conclusion

The analysis and optimization reveal that PLE can maximize profits by focusing solely on mower production with the current resource allocation. By making strategic adjustments to department hours, additional profit gains can be realized. The sensitivity analysis underscores the importance of assembly hours and paint availability in optimizing production.

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