

OFFICIAL MANUAL GUIDE

Production Analysis Guide

Formulas, Control & Optimization
for the Manufacturing Shop Floor

CASE STUDY

Generator and Base-Frame Manufacturing Shop Floor

SCOPE

Production analysis, the ten core formulas, and daily / weekly / monthly control & optimization

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ROLE

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VERSION

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Turning production numbers into decisions — maximum output at minimum cost, measured and verified on the shop floor.

OVERVIEW

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HOW THIS GUIDE IS ORGANIZED

Part 1 explains what production is. Part 2 gives the formulas. Part 3 shows when to use each one — daily, weekly, monthly — and what to check when a number looks bad. Part 4 turns the numbers into decisions: maximum output at minimum cost.

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PART ONE

Foundations

- 1 Production, Factors & the Production Function
- 2 Advanced Analysis & Manager-Level Planning

PART 1 · SECTION 1

Production, Factors & the Production Function

Production analysis is the science behind how a factory turns raw materials into finished goods efficiently.

INPUT — materials, machines, workers

› PROCESS — cutting, welding, coating, assembly

› OUTPUT — finished product ready for dispatch

Demand up → production up; demand down → production down.

THE FOUR FACTORS OF PRODUCTION

Factor	On the factory floor
Land	Factory building, warehouse, yard space
Capital	Machines, CNCs, forklifts, tools, fixtures, jigs
Labour	Operators, welders, painters, assemblers, inspectors
Organization	Management, supervisors, planners, production control

THE PRODUCTION FUNCTION

$Q = f(L, C, M, T)$ — output depends on Labour, Capital, Management and Technology. More welders lift output; a CNC beats manual cutting; good planning means smooth flow; automation and ERP raise output.

SHORT RUN — $Q = F(L, C, M)$

Some inputs are fixed. You cannot expand the factory or buy a CNC today — you adjust labour, shifts and overtime.

LONG RUN — $Q = F(L, C, M, T)$

All inputs can change: build a warehouse, buy machines, hire workers, upgrade technology.

SUPERVISOR ROLE

Check daily demand against daily production capacity. Daily work is short-run: you manage what you already have.

PART 1 · SECTION 2

Advanced Analysis & Manager-Level Planning

Input efficiency. If 100 kg enters welding but only 80 kg reaches assembly, you have wastage, rework, scrap and poor process control. Track material yield, machine utilization, labour productivity, cycle time and defect rate.

In the pipe	On the floor
Blockage	Machine breakdown
Leakage	Defects, rework
Narrow pipe	Bottleneck station
High pressure	Overtime, worker fatigue

SHORT RUN (DAILY)

- Worker allocation
- Shift planning & overtime
- Work sequencing & priority orders
- Quick maintenance

LONG RUN (MONTHS)

- Buy new machines
- Expand factory
- Hire more workers
- New technology; change layout / workflow

DEMAND VS SUPPLY PLANNING

Demand = 500 units/week, capacity = 400 units/week. Close the gap with extra shifts or overtime, better cycle time, less downtime, more manpower — and more machines in the long run.

Where cost is reduced: reduce scrap, reduce rework, improve machine efficiency, cut idle time, improve layout, reduce movement, and operator guidance. **Decisions are made from:** data, observation, worker feedback, machine reports, quality reports and the demand forecast.

GOAL

Raise productivity (Output ÷ Input) without raising cost. Example: 100 units ÷ 10 workers = 10 units per worker.

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PART TWO

The Formulas

- 3 The 10 Production Formulas
- 4 Law of Diminishing Returns & MRTS

PART 2 · SECTION 3

The 10 Production Formulas

From beginner to professional — the core calculations behind every production decision.

1 · TOTAL PRODUCT (TP)

TP = Total Output Produced

CNC makes 120 parts today → TP = 120 units

2 · AVERAGE PRODUCT (AP)

AP = TP ÷ Input

120 units ÷ 10 workers = 12 units/worker

3 · MARGINAL PRODUCT (MP)

MP = Δ Output ÷ Δ Input

100 → 115 after +1 worker → MP = 15

4 · LAW OF DIMINISHING RETURNS

MP falls as input rises (past a point)

See the table in Section 4

5 · TOTAL COST (TC)

TC = Fixed Cost + Variable Cost

10,000 + 5,000 = 15,000 AED

6 · AVERAGE COST (AC)

AC = TC ÷ Output

15,000 ÷ 300 = 50 AED/unit — helps you price

7 · MARGINAL COST (MC)

MC = Δ Cost ÷ Δ Output

800 ÷ 20 = 40 AED

8 · PRODUCTION ELASTICITY

$\% \Delta$ Output ÷ $\% \Delta$ Input

How sensitive output is to labour/capital

9 · ISOQUANT

Q = f(L, K), Q constant

100 units: 10+1, or 7+2, or 5+3

10 · MRTS

MRTS = MP(Labour) ÷ MP(Capital)

10 ÷ 20 = 0.5 → 1 machine replaces 2 workers

Formula	Question it answers
TP / AP	Did we hit target? How productive is each worker?
MP	Should we add another worker? Is the line overloaded?
TC / AC	What does production cost, and what should the unit price cover?
MC	Is it expensive to increase production? Should we make extra units?
Isoquant / MRTS	Which mix of workers and machines is cheapest for the same output?

PART 2 · SECTION 4

Law of Diminishing Returns & MRTS

The most important rule in production: past a certain point, adding more input gives less and less extra output.

Workers	Total output	Marginal product
5	100	–
6	120	20
7	130	10
8	135	5
9	136	1

Machine capacity is fixed, so extra workers crowd the same machine — exactly what happens when too many workers surround one station.

MRTS — WORKERS VS MACHINES

MP of labour = 10 units, MP of capital = 20 units. $MRTS = 10 \div 20 = 0.5$. One machine adds as much as two workers — so replace workers with a machine only if the machine costs less than two workers.

ISOQUANT — SAME OUTPUT, DIFFERENT MIX

Option	Workers	Machines	Output
A	10	1	100
B	7	2	100
C	5	3	100

Pick the cheapest combination that still delivers the output safely and with quality.

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PART THREE

Control on the Floor

- 5 Daily & Weekly Analysis
- 6 Monthly Analysis & Reading the Numbers

PART 3 · SECTION 5

Daily & Weekly Analysis

Daily analysis is fast and simple — output, workers, machines, cost. Weekly analysis looks at trends, not single numbers.

DAILY — SUPERVISOR LEVEL

Metric	Formula	Example	If it looks bad, check
Total Product	Total output today	$120 + 80 + 200 = 400$ units	Did we meet today's target?
Avg Product	$TP \div \text{Workers}$	$400 \div 20 = 20$ units/worker	Downtime, material shortage, fatigue, planning
Marginal Product	$\Delta \text{Output} \div \Delta \text{Labour}$	$380 - 350 = 30$ units	Low MP = overcrowded line
Avg Cost	$TC \div \text{Output}$	$12,000 \div 400 = 30$ AED/unit	Overtime, scrap, rework, breakdowns

WEEKLY — SUPERVISOR TO MANAGER LEVEL

Metric	Formula	Example	If it looks bad, check
Weekly TP	Sum of daily outputs	$400+380+420+390+410 = 2,000$	Is weekly demand met?
Weekly AP	$TP\text{-week} \div \text{Labour hours}$	$2,000 \div 800 = 2.5$ units/hr	Efficiency trend over time
Weekly MP	$\Delta \text{Weekly output} \div \Delta \text{Labour hrs}$	$200 \div 50 = 4$ units/hr	Falling = workers overloaded or machines limiting
Weekly MC	$\Delta \text{Cost} \div \Delta \text{Output}$	$5,000 \div 200 = 25$ AED	Rising = expansion is becoming expensive

PART 3 · SECTION 6

Monthly Analysis & Reading the Numbers

Monthly analysis is strategic — used for planning, budgeting and management reporting.

Metric	Formula	Example	Used for
Monthly TP	Sum of weekly outputs	$2,000+2,100+1,950+2,050 = 8,100$	Monthly KPI, reporting, demand planning
Monthly AC	Monthly cost ÷ TP-month	$210,000 \div 8,100 = 25.9 \text{ AED/unit}$	Drops = efficiency up; rises = management asks why
Monthly MC	Δ Monthly cost ÷ Δ Output	$10,000 \div 300 = 33.3 \text{ AED}$	Increase output? Add machines? Cut overtime?
Monthly AP	TP-month ÷ Labour hours	$8,100 \div 3,200 = 2.53 \text{ units/hr}$	Falling: downtime, fatigue, material delays, planning

READING THE NUMBERS — SYMPTOM TO ACTION

You see	Likely meaning	First action
AP falling	Lost time or poor flow	Check downtime, material, planning
MP low or falling	Line overcrowded / machine-limited	Stop adding labour; fix the machine or bottleneck
AC rising	Waste or overtime creeping in	Check scrap, rework, overtime, breakdowns
MC rising	Extra output costs more and more	Review before expanding production
Target missed, AP normal	Capacity or demand gap	Plan shifts, overtime, cycle-time improvement

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PART FOUR

Production Optimization

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- 8 Cycle Time, Bottlenecks, Utilization, Yield, Isoquants
- 9 Optimization KPIs & the Golden Rule

PART 4 · SECTION 7

The 5 Targets & the Optimal Labour Level

Produce more with the same resources, or the same with fewer — maximum output at minimum cost.

Target	Before	After
1 • Labour	10 workers → 500 units	10 workers → 600 units (balanced), no extra labour cost
2 • Machine	Utilization 60%	Utilization 85% — same machine, more output
3 • Material	100 kg → 85 good units	100 kg → 95 good units (less scrap)
4 • Time	Cycle time 10 min	Cycle time 8 min — output rises automatically
5 • Cost	AED 40 per unit	AED 32 per unit — profit increases

Productivity: 1,000 units ÷ 20 workers = 50 units/worker. With 1,200 units and the same 20 workers: 60 units/worker. That is optimization.

FINDING THE OPTIMAL LABOUR LEVEL

Workers	Output	MP
5	100	–
6	125	25
7	145	20
8	160	15
9	170	10
10	175	5

BEST RANGE: 6–8 WORKERS

Each worker still adds significant output. At 10 workers: more salary, more congestion, little extra production — diminishing returns. The exact best number also depends on what one extra unit is worth versus one extra worker's cost.

REAL EXAMPLE — WELDING LINE

12 welders, 1 welding machine, 250 units. Add 3 welders → 255 units (only 5 extra). Do not add labour — improve machine capacity.

PART 4 · SECTION 8

Cycle Time, Bottlenecks, Utilization, Yield & Isoquants

CYCLE TIME

Available Time ÷ Output

$480 \div 120 = 4$ min/unit. Cut to 3 → 160 units, no extra workers

MACHINE UTILIZATION

Running ÷ Available × 100

$6 \div 8 = 75\%$. Aim 80–90%, not 100%

MATERIAL YIELD

Good Output ÷ Input × 100

$92 \div 100 = 92\%$ yield, 8% scrap

PRODUCTIVITY

Output ÷ Input

$1,000 \div 20 = 50 \rightarrow 1,200 \div 20 = 60$

BOTTLENECK OPTIMIZATION

Station	Capacity	Status
Cutting	100 pcs/hr	
Drilling	80 pcs/hr	Bottleneck (lowest)
Assembly	120 pcs/hr	

RULE

Never focus first on the fastest process. Focus on the slowest. Raising drilling from 80 → 100 pcs/hr raises total line output.

ISOQUANT THINKING — CHOOSE THE CHEAPEST MIX

Option	Workers	Machines	Output
A	20	5	1,000
B	15	7	1,000
C	10	10	1,000

All three produce 1,000 units. The lowest-cost combination becomes the preferred one. **Ask every day:** can output increase without adding labour? Can cycle time be reduced? Where is the bottleneck? Is utilization low? Is scrap too high? Is overtime hiding inefficiency? Is marginal product still worth the extra cost?

PART 4 · SECTION 9

Optimization KPIs & the Supervisor's Golden Rule

KPI	Formula	Target
Productivity	$\text{Output} \div \text{Input}$	Increase
Average Product	$\text{TP} \div \text{Labour}$	Increase
Marginal Product	$\Delta\text{Output} \div \Delta\text{Labour}$	Monitor
Average Cost	$\text{TC} \div \text{Output}$	Reduce
Marginal Cost	$\Delta\text{Cost} \div \Delta\text{Output}$	Control
Yield	$\text{Good Output} \div \text{Input} \times 100$	Increase
Utilization	$\text{Running} \div \text{Available} \times 100$	80–90%
Cycle Time	$\text{Available Time} \div \text{Output}$	Reduce

OPTIMIZE IN THIS ORDER

Eliminate waste → reduce downtime → remove bottlenecks → balance manpower → improve machine utilization → reduce cycle time → add labour only if necessary → buy new machines only after proving current capacity is fully utilized.

THE GOLDEN RULE

If productivity improves while quality and safety are maintained, you are optimizing.

You can now analyze production from inputs to daily, weekly and monthly formulas, read what the numbers mean, and optimize output at minimum cost.

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QUICK REFERENCE

Cheat Sheet & Templates

10 One-Page Cheat Sheet

A Analysis Sheets & Templates

QUICK REFERENCE · 10

Production Analysis Cheat Sheet

Concept	Formula	Example
Total Product	$TP = \text{Total Output}$	120 units
Average Product	$AP = TP \div \text{Input}$	$120 \div 10 = 12$
Marginal Product	$MP = \Delta \text{Output} \div \Delta \text{Input}$	$115 - 100 = 15$
Total Cost	$TC = FC + VC$	$10,000 + 5,000 = 15,000$
Average Cost	$AC = TC \div \text{Output}$	$15,000 \div 300 = 50$
Marginal Cost	$MC = \Delta \text{Cost} \div \Delta \text{Output}$	$800 \div 20 = 40$
Elasticity	$\% \Delta \text{Output} \div \% \Delta \text{Input}$	–
Isoquant	$Q = f(L, K)$	7 workers + 2 machines = 100
MRTS	$MP(L) \div MP(K)$	$10 \div 20 = 0.5$
Productivity	$\text{Output} \div \text{Input}$	$1,000 \div 20 = 50$
Cycle Time	$\text{Available Time} \div \text{Output}$	$480 \div 120 = 4 \text{ min}$
Utilization	$\text{Running} \div \text{Available} \times 100$	$6 \div 8 = 75\%$
Yield	$\text{Good} \div \text{Input} \times 100$	$92 \div 100 = 92\%$

GOLDEN RULE — OPTIMIZE IN ORDER

Waste → Downtime → Bottlenecks → Manpower → Utilization → Cycle Time → Labour → Machines.

APPENDIX

Analysis Sheets & Templates

A · DAILY PRODUCTION ANALYSIS SHEET

Metric	Value	Notes
Total Product (TP)		
Workers		
AP = TP ÷ Workers		
MP (change in output)		
Total Cost		
AC = TC ÷ Output		

B · WEEKLY & MONTHLY SHEET

Total Product · Labour Hours · AP per labour hour · Total Cost ·
AC · MC — recorded for Week and Month.

C · OPTIMIZATION CHECK SHEET

Productivity · Machine Utilization % · Material Yield % · Cycle
Time · Bottleneck Station · Cost per Unit — Current vs Target.

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A production guide for the manufacturing shop floor — turning numbers into decisions: maximum output at minimum cost.