MENGM0056 - Product and Production Systems
Scenario 2: Automotive Components - Aluminium Gearbox Casings

Hand-out for Group Coursework (2025/26)

UUID seed: 36ddb4a1-ecd1-44c6-81e5-d113e4a01c35 **Checksum:** 76396060a951

Purpose

This scenario simulates a cast-and-machine workflow for aluminium gearbox casings. Your group receives seeded baseline parameters and must propose improvements that reduce cost and environmental impact while maintaining the weekly output target and quality.

Narrative

Aluminium and energy prices have risen, and new environmental performance reporting requires reductions in both scrap and energy per good part. Production capacity must be maintained to satisfy weekly orders. Capital expenditure is constrained in the short term, so parameter, policy, and scheduling changes are preferred.

Entities and flow (fixed structure)

Gravity die casting → X-ray NDT → Heat treatment → CNC rough/finish → Washing → Coordinate-measuring machine (CMM) → Pack.

Baseline parameters (seeded)

Global

Shifts per day	3
Shift length	7.5 h
Weekly output target	4228 good parts/week
Weekly demand CV	0.122
Sustainability emphasis	both

Stations and process timings

Stage	Count	Time	Quality	Notes
Casting cells	3	190.4 s/part	Scrap 0.0378	Gravity die casting
X-ray NDT	2	113.4 s/part	Detect 0.93	Rework path 416.0 s if repairable
Heat treatment oven	1	401.2 min/batch	-	Batch size 225 parts
CNC machining centres	5	428.0 s/part	Scrap 0.0072	Combined rough and finish

Washing	1	79.0 s/part	-	Deburr and wash
CMM inspection	1	753.0 s/part	Scrap 0.0004	Late discovery risk

Materials and energy

Net casting mass	6.56 kg
Gating and runners	1.4 kg
Recoverable yield from gating	76%
Alloy price	£3.27 /kg
Scrap recovery value	£1.36 /kg
Casting energy	3.24 kWh/part
Machining energy	1.01 kWh/part
Heat treatment energy	1.71 kWh/part
Tariff off-peak	27.1 p/kWh
Tariff peak	33.8 p/kWh
Peak window	15:00 – 18:00

Reliability

Resource	MTBF (min)	MTTR (min)
Furnace	442.9	24.7
CastingCell	422.2	11.8
Oven	540.5	25.4
CNC	556.9	14.1
CMM	671.8	15.5

Costs

X-ray NDT imaging cost	£0.13 /part
Coolant and consumables	£0.04 /part
Labour cost	£19.59 /h
Rework labour cost	£27.34 /h
Environmental cost proxy	1.9 p/kWh

Required KPIs

- Scrap percentage by stage and rolled throughput yield (RTY).
- Energy consumption per good part, and energy cost per good part.
- Material utilisation: net mass divided by total poured, and alloy cost per good part.
- Weekly throughput and on-time completion against the weekly output target.
- CMM queue time and heat treatment oven utilisation.

Techniques to apply

- **Modelling & KPIs**: RTY ladder; energy and material balance per good part.
- **CAE**: Casting gating and riser changes; distortion risk and machining allowance sensitivity.
- **Mathematical programming**: Oven batch sizing and start-time scheduling to avoid peak tariffs; CNC assignment and shift planning.

- **Uncertainty modelling**: Demand variability; breakdown distributions; defect modes and NDT detection uncertainty.
- **Metaheuristic optimisation**: Multi-parameter process window search for casting temperatures, die temperatures, and shot speeds under yield and cycle constraints.
- **Simulation**: Discrete-event simulation for bottlenecks at CMM and ovens; evaluate queueing and batch policies.

Improvement levers (examples, not exhaustive)

- Shift oven starts to minimise time in peak tariff windows while protecting weekly output.
- Modify gating and riser design to cut porosity and reduce machining allowances.
- Balance CNC routing based on cycle spread; consider dynamic assignment to reduce queues.
- Introduce NDT triage rules for repairability to prevent non-valuable rework.
- Implement scrap segregation to maximise recovery value.

Deliverables

1. A report (max 20 sides of A4 including figures and references; appendices unmarked but admissible as evidence).
2. The report should include a weekly production plan demonstrating compliance with the output target and tariff policy.
3. Model files (e.g., simulation, optimisation, CAE) as appendices or evidence.

Assessment emphasis

Sound KPI selection and modelling; correctness and transparency of calculations; appropriate choice of techniques; quality of experimental design; depth of analysis on scrap and energy; and clear, defensible recommendations that meet operational constraints.

Data ethics and reproducibility

Report your UUID seed and any random seeds used within tools. Include enough detail to allow independent regeneration of your parameter tables.