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Clarity before transformation

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DATUM ADVISORY

Case Study: Moulding Process Quality Improvement (Six Sigma DMAIC)

Executive Summary

A moulding operation was experiencing chronic quality defects, rising scrap, and repeated heater failures. Two independent symptoms, short mouldings and temperature-related breakdowns, pointed to a deeper capability issue within the process.

This case study shows how a structured, evidence-first DMAIC approach uncovered the real constraint: an incapable temperature-control system that had been accepted as "normal" for years. By challenging inherited assumptions and rebuilding process capability, the operation achieved stable, defect-free performance.

1. Context and Problem Signals

The business was experiencing:

- High scrap rates on critical moulded GRP components (10 tonnes of scrap per year)
- Frequent unplanned maintenance on hydraulic press heaters
- Increasing material shortages and rising waste disposal costs

Two independent signals, quality defects and heater failures, pointed to a deeper systemic issue. A Six Sigma project was commissioned, and I was asked to lead it.

2. Process Background

The operation produced thermoset moulded GRP components using:

- A heated mould tool mounted on a hydraulic press
- 100-tonne pressure
- 130°C cure temperature
- ~10-minute cycle time

Two defect types dominated:

1. Short mouldings (incomplete fill and poor surface finish)
2. Heater failures (undetected until temperature drift caused defects or alarms)

These symptoms suggested a temperature stability problem.

3. Define & Measure: Establishing the Evidence Base

To move beyond anecdote, three measurement systems were introduced:

- Operator quality log (timing, defect type, cycle observations)
- Temperature data logger (continuous tool temperature profile)
- Maintenance failure log (heater failures, timestamps, retained failed parts)

This created a clean dataset for analysis.

4. Analyse: What the Data Revealed

4.1 Temperature Instability

The tool temperature cycled between **128°C and 146°C**, despite a 130°C setpoint. Defects correlated strongly with the extremes of this cycle.

4.2 Heater Failure Modes

A Pareto analysis showed:

- Most failures were burnt-out crimp terminals
- Secondary failures were heater element perforations

Inspection of failed parts revealed:

- Tin-plated copper terminals degrading at high temperature
- Heater elements developing "hot spots" due to poor thermal contact

These findings reframed the problem: The process was not capable because the control system was not capable.

5. Improve: Engineering the Right Solutions

5.1 Temperature Control Upgrade

The original system used:

- Slow electro-mechanical contactors
- Basic thermostats or simple digital controllers
- Large thermal mass = slow response = high hysteresis

Research into PID control and solid-state relays showed they could deliver fast, precise switching.

The solution:

- Replace contactors with solid-state relays
- Install PID controllers with auto-tuning
- Fit higher-grade thermocouples

This created a stable, responsive heating system.

5.2 Heater Reliability Improvements

Two root causes were addressed:

- Terminal failures (replaced tin-plated copper with nickel-plated high-temperature terminals)
- Element hot spots (introduced thermal contact paste to ensure uniform heat transfer)

Both changes were mandated across all six machines.

6. Control: Results After Implementation

After commissioning the upgraded machine:

1. Temperature variation reduced from ±40°C to ±2.5°C
2. Zero defective mouldings produced during the monitoring period
3. Zero terminal failures recorded
4. Maintenance callouts dropped from daily to none
5. Operators reported improved consistency and confidence
6. Energy usage reduced due to stable heating and fewer reworks

Long-term monitoring confirmed sustained performance.

7. Wider Opportunities Identified

The project revealed further improvement potential:

- Upgrade remaining machines to PID control
- Insulate tools to reduce heat loss
- Conduct temperature profiling for all tools to optimise warm-up cycles

These became part of the plant's continuous improvement roadmap.

8. What the Organisation Learned

1. Assumptions can persist for years. Terminal failures were accepted as "normal" until challenged.
2. Waste becomes visible only when it hurts. Scrap was tolerated until poor output caused shortages and cost escalation.
3. Structured thinking beats firefighting. A simple, disciplined DMAIC approach delivered a permanent fix.
4. Technical problems often mask governance problems. The real issue was the absence of process capability thinking rather than the heaters themselves.

9. Why This Case Matters for Datum Clients

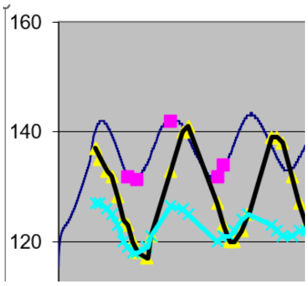
This project demonstrates how technical symptoms often mask deeper operating-model issues:

Systems Thinking	Quality defects and maintenance failures were two expressions of the same root cause.
Evidence-First Diagnosis	Measurement replaced anecdote and revealed the true failure mode.
Challenging Inherited Norms	Long-accepted heater failures were not "normal"; they were a capability gap.
Simple, Targeted Solutions:	Solid-state relays, PID control, and better terminals delivered stability without over-engineering.
Sustained Control:	The fix was embedded into maintenance standards, ensuring long-term reliability.

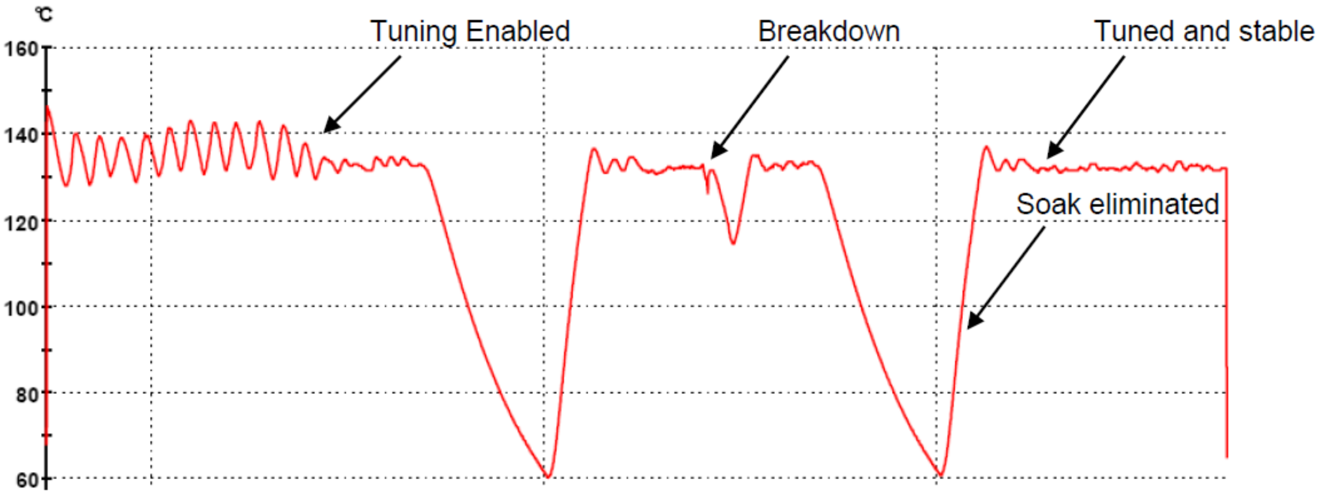
For SMEs, this case shows how structured thinking and disciplined problem-solving can eliminate chronic waste, reduce downtime, and build lasting operational capability.

Appendix A

Some of the analysis showing the correlation of defects (purple points) and tool temperature (blue line).



Example of the control achieved following the project completion.



Process control after tuning

An explanation of "Soak"

With the older controller, in a crude attempt to reduce overshoot, the controller halted the heating at around 80% of set-point for an amount of time to allow the temperature to stabilise. While this reduced the overshoot, it increased the time for the heating cycle, meaning that operators waited longer to begin production. This feature was not understood by the operators, and it frequently led to puzzled maintenance folks trying to work out what was wrong with the machine, and it became the 'magic' fix when the machine began heating up again at the end of the soak period.

Finally, during the project, the soak was understood by looking at the data captured by the temperature monitor.