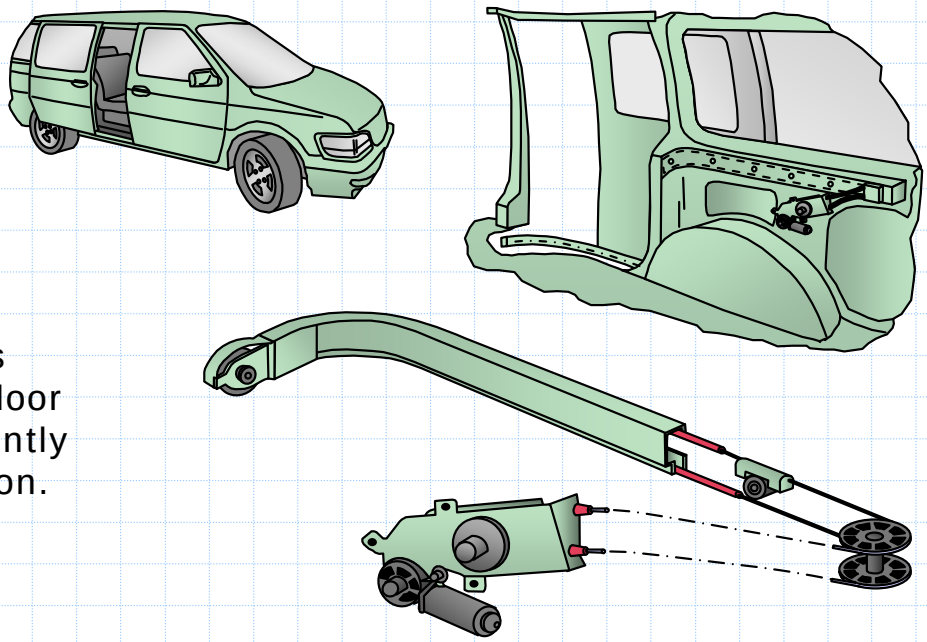
Minivan Door Auto-close



A vehicle manufacturer experienced warranty failures where the automatic sliding door of a minivan would intermittently re-open for no apparent reason.

Problem

Like automatic windows, this door had a safety feature that meant that if an object such as a hand were in the path of the closing door, the door would reverse direction and reopen. Unfortunately, on a small number of vehicles, this reversal would intermittently happen when the door actually should have been locking. Attempts to fix the problem used up huge resources, including over 200 engineering changes over a couple of years, with no improvement.

Strategy & Tactics

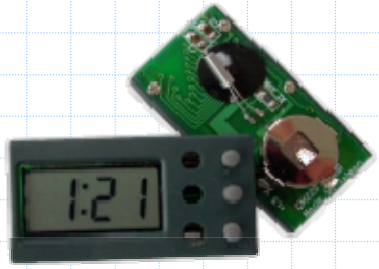
Rather than attempt to reproduce an event that was quite rare, even on a known faulty vehicle, it is a much more effective strategy to execute a convergent search by characterising behaviour and then splitting impedances. This is easier than it sounds, and actually only took a few hours with simple data acquisition. The result was simply that cable tensions were not being correctly adjusted during vehicle assembly.

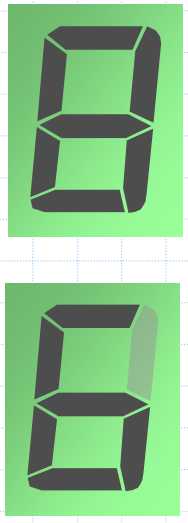
Benefits

Warranty costs for this fault were immediately eliminated for new vehicles, with a simple fix for any residual field failures.

The type of behavioural characterisation employed on this problem should be applied to the very first product off the line. It would have flushed out this failure before the product got to the customer.

Liquid Crystal Display Faults





An LCD manufacturer experienced warranty failures where the digits were incorrectly displayed due to missing segments. Failures started to occur after 3 months operation, and were very expensive to repair.

Problem

100% pass rate at end of line testing, but 2% or 3% failures during warranty period.

Strategy & Tactics

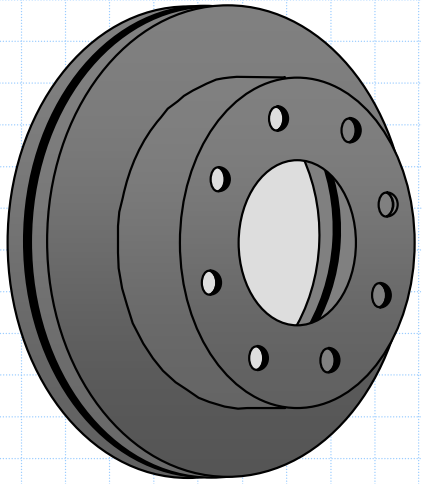
Instead of treating this problem as an attribute (on-off) characteristic, the key is to be able to characterise performance at both time zero, and after operation. We need to know how well the device is working, not does it work or not. It turned out that most of the population performed poorly, but good enough to pass, even at the end of the line. A strategy of splitting impedances was able to identify the causal mechanism within a couple of days, allowing a zero cost solution to be implemented very quickly.

Benefits

The solution did not add cost to the product, and the warranty cost quickly subsided.

The type of behavioural characterisation employed on this problem should be applied to the very first product off the line. It would have flushed out this failure before the product got to the customer.

Brake Rotor Lateral Run-out



Brake rotors are manufactured by turning castings, then grinding them. Lateral run-out must be maintained within very tight spec. limits to avoid an unacceptable driving experience.

Problem

A manufacturer had identified major cost reductions by eliminating operations, but the new process caused a percentage of finshed parts to be outside run-out specification limits. The product was unprofitable with the existing manufacturing process. The goal was to come up with a low-cost solution to reduce the variation in lateral run-out.

Strategy & Tactics

Run-out, roundness, straightness, flatness, cylindricity are all geometrical characterisations that frequently mislead problem-solvers. Most of the information required is contained within a single component, but has been discarded in favour of a single number that deceives people into employing statistical analysis to many components.

This problem was easy when we used a combination of Isolation and Impedance Splitting Strategies to establish a causal explanation that lead to a relatively simple fix. 3 parts were all that was required for diagnosis. Clamping rotors for turning distorted them slightly. The lathe machined the rotors flat, but once the clamp released, the parts had run-out that grinding would not correct.

Benefits

The non-conformance problem was an obstacle to lean manufacturing implementation for this component. A statistical-based study had failed to identify a solution.

Totally eliminating rejects for lateral run-out was the key to realising the lean goals for rotor manufacture.

Biological Assay Performance Variation

A manufacturer of healthcare products was concerned with performance of microtitre plates. These have an array of wells in which sample reactions are assayed by passing high-intensity light to the wells. The light colour emitted by the reaction happening in each well is quantified by a detector.

Problem

Plates are coated with appropriate chemistry for whatever application they are assigned, usually involving 2 to 3 different coats, with washing and drying before and after each coat. Testing is destructive, so quality control involves a sampling plan, with a tight color tolerance for each batch to be shipped. Variation was too large, and needed to be diagnosed.

Strategy & Tactics

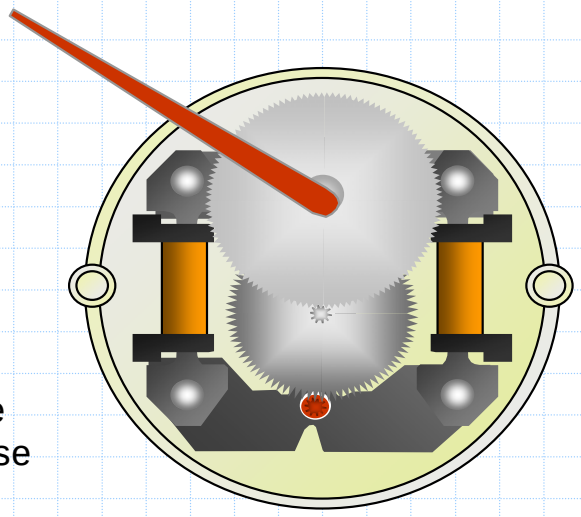
An Isolation Strategy was employed – splitting between inputs to the process and the functions of the process. Tactically, this only involved the same number of plates as a regular production test sample, and was completed in a couple of hours. The causal mechanism lived in the first drying operation, not coating or washing. Over-aggressive air flow drying caused the variation.

Benefits

The variability of the production sample tests was reduced from over 100% of the tolerance to under 25%.

Previously planned, expensive and time-consuming experimentation with 14 variables (none of which involved air flow) was avoided.

Vehicle Instrument Panel Stepper Motor Failures



Stepper motors costing less than €1 were causing warranty repairs of €1000 because the indicator would stick.

Problem

This intermittent but extremely expensive failure was being investigated by a large team from both the supplier and customer. They had managed to reproduce the failure by running the device continuously for several hours under severe operating conditions. This meant that every test they performed generally took 1 to 2 days.

Strategy & Tactics

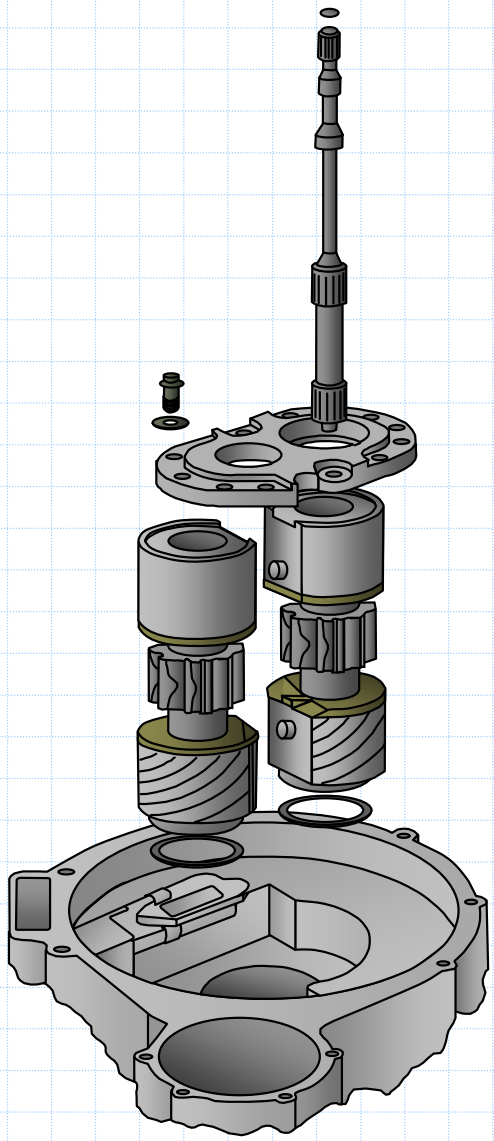
Rather than try to reproduce the attribute failure (stuck pointer), it is much more effective to characterise the device's behaviour. By doing this, it was possible to conduct tests in seconds, and within a small production sample, observe the whole range of performance. Then we found that, rather than being rare, stepper motors at risk of sticking are in fact very common. It also meant that the cause of the faulty components in the manufacturing process, an injection moulding operation, was easy to converge upon within a couple of days.

Benefits

The explanation for how the problem occurred was found in less time than it took to run a single 'attribute' test, dozens of which were planned.

Following the diagnostic investigation, the behavioural characterisation employed was then applied to the test samples submitted for reliability validation. Some of these samples had poor performance, but they had passed the test. The huge warranty costs could have been easily avoided.

Out of Specification Gear Pumps



Aerospace fuel pump flow performance below minimum specification

Problem

This pump suffered high rework levels, specifically for low flow. This was a major impediment to implementing lean manufacturing principles. Pumps just inside specification would typically require premature overhaul

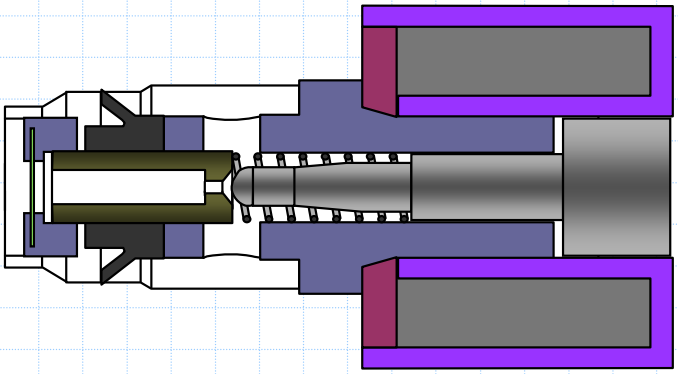
Strategy & Tactics

When performance is characterised with a single variable, such as flow, we lose a lot of information, somewhat like trying to watch a theatre play, but only being able to see shadows of the actors. Much valuable information from a single product is lost, and engineers try to replace this with statistical analysis of a single number. Work with one pump lead to convergence on the component characteristics responsible for the behaviour. A very low cost additional operation eliminated the rejects.

Benefits

This problem had been the focus of expensive experimentation for more than two years, with no improvement. After finding the causal explanation for low flow, rejects were eliminated.

Vehicle Brake Failure – ABS Module



Complete braking system failure on vehicles within days of assembly.

Problem

A vehicle manufacturer parked vehicles prior to shipping. When driving a small number (1 or 2 in 1000) of the vehicles onto the rail car, the brake pedal would go to the floor and the vehicle would crash. Pressing the pedal again, the brakes would function normally, and no-one had succeeded in reproducing the failure.

Strategy & Tactics

If the problem can never be reproduced on a vehicle that had failed, it is very unlikely that tearing down the assembly will reveal anything. It is more likely that any clues would be destroyed. We need to characterise functionality on vehicles before somebody puts their foot on the pedal. A preliminary mapping of how the system functions indicated that we should start by characterising the ABS valves. This revealed a large difference between impedance upon driving the vehicle off the assembly line, and impedance of the same valves after sitting in the parking lot at -20°C for two days. There were also large differences between ABS modules vehicle to vehicle.

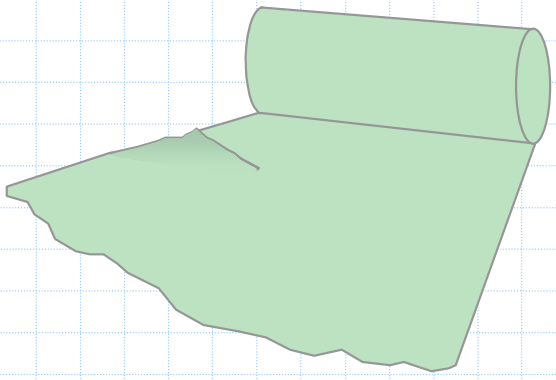
With this knowledge, and parts from the bad end of the spectrum available, we succeeded in recreating the problem in a refrigerator. What was happening was that rust-preventer had reacted with brake fluid, then crystalised at low temperature. Crystals would go back into solution when the fluid moved or warmed up, but not before a catastrophic failure.

Benefits

The solution was to avoid the combination of brake fluid and rust preventer formulations, and the problem was eliminated.

Although more difficult to detect, standard reliability testing included taking the products below -20°C, therefore, if performance had been tested as we did, the problem was likely to have been found at an early stage.

In-Process Wrinkling



Widespread in-process wrinkling of reinforced polymer sheet rolls.

Problem

In-process wrinkling and related phenomena cause a great deal of disruption and waste materials in a wide range of processes and materials. This large corporation suffered the problem in all of its plants world-wide, and many different areas of each plant. Though there was a lot of symptomatic knowledge of cause-effect relationshipss, there were many possible causal explanations. The company lacked a strategy and tactics with which to attack the problem, particularly as wrinkles are infrequent.

Strategy & Tactics

The nature of a sheet wrinkle gives some indication of the direction of stresses involved. Wrinkles form as a result of energy being contained and released in the sheet, specifically due to compressive forces. For the wrinkle sketched, the force differential is across the roll, the maximum being at a slight angle. All wrinkles had precisely the same angle, indicating a consistent differential. To characterise energy storage for the sheet, we need to think in terms of displacement as well as force.

In this way, it is possible to execute a progressive search without actually seeing a wrinkle. First, we isolate where in the process the cross-direction forces are greatest with respect to process-direction forces, without worrying about what causes the differential gradient. We proved that we had control over the formation of wrinkles once we had a causal explanation that fitted all constraints.

Benefits

This particular problem was addressed during the afternoons of a four-day workshop, yet had consumed a great deal of resource over many years. The results applied to the same process in other plants, eliminating much disruption.

More importantly, the company now had a strategy and tactics, and applied them to many more wrinkle problems with different causal mechanisms.