INTRODUCTION AND EXPERIMENTAL PURPOSE

A manufacturer of small household appliances was experiencing an epidemic of complaints about leaking kettles. The problem was so serious that as many as 35% of the units were returned to the company after just a few months of use. Interestingly, kettles are subjected to a 100% inspection for leaks after assembly.

A team of specialists, composed of production technologists and quality engineers, was therefore appointed to find the source of the problem. Several hypotheses emerged:

- Incorrect component dimensions, specifically the lower diameter of the kettle body and its base diameter (see Fig. 1). Indeed, measurements showed that some of the leaking kettles had deviations from specifications, but among the complained-about products, there were also some that fully complied with the requirements.
- Defects in components supplied by external suppliers, such as heating elements and gaskets. Some irregularities were also found here, but none were consistent with all the defective units.

In response to these findings, more stringent inspections were implemented: 100% of components were inspected, allowing only those that met all specifications to be assembled. The result? The number of rejected components increased, but the number of complaints from the market remained stable.

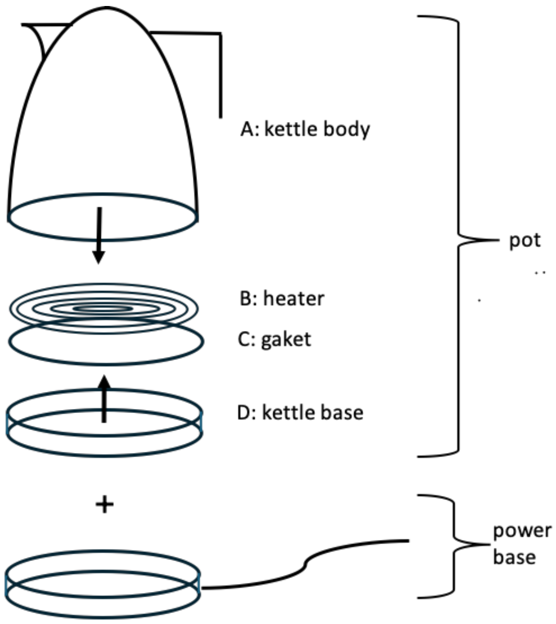


Fig. 1. Parts of the kettle

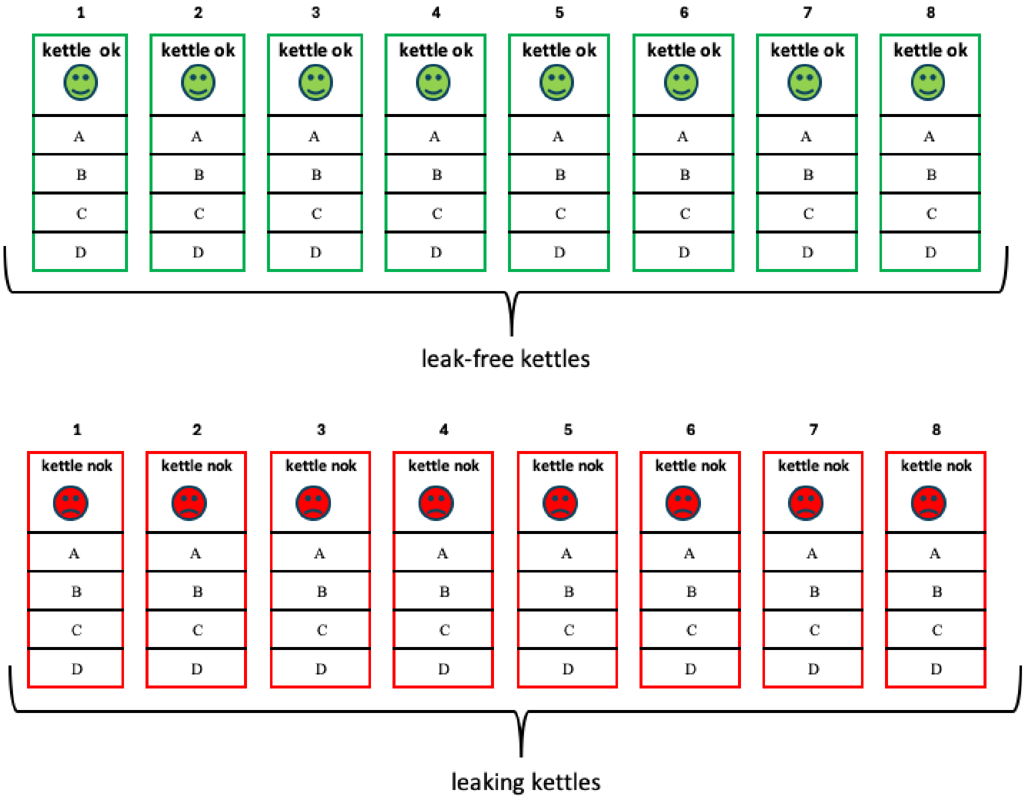
TIME FOR A MORE STRUCTURED APPROACH

Since previous efforts had failed, a team of consultants from OpEx Group was brought in to address the issue. We used a DOE (Design of Experiment) as a learning tool, aiming to answer the following questions:

1. Is the assembly process responsible for the leaks? If so, what factors in the assembly process are causing the leaks?
2. If not, which specific component is causing the problem?

IS THE ASSEMBLY TO BLAME?

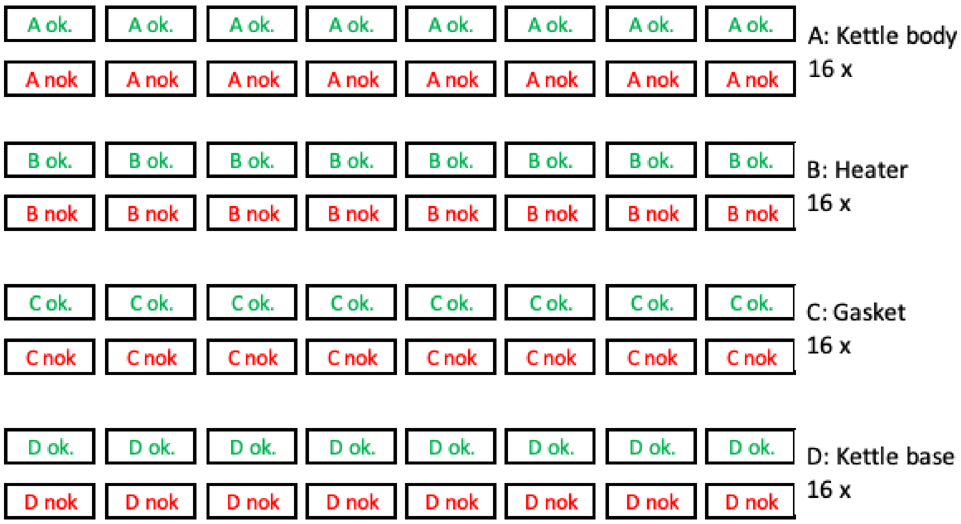
To test this, we selected eight leaking kettles and eight good ones. All the kettles were disassembled into their individual components—labeled A, B, C, and D (as shown in Figure 1)—and reassembled using the exact same components.



The result? Good kettles remained good, while the leaking ones continued to leak. This indicates that the problem lies not with the assembly method, but with one of the components themselves.

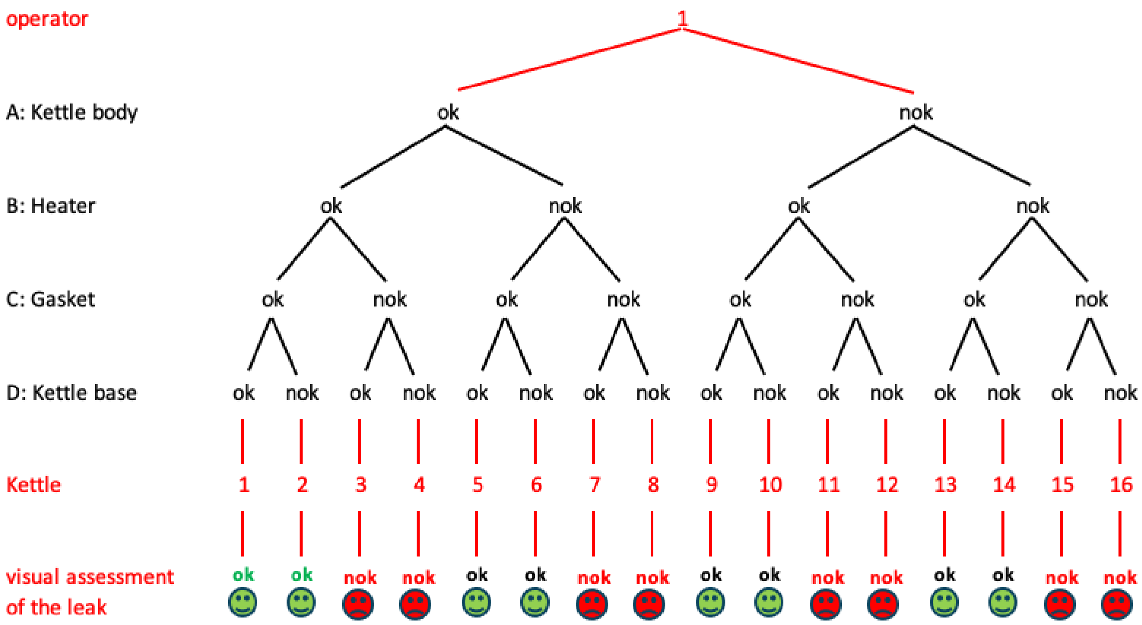
WHICH COMPONENT IS RESPONSIBLE FOR LEAKING KETTLES?

We disassembled all the kettles again.



!!! Important: "ok" and "nok" do not mean that the component is good or bad - only what kind of kettle it came from (leaky or good).

To determine which component causes leaks, we used a 2^4=16 full factorial experiment, where the factors were components A through D, tested at two levels (whether a given component came from a good or leaky kettle). This resulted in the assembly of 16 new kettles, which we then tested for leaks. The assembly diagram (component selection) and the leak assessment on the finished product are presented in the diagram below.



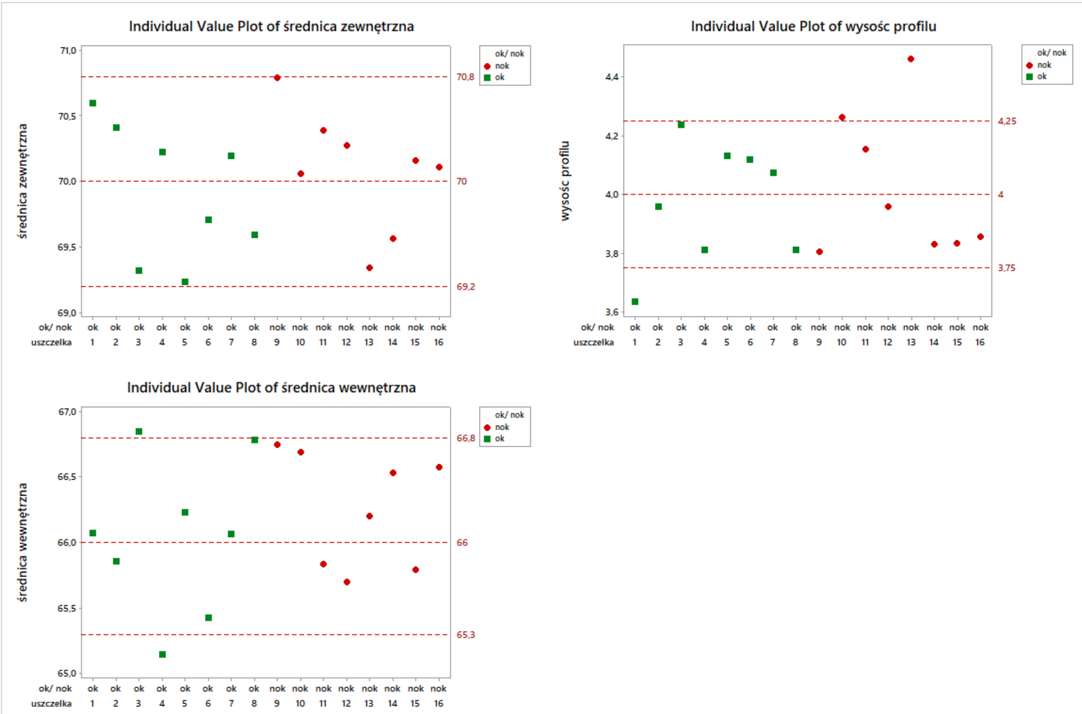
The results were clear: the gasket (component C) was responsible for the leaks. Regardless of the other components of the kettle, if the gasket came from a faulty appliance, the kettle leaked. For final confirmation, we once again swapped the leaking and good kettles with gaskets, which confirmed the above conclusions. We now have one final question to answer:

WHAT IS THE DIFFERENCE BETWEEN GOOD AND BAD GASKETS (NOW WE CAN CALL THEM THAT ☺)?

Now, that it was clear that the problem was with the gaskets, it was necessary to determine what specifically distinguished the good ones from the bad ones.

Three key dimensions, that are monitored on a daily basis during deliveries, were examined:

- inner diameter,
- outer diameter,
- gaskets height.



But surprise! None of these parameters clearly distinguished good gaskets from bad ones. Even the "defective" ones often met specifications. This confirms the words of W. Edwards Deming: "*A component cannot be considered bad simply because it doesn't meet specifications until it can be proven to adversely affect the finished product.*" Although we have proven that the gaskets are to blame for leaks, their dimensions are not the cause of the problem.

Since dimensions weren't an issue, we examined the gasket surfaces. It turned out that:

- Good gaskets were smooth, shiny, almost glazed,
- Defective gaskets had a matte surface, sometimes slightly rough, with a slight bloom.

An investigation at the supplier revealed, that at some point, they had started using cheaper silicone, which, although it met the specifications, had a lower chemical purity than the original. This was the culprit for the leaks. As you can see, having components that meet specifications doesn't guarantee that the finished products won't have problems.

After identifying the source of the problem:

- The material specifications were updated,
- The cheaper silicone was discontinued by suppliers,

- The problem of leaking kettles disappeared completely.

The rigorous inspection of injection molded components and the dimensions of gaskets and heating elements at the inlet was also discontinued.

The example of leaking kettles is a clever use of DoE to define which component is responsible for a defect in a finished product. A necessary condition for using this approach is the ability to repeatedly assemble and disassemble the finished product from the same components. If this is not possible at all, the classic use of DoE to find the root cause remains.

QUESTIONS:

- What if the finished product is only disassembled to a certain level?
- A kettle is a simple product. How should one proceed, when the finished product consists of a dozen or even several dozen components?

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