Technology White Paper - Reverse Engineering with portable CMMs

What is reverse engineering?

Reverse engineering is the process of taking apart an object to see how it works in order to duplicate or enhance it.

The ordinary engineering design process is a series of steps that involve designing a product by means of a drawing, then manufacturing it to meet certain criteria and/or to accomplish a certain task.

In reverse engineering, the steps are inverted. It's a process that examines an existing product to determine detailed information and specifications in order to learn how it was made and how it works. This typically involves disassembly of the object and then analyzing, measuring and documenting the parts. Duplication of the object is enabled by capturing physical dimensions, features, and material properties.

Next, 3D scan data serves as a visual guide for sketching the CAD drawing. A reproduction of the original object is then accurately created based on that drawing.

Why reverse engineering is needed

A common scenario where reverse engineering is needed is when a company has a machine and a part fails. A replacement part is needed, but the manufacturer has discontinued the machine and therefore no longer manufactures parts for it. The owner of the machine can then reverse engineer a replacement part from the failed part, preventing the machine from becoming redundant.

Reverse engineering can also shorten a company's product development time. It effortlessly captures a product in 3D digital form and exports the data for quick prototyping, or manufacturing.

There are various other situations in which reverse engineering can be used:

- Creating an original part design that has inadequate or no documentation available.
- Redesigning a part to eradicate a bad feature or to fortify good features.
- Competitive technical intelligence. To know what one's competitor is actually doing, as opposed to what they say they are doing.
- Supporting modifications where original CAD models cannot.

- Updating obsolete products with current technology or reusing obsolete objects in a different but useful manner.
- Supplying a part with little downtime that is critical to a system, reproduced in large quantities, or reflects a big investment.
- Saving money. When one finds out what an electronic device is capable of, it can spare a user from purchasing a separate product.
- To examine how a product works by determining the specifications of its components and estimate costs and possibly identifying potential patent infringement.

To reverse engineer an object, you need to capture the component's physical dimensions, features, and material properties. If the dimensions are not 100% accurate, the reverse engineered product will not be an accurate reproduction of the original and may not function.

Hand tools such as calipers and micrometers are good at taking simple measurements, but they are not practical if the part has complicated features. With reverse engineering nowadays, a coordinate measuring machine (CMM) is able to measure the dimensions of an object faster and more accurately than these traditional hand tools.

The average coordinate measuring machine has three axes. The X, Y, and Z axes intersect each other at right angles, which is common in 3D machines. Each axis has a scale that indicates the position of a point on that particular axis.

CMMs use probes to record points as the probe makes contact with the surface of the part being measured. When a probe is used that must physically touch the item, unlike a laser or a light, then the measurements are adjusted to compensate for the size of the probe. Each point is measured until the CMM collects enough data for the software to determine angles, lengths, diameters, and other geometric elements.

The machine then reads input from the probe as directed by the operator or software. The XYZ coordinates of each point are then used to determine the size and position.

A CMM can measure dimensions either by physical contact with the object or with a laser scanner. The data collected by the CMM, known as a point cloud, is converted into surfaces. This measurement data is then transferred into a CAD package for refinement, analysis, and generation of cut tool paths for CAM.

Portable CMMs

Traditional CMMs use a probe that moves on three orthogonal axes to measure an object's physical characteristics, whereas portable CMMs use articulated arms to enable total freedom of movement around the object. Both determine and record the location of a probe in 3D space and report the results through software. The main benefit of the portable CMM, however, is its portability. It's also substantially smaller and lighter and can be taken to the part needing inspection. This minimizes machine downtime and a decrease in quality control.

Unlike traditional CMMs, portable CMMs do not require controlled temperature conditions. They're also easier to use and are considerably less expensive than traditional CMMs.

Non-contact measurement is also possible if a laser line scanner is attached to a measurement arm. A laser scanner quickly captures data to create a point cloud of millions of points of data that can be used to create a CAD package. Adding a laser scanning probe to a measurement arm not only increases the speed in collecting large amounts of data, it's also easier to use and lowers the risk of impacting a part during measurement.

The COMDO ScanArm

The COMDO ScanArm is a portable CMM and is perfectly suited for reverse engineering applications. As mentioned above, non-contact measurement is generally a faster way to inspect and measure parts. The industry as a whole is moving away from hard probing in favor of laser scanning. A major advantage of laser scanning is that soft, delicate, and complex shapes can be easily inspected without coming into direct contact with the device.

The essential part of the system is the ComdoArm, an articulating measurement arm that captures dimensional data by hard probing the surface being measured. With contact measurement repeatability up to .026mm and accuracy up to +/-.036mm, the ComdoArm weighs roughly 11.6kgs.

Laser scanning capability on the ScanArm is possible by adding a COMDO Laser Line Probe (LLP) to the ComdoArm. The advantage of this is that the laser probe is small enough to remain attached to the ScanArm, allowing the system to operate as either a contact (hard probing) or a non-contact (scanning) device without any alterations to the machine itself.

The COMDO LLP is the most compact and lightest laser probe on the market today, with measurements being accurate up to 37μm (+0.0016 inch). Its light weight and accuracy allow for effortless reverse engineering that won't cause fatigue to the user.

The innovative triangulation algorithms enable a more accurate triangulation process, which is a process used to find the position of objects in 3D space. A laser beam emitted by a diode is projected onto the surface of the object being measured. A camera looks at the laser beam and determines the location for

each point on the line. High-resolution image sensors and high frame rates improve scanning speed and produce high-density point clouds capable of detecting finer details.

A key benefit of the COMDO ScanArm is that it's portable and can be carried to the part or machine that needs to be measured. The operating temperature for this portable CMM ranges from 50 to 140 °F. Fixed CMMs on the other hand, are larger machines that require their own specialized air-conditioned rooms to strictly control temperature and conditions. A great challenge with fixed CMMs is that objects to be measured, irrespective of their weight and size, must be transported to and from the inspection area.

Reverse engineering success story

The Scuderia Ferrari Autosport team has the most wins of any Formula One car team. To make sure each race car leaves the shop with the same design set-up specifications, the Ferrari team reverse engineers sanctioned parts and carbon fiber components for their cars. They use the COMDO ScanArm to scan incoming parts and to scan the entire race car assembly to ensure proper set-up.

Having COMDO in-house enables the Ferrari technicians to measure and inspect parts, scan models, and verify set-ups. They also save on time and money by not having to use outside service providers to do their reverse engineering measurements for them.

Conclusion

Reverse engineering is an important process that can significantly extend the life of machines by allowing the machine owner to fabricate his or her own parts when the OEM has discontinued the machine and parts. Parts can be updated with new technology or redesigned to add new features or even eliminate flaws, thanks to reverse engineering.

A lightweight, portable CMM that offers both contact and non-contact measurement is the easiest, fastest, and most affordable way to measure parts and products for reverse engineering. The combination of these benefits - which are all present in the COMDO ScanArm - provides a fast and efficient solution for today's competitive needs.

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