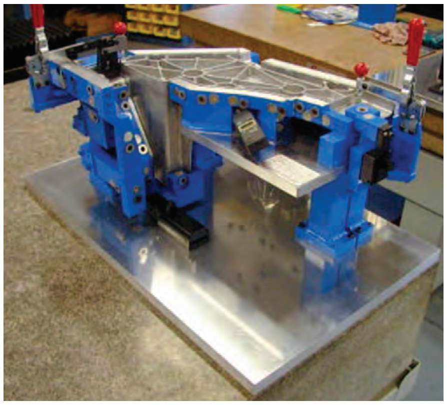
Technology White Paper

An Alternative to Check Fixtures

The automotive and aerospace industries have long faced a dilemma. Given the critical nature of the final products they build, all parts and sub-components need to be free of defects. However, manufacturers need to keep their costs down and efficiency up in order to remain competitive in the marketplace. These conflicting objectives have allowed 'check fixtures' to become prevalent in these and other industries.

Simply put, a check fixture is a device that, when fixed in place, allows production parts to be inspected by comparing the part to the geometry and features of the fixture. This is done by providing a nest for the part or conversely, the fixture will sometimes nest in the part for the fixture. The concept behind this is that if the part and check fixture fit together the part is "good". These fixtures, used in conjunction with hand tools to take any additional required measurements, have long provided a balance between part integrity and the need to keep costs down on the manufacturing floor. Nevertheless, check fixtures have several drawbacks.



Upfront Time and Expense

While check fixtures allow quality specialists to measure parts relatively quickly, getting them to measurement personnel in the first place is a challenge. First, an engineer must take the print and other data for the product being built and analyze it. From this a design model for the part itself is created. The sample part is reviewed and approved. From this information detailed prints of the check fixture are made. This requires an engineer's time and is usually a complex process. Care must be taken to design the fixture in such a way that by simply measuring the part, it does not become deformed or damaged. The part must also be able to be mounted and removed easily and quickly from the fixture. Once the fixture design is reviewed and approved, it is built.1

It is crucial that any errors be found before the fixture is released to the floor to prevent bad parts from being called good or good parts from being deemed unacceptable. This requirement means a long and extensive inspection process for the fixture is needed before it is released to the factory floor. If a mistake is found during this inspection, typically the ECO (Engineering Change Order) process begins and there is lost time for redesign and correction of the fixture, scheduling issues with other departments, and finally, re-inspection of the fixture. Meanwhile, production is severely impacted because they do not have the proper inspection tools required to get parts into finished goods.

Final upfront expenses are typically anywhere from $40,000 – $140,000 to design and build a check fixture with potential costs being even higher if the part is large, complex, or needs to be reworked before final release to the factory. As a rule of thumb, many companies budget $100,000 for the average check fixture that can fit comfortably on a table top and does not have too many complexities built into it.

Qualitative vs. Quantitative Results

Once the check fixture is released to the manufacturing floor it is ready to be used. This generally means that qualitative data is gathered from the inspection process in the form of either a 'go' (the part is "good") or 'no-go' (the part is bad). It is possible to get some quantitative information from a traditional check fixture, but this tends to require even more upfront costs to build smaller fixtures that are then used to measure feature forms and positions when the part is nested with the larger check fixture.

This difficulty in getting quantitative data is not ideal for modern manufacturing companies that are trying to run lean manufacturing and have robust six sigma programs in place. These programs prefer to monitor individual part attributes and characteristics quantitatively so that statistical analysis can be run, trends identified, and manufacturing processes adjusted before parts fall out of spec. In many cases there is a further goal to keep as many built part features and dimensional values as possible centered at or near the nominal target value.

The Uniqueness of Check Fixtures

After a company spends approximately $100,000 for a check fixture, which is then only able to provide qualitative data, the last thing they want to do is build more of them. However, this is precisely what happens when a new part is introduced to manufacturing. This is because check fixtures, which are designed to nest with an individual unique part, are themselves unique. This implies that for every individual part a company builds which requires a check fixture, a brand new one needs to be designed and fabricated.

Space Constraints and Maintenance Costs

Once a program is completed or there is an interruption in the production of a particular part, check fixtures must be stored for further use, sometimes for an indefinite period of time. Some government programs, for example, require the manufacturer to store fixtures for at least seven years after a program goes "end of life". Other programs mandate that check fixtures not be thrown away until permission is given to do so. This could mean the fixture needs to be labeled and stored

properly for ten or more years. In a typical job shop, this often means hundreds or even thousands of square feet devoted to storing check fixtures. This presents logistical challenges because the fixtures need to be cataloged properly so that they can be found quickly if they are ever needed again. Also, special care must be taken to protect them from both mechanical and environmental damage. It is not unusual for a company to allocate 4% of the fixture's original cost to storing and maintaining it every year.

A Better Way

Given the expense and limitations of check fixtures as well as the large time investment required to make and maintain them, it is not surprising that some companies have turned to the latest technology to help them eliminate check fixtures from their processes. The solution that many of them have found is combining modular tooling, which can be used to build holding fixtures, with portable CMMs (Coordinate Measuring Machines). Modular tooling can consist of a base plate with tapped holes set up in a grid pattern that allows screws, standoffs, clamps and other holding and fastening items to be attached to it. In other versions plates with parallel rows of T-slots are used to position the part which is then held by self-wedging tension clamps or some other similar method. These items can be fastened in an almost unlimited number of different ways in order to hold thousands of different parts. A set of modular tooling large enough to hold tabletop sized parts usually requires a relatively small upfront investment usually on the order of $5,000 or less.

However, even though this provides a convenient way to hold parts, without a better measurement method the modular tooling does not provide a lot of additional value to the manufacturer. Check fixtures still need to be built, verified, maintained and stored in the same fashion as before even if their final form is somewhat simplified because the modular tooling provides an easier and more efficient holding method. To get rid of the fixtures themselves, portable CMMs are crucial.

Portable CMMs come in many forms, the most common of which are articulating arms, laser trackers and hand-held 3D laser scanners (which are articulating arms with laser scanners positioned at the end of them). The choice of which technology to use is dependent upon the parts being measured and the information needed from the parts. The costs to purchase, install and shakedown these solutions can range from as low as $20,000 up to approximately $150,000 depending on the individual manufacturer's needs. To a large extent, the startup costs are a function of the part size; the larger the part, the higher the startup costs. This is analogous to the costs associated with check fixtures themselves. In general, the larger the manufactured part, the larger the required check fixture and the more the check fixture costs. This means that in almost all cases, the modular tooling and portable CMM solution will pay for itself after it eliminates the requirement for the first check fixture that would have needed to be built if the CMM solution was not in place.

Articulating Arms

These devices use an internal coordinate system located in the base of the arm to calculate position data of a spherical probe. This probe is located at the tip of the last in a series of three tubes connected end to end that protrudes from the base. The tubes are connected by freely rotating joints. This gives the arm its name – the product looks like and moves similarly to a human arm, except that the portable CMM can boundlessly rotate while the human arm has limited rotation.

Points in space are digitized by touching the probe to a feature and pushing a button to capture the point's location. The sphere's diameter is known with a high degree of certainty which allows the software to account and compensate for it. This ensures that features such as diameters of holes are measured accurately and do not add the probe diameter to the measured value.

Articulating arms usually employ a robust inspection software package that allows previously hard to measure items like true position, concentricity and hole to hole distance to be quantified in less than one minute, thus rendering the check fixture obsolete in most cases.

Laser Trackers

Laser trackers also measure the position of a spherical probe, but unlike an arm, the probe is not connected directly to the laser tracker. This probe, commonly known as a Spherically Mounted Retroreflector (SMR), is usually hand-held or mounted on the end of a machine tool or robot. The laser tracker emits a laser beam which is bounced off of a retroreflector or corner cube mounted at the center of the probe. The return beam reenters the laser tracker where the distance to the target can be determined using interferometry or phase shift analysis. In addition, the horizontal and vertical angles to the probe are determined using precision angular encoders attached to the mechanical axis of a gimbaled beam steering mechanism. Using the two angle measurements and distance determined using the laser, the laser tracker can report the coordinate location of the probe to extremely high accuracy levels. In addition, the laser tracker can follow or track the target as it moves in real time. This unique feature, coupled with the laser tracker's ability to measure points up to 1,000 times per second, enables the user to digitize data on complex surfaces and measure the location of moving objects.

Hand-held 3D Laser Scanners

These devices mount on the end of a traditional articulating arm CMM and project a laser line on the part to be inspected. The part reflects the light back toward the scanner where some of it is captured by a camera. The distance between the laser and the camera is known with a high degree of certainty. Through standard triangulation methods, three-dimensional locations can be determined. By employing a typical laptop or desktop computer, enough data is captured to allow software to create a 3D model of the part which can then be compared directly to the CAD model of the part. In addition to being able to quantify features, dimensions, and GD&T callouts, individual points can be quantified in terms of their deviation from the model.

Conclusion

By utilizing modular tooling fixtures and portable CMMs, manufacturers can eliminate the need for many or all check fixtures in their factories. The solution pays for itself as soon as a check fixture that would normally need to be built, is no longer required. In addition, the modular tooling and portable CMM solution eliminates the need for storage, maintenance and rework costs for check fixtures not currently in use. However, and perhaps most important of all, the portable CMM solution yields actionable, quantifiable data that manufacturers can use in a six sigma and/or lean manufacturing environment to improve their products and become more profitable.

REFERENCES:

1. www.divtwo.com/stf_gage_ex.htm