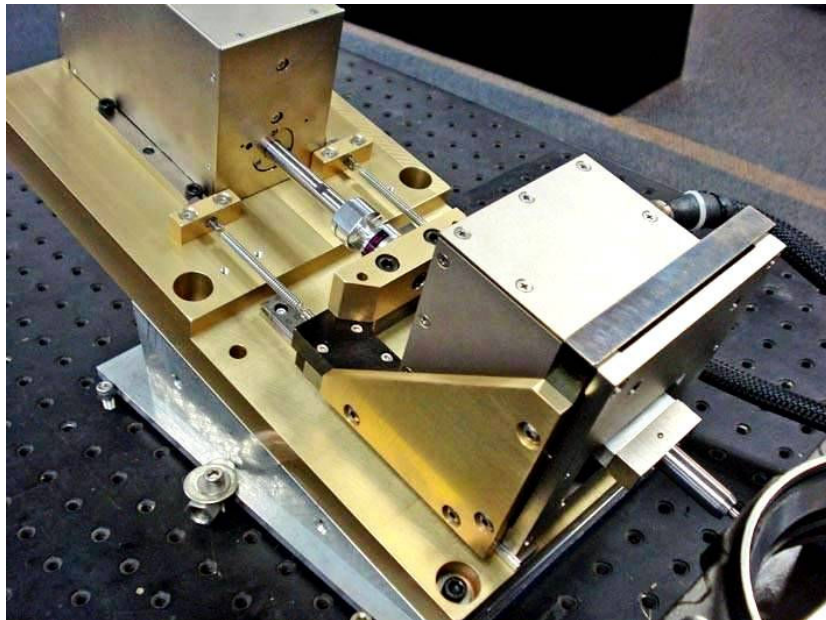


**QUALITY CHECK & INSPECTIONS
IN PRODUCTION TIME**

with

**THE NEW SMAC
MULTI-AXIS ACTUATOR SYSTEM**

XYZ COORDINATE VERIFICATION MACHINE



THE 3D-XYZ COORDINATE MACHINE FROM SMAC

An actuator system that combines all the advantages of our unique SMAC technology...

The new SMAC XYZ system is a quality check (QC) development that measures and verifies three dimensional features. We are using modified SMAC actuators and multiple actuator assemblies to set up this multi-axis control solution. Any SMAC actuator can be combined into one system: slide, linear, and rotary/linear units. Specific arrangements of the units deliver the capability to learn and follow a certain 3D contour or motion path. Complex programming is not required as the user can simply manually "trace" the 3D path required by the actuators; it is then automatically stored in the controller's memory, alternatively a comparative check can be made using a reference part. The system also features and utilizes linear interpolation, which enables a constant speed while following the chosen XYZ axis contour. SMAC offers the complete inline gauging solution with a range of flexible control interfaces.

The XYZ system relies on the patented SMAC "Soft-land" technology and provides measurements with exceptionally high speed, precision, accuracy and repeatability.

The Industry's Need for High Quality Measurement Systems

Strict specifications and quality standards in production lines have become a major issue in the acceptance and use of industrially manufactured parts over recent years. All major industries, e.g. automotive, aerospace and medical product manufacturers, using assembly standards have moved from sigma level sampling to ZERO DEFECT requirements. Without being able to provide 100% accuracy in production, companies will increasingly struggle for acceptance in the supply chain. SMAC sample applications for XYZ's are bore gauging, groove inspection, quality checks, measuring, electronic assembly, bearing inspection, inspection of adjustment mechanisms. Typically, our system are utilised in the automotive, pharmaceutical, medical, biotech, and electronic industry, robotics, SMT, and glass manufacturing, but to name a few.

Until recently, the common method to guarantee the process has been the use of Eddy Current Probes, lasers, proximity sensors or other vision systems. These systems have only been partly successful in testing, measuring and checking the quality of manufactured parts. The main problems with conventional quality measurement procedures are that they are not as accurate and precise as needed; in addition, they are often time consuming and costly. Increasingly, the industry is showing a high demand for more efficient solutions of their QC management.

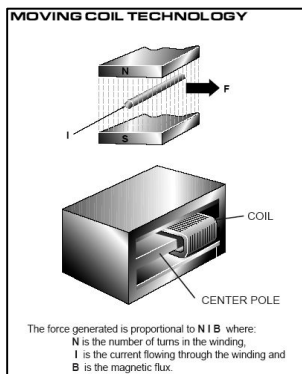
SMAC actuator systems provide a very cost effective inline gauging solution, and can be easily calibrated and correlated to proven manual or CMM inspection methods. SMAC actuator systems are designed for shop floor environments and are unique in enabling 100% detailed inspection and verification of all parts within the production line, providing SPC data acquisition and other process control systems at the same time. Additionally, tool wear becomes apparent sooner and quality check can be conveyed during the production cycle, increasing efficiency and performance quality of all manufactured parts. To sum up, higher quality, throughput, and lower costs, will result in increased customer confidence.

SMAC technology:

The voice coil linear actuator is a robust high-precision manufacturing and measurement tool which is designed for long-life and durability. Users benefit from high speed, repeatable tool with no backlash and low hysteresis. Each actuator can be programmed in three modes: force, position & velocity. These values are constantly monitored and verified against the required specification. The standard encoder resolution with all SMAC actuators is 5 micron; the highest resolution possible is 0.1 micron with a repeatability of +/- 2 encoder counts.

THE MOVING COIL

At the heart of all SMAC actuators is the moving coil.



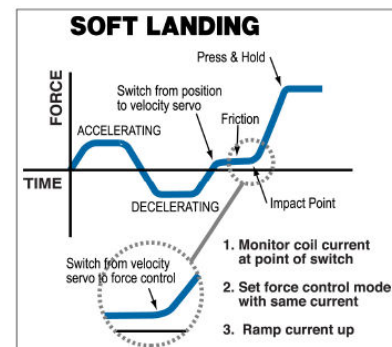
The principle is broadly the same as you will find in any permanent magnet loudspeaker: The voice coil sits in a strong magnetic field, and by passing a current through the coil a force is generated in either direction. The coil is wound on an aluminium bobbin for strength and dimensional control.

The current is relatively low compared to other linear motor manufacturers. SMAC uses approximately 2A (others: 6-10A). The Coil runs cool and therefore at a high duty cycle.

“SOFT-LAND” technology

The unique patented “Soft-land” function from SMAC involves a very high speed approach of the actuator. The actuator then performs a contact measurement with a programmed landing force and velocity.

100% data collection & feedback – directly into your PLC system or SPC software.



SMAC QC solution compared with conventional solutions

(Steve Curtiss' findings based on his experiences in the field. Steve Curtiss, SMAC application manager in the US Michigan area, has been with us for more than 6 years.)

<p>Cameras</p> <ul style="list-style-type: none"> ▪ Optical distortions possible ▪ Need of steady light source for images without shadows ▪ Vibrations can blur the image ▪ Difficulties under harsh environments (oil, coolant mist, etc.) ▪ Often manual gauge method required 	<p>SMAC actuators</p> <ul style="list-style-type: none"> ▪ Contact measurement, no optical distortion ▪ no reliance on additional equipment ▪ Immune to vibrations ▪ Work in all shop floor CMM environments ▪ Automatic gauge measurement with 100% verification
<p>Laser</p> <ul style="list-style-type: none"> ▪ Reflective inaccuracies ▪ Problems with textured or certain color surfaces ▪ Often manual gauge method required 	<p>SMAC actuators</p> <ul style="list-style-type: none"> ▪ Can be programmed to measure any material ▪ Contact measurement, no reflection or light distortion ▪ Automatic gauge measurement with 100% verification
<p>LVDT</p> <ul style="list-style-type: none"> ▪ Inaccuracies through variable air pressure of pneumatics ▪ Non-programmable ▪ Non-linear, positional data has to be scaled ▪ Short operating strokes ▪ Poor resolution of position ▪ Additional motion source needed ▪ Poor force control ▪ Poor repeatability 	<p>SMAC actuators</p> <ul style="list-style-type: none"> ▪ Force, speed & position can be programmed and exactly identified at all times ▪ Linear feedback encoder, 100% data capture ▪ Strokes up to 200mm ▪ Accuracy & precision with all data ▪ No ancillary equipment required ▪ programmable force control ▪ excellent repeatability and accuracy
<p>Eddy Current</p> <ul style="list-style-type: none"> ▪ Accessibility of surface of material needed ▪ Bad readings caused by finish of material ▪ Relies on conductivity of material ▪ Limits on the depth of penetration into the material (flaws that lie parallel to the probe may be undetectable) ▪ Expensive & fragile (Eddy Current Probes have to be mounted on a spring loaded system with limit switches the can hopefully detect a crash scenario when it happens. The probes are \$300 to + \$500 to replace.) 	<p>SMAC actuators</p> <ul style="list-style-type: none"> ▪ Can measure internally machined features, i.e. undercuts ▪ Data won't be affected by material ▪ Independent from state of material ▪ Time efficient & cost effective, life cycles >100 million, easy exchangeable, easy to mount, gauge correlation

SMAC sample applications

SMAC unique electric actuator configuration such as mini inline XYZ gauging systems gives you the capability of parts inspection (eliminating faulty ones) and quality control of the manufacturing process by immediate feedback and adjustment of critical features. Volumes up to 100 cubic mm can be covered by a single system.

The SMAC multi-axis system is able to measure various features simultaneously: external/internal dimensions, threads, bores, grooves while checking for burrs. All this can be done in common shop floor environments. The SMAC measurement system can be calibrated and correlated easily to manual gauge methods. Additionally, the actuators provide accurate inspection, SPC data acquisition and process control feedback; thus increasing quality and throughput.

Proof 1:

Inspection of bearing wheels in production time for a well-known automotive supplier.

SMAC set up a multi-axis system to check bearing wheels during the production cycle. The parts were checked for accurate dimensions, position, and grooves presence, thus guaranteeing zero-defects without interrupting the assembly line. The two linear slide actuators moved the parts on a linear X-axis while two other actuators check them on an X/Z-axis.

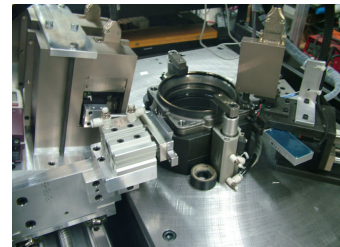
The system is able to conduct 8 checks in a cycle time of less than 3 seconds:



- | | |
|-------------------|---------------------|
| 1. Run out | 5. Major diameter |
| 2. Tri-lobing | 6. Groove diameter |
| 3. Concentricity | 7. Width & location |
| 4. Datum Location | 8. Overall height |

Implementation:

An LAR55-100 under the table was checking the M14 threaded holes while another LAR55-100 gauged M6 threaded holes. Two LAL20 which were set up as a gripper system checked the depth of the lower chamfer side of the M14 holes. Another four actuators check several features on the top side of the wheel bearing. While XY25's measured the bore depth features, the LAL95 is checking the hole alignment.



Proof 2:

Gauging application for a major automotive supplier

The customer manufactures clips and pistons for use in the automotive industry. The customer has only used a vision system, laser and LVDT – all in one system – to check if clips were seated correctly onto a piston assembly, as well as inspecting various features of a piston. The laser system worth \$85k failed to meet the requirements to conduct multiple tests, as it was unable to detect missing, or bent clips that were out of place.

SMAC solution:

The SMAC gripper (GRP50) was used to centre the rings on the piston for vision and scanning inspection. The linear slide actuator (LAS95) then carries a laser to see if the rings are placed correctly on the piston. Another linear actuator (LAL95) is used to focus the camera which has to check various features on the piston. Furthermore, another LAL95 with a 0.1µm encoder measured the diameter of the wrist pin before being attached to the assembly

Proof 3:

Airbag Base Bore Gauging and Groove Inspection

An Airbag valve is a safety critical part that holds the detonating charge. The integrity of the internal groove is essential for the part to function properly.

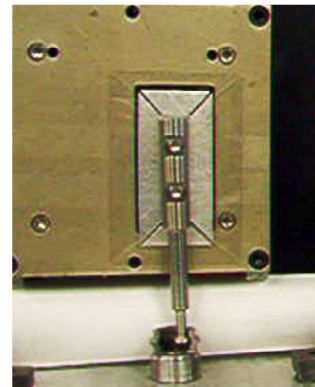
PROBLEMS:

1. Improper positioning of the component's groove could cause faulty seating of the hose that connects between the bag and the piece SMAC was gauging.

2. groove was not cut deep enough: This could cause the piece on the end of the hose that snaps into the groove to not be seated in deep enough, and could cause it to come detached during deployment of the airbag, thus losing the pressure do to a leak or rupture type condition. In return the airbag may not deploy at all or deploy but not do much for the driver, due to the loose of pressure.

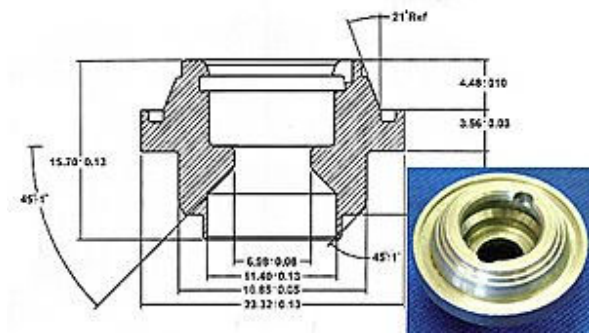
3. Or the groove was missing completely.

Initially 40 to 50 people were hand sorting these parts and still missing bad ones. Meetings that were logistically difficult to organize and time consuming were held in order to solve those problems, but without much improvement on the situation.



SMAC solution:

Originally conducted by human hand, the inspection and sorting of the airbag components is now conducted by a fully automated SMAC actuator system that measures and tests the parts within the production cycle. The quality check requires a total of nine independent gauging, two checks externally on the component and seven checks internally within the part. The cycle time from start to finish for each component is 1.2 seconds. It runs 24/7 and enables 100% data feedback and verification of each individual test with each individual part.



Key Operational Details

The Groove data was the primary concern.

- Groove Location
- Groove Depth
- Groove Diameter

Additional QC checks with an LXY15

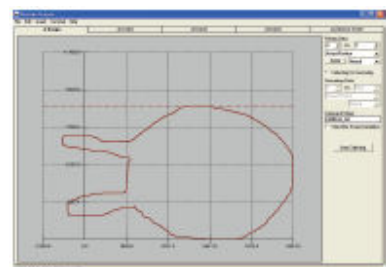
- Flatness of Face
- Bore Depth
- Bore Diameter
- Bore Surface Finish

Proof 4: 3D Gluing System

Duplication of an existing XYZ system for injecting a compound onto a speaker diaphragm with SMAC actuators. SMAC also used a Galil multiple axis motion controller with linear interpolation feature that allows for constant speed move while following the XYZ contour.

Implementation:

Eduardo Pelayo (SMAC Mexico) and Jim Huang (SMAC Taiwan) worked with SMC Mexico to develop a 3-dimensional gluing system, for one of the top speaker manufacturers in the world to replace an Asymtek machine. All three axes, each of them with a 50mm stroke, work together, “drawing” the outline of a speaker system to check the correct size and position that are required for the speaker. While the X-axis with an LAS300-050 and the Y-axis with an LAS95-050 moved the actuator with a 2-dimensional motion profile, the Z-axis completed drawing the outline. A pen marker attached to the Z axis will collect the data about the shape of the speaker part.



Trace Result

SMAC simulated the component’s slightly differing shapes with the help of an especially for SMAC designed Galil controller which provided the data for



all axes to trace the low speaker marked by ink (see graphics) on the surface. The Galil has a multi dimensional contouring feature that can be used to trace the path needed - very quickly - then have it programmed. SMAC uses different encoder resolutions in XYZ's and Galil has made a SMAC only modification to accommodate this.



GALIL AXIS MULTI CONTROLLER (specially designed for SMAC by Galil)
New controllers including a special from Galil 4 + 8 Axes that will serve as a basis for QC devices. It's a German CAN bus capable controller for Europe.

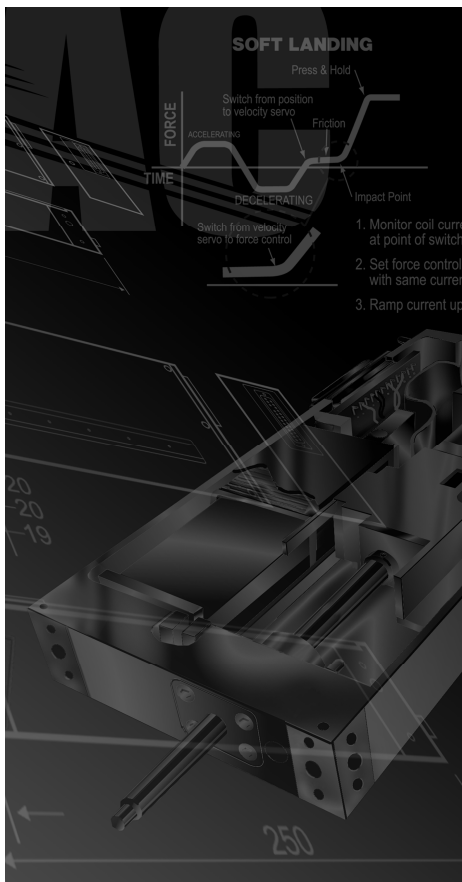
Uniqueness of SMAC actuators

- *SMAC PATENTED "SOFT-LAND" TECHNOLOGY*
- *MOVING COIL TECHNOLOGY*
- *VERY HIGH ACCURACY & REPEATABILITY*
- *100% ZERO-DEFECT PARTS*
- *100% PRECISION & VERIFICATION*
- *100% PROGRAMMABILITY OF FORCE, POSITION & VELOCITY WITH ALL AXES*
- *100% DATA COLLECTION & FEEDBACK*
- *NO BACKLASH*
- *LOW HYSTERESIS*
- *MULTI-FUNCTIONALITY IN VARIOUS INDUSTRIES*
- *STANDARD IP50 RATING*
- *INNOVATIVE DESIGNS FOR SHOP FLOOR ENVIRONMENTS*
- *ECONOMICAL & EFFICIENT*
- *LONG LIFE ENDURANCE THROUGH DIRECT DRIVES*
- *USER FRIENDLY MOUNTING OPTIONS*
- *CUSTOM-MADE MODIFICATIONS AVAILABLE*

POTENTIALS of SMAC XYZ coordinate verification machines:

We understand that most parts have a number of sides that must be checked during the production cycle. This process has to be conducted within the manufacture cycle time. The SMAC XYZ system has the potential to perform these checks very fast, but also simultaneously on each side of the part in question. Customers will gain more accuracy and efficiency in time and costs.

SMAC has systems with up to 32 axes in mind.



SMAC Inc. is the world leader in Moving Coil Actuators and associated control systems. With headquarters in Carlsbad, California, SMAC delivers high tech solutions to industries with linear & rotary Moving Coil Actuators, positioning stages and electronic control.

The SMAC Corporation designs and manufactures advanced electric actuators. All SMAC actuators are quality products specifically designed and built for long service. Therefore, all actuators are guaranteed for a period of twelve months from the original date of shipment from our factory.

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