Matthew Moeser, Stratasys Test Operator ready to do multiple dogbone tests with the AutoMeasure

Accurate industrial testing machine printed from SAF™ PA12

Testing the quality of parts produced from a new material such as SAF™ PA12 is an arduous process in that numerous tests need to be completed taking up many hours in manually taking measurements, loading samples and testing. To free up an operator's time to focus on more important tasks, Stratasys' engineers developed an automatic measuring machine, 3D printed from the very material it was tasked with testing at the time: SAF™ PA12.

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It was straightforward to design the AutoMeasure, as the H350 allowed me to create different iterations quickly, the parts always came out on spec, and I was easily able to DfAM because of the consistency of accuracy throughout the build volume."

Nyall Davis

Industrial 3D Printing QA Technician

Case Study

The Challenge

The process of bringing new materials to market for the H350™ involves consistently monitoring and measuring the quality of parts. The mechanical quality and consistency of the parts is assessed using uniaxial tensile testing of dogbone samples.

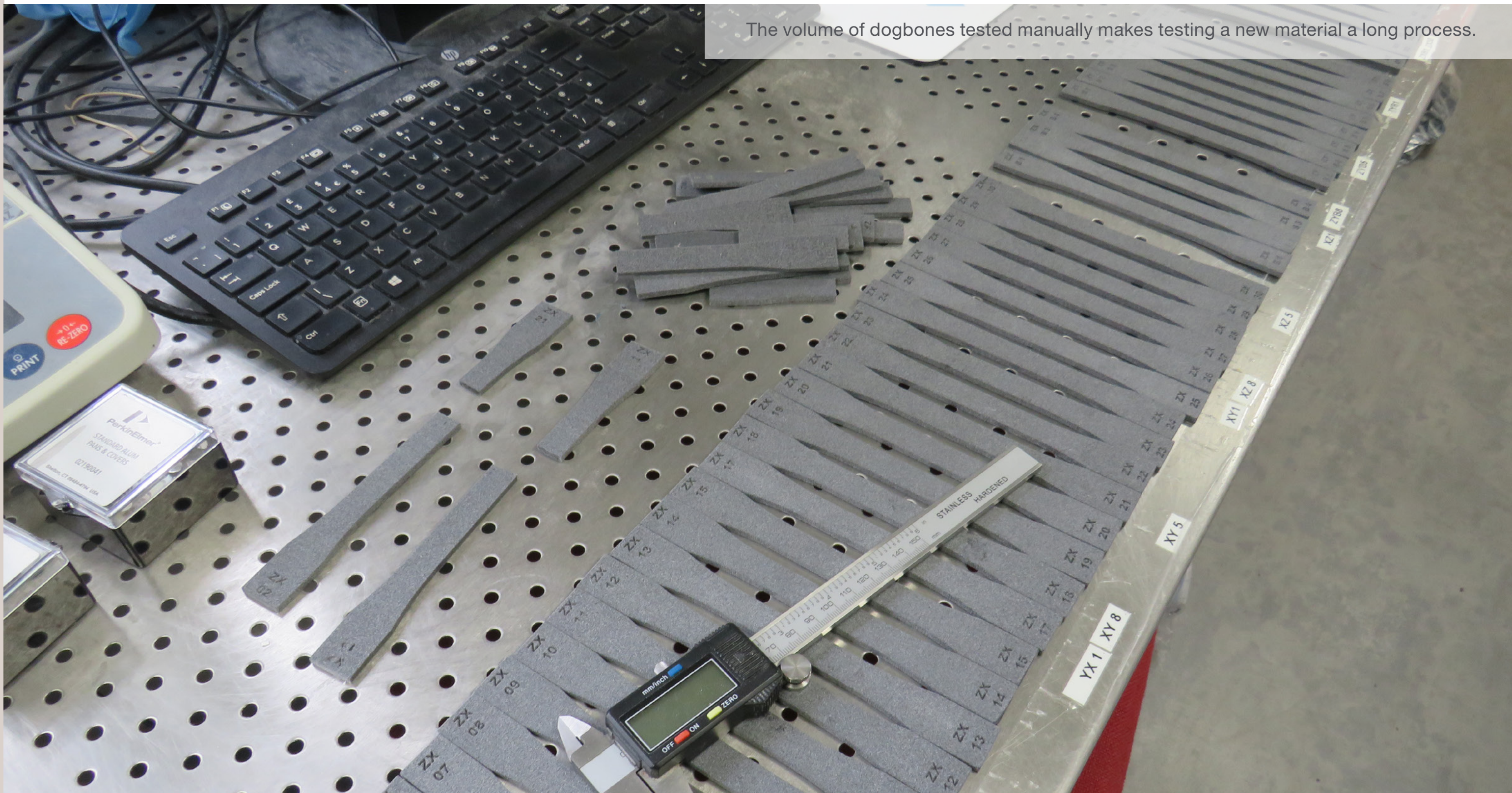
A uniaxial tensile test involves recording the force it takes to pull the test dogbones apart. This simple test yields a lot of information on the material. Tests include Young's modulus, yield stress, ultimate tensile strength and elongation at break which help track how well the material is fused. Monitoring changes in these properties across a build, between builds and between machines helps form a picture of machine and material consistency.

Sheer volume of tests puts operators under time pressure

Performing a single tensile test on a dogbone is fairly quick and easy. First the cross-sectional area is measured to ensure that results are accurate, the sample is then loaded into the tensile tester, pulled at a pre-determined rate until failure, and unloaded.

However, when you need to test 30 tensile dogbones in a single test build, with up to 10 machines working on a single material at a time, 2700 dogbones are produced and tested in a single month. This schedule is punishing and it's hard to keep pace with testing milestones which are critical to provide the R&D teams with the data they need to direct development efforts.

The solution was to create an automatic dogbone measuring machine. A machine able to take a full test build's of dogbones (30), take 3 repeat measurements of width and thickness of each and input these values into the tensile testing software.



The volume of dogbones tested manually makes testing a new material a long process.

The **Solution**

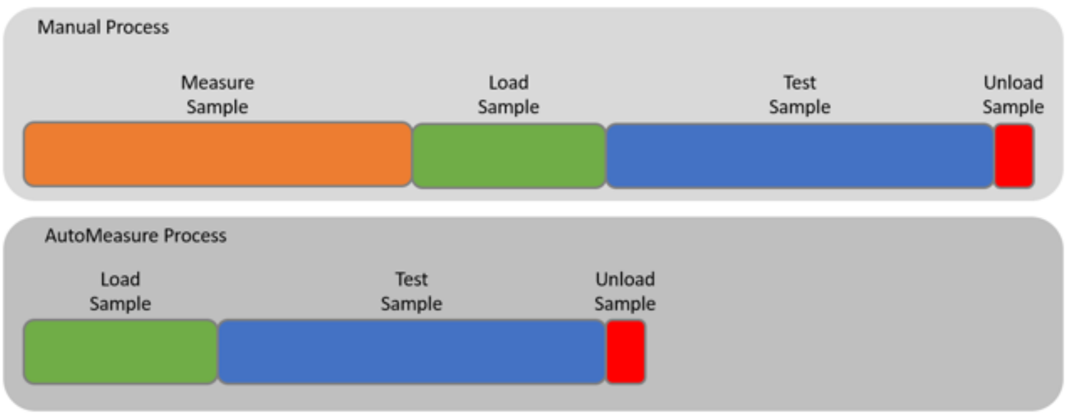
Dubbed the AutoMeasure, the machine fully automates the process and removes the need for operator intervention in the measuring process. When operated manually using calipers, the process takes 30 seconds per dogbone, 15 minutes per build. The automated process removes this time and frees it up for the operator to work on other, more interesting or involved tasks instead. This leads to ~287 hours of operator time saved per year with no changes to safety or data critical parts of the process.

To increase throughput, without putting undue pressure on the operator, the time required for some, or all, of these steps needed to be reduced.

Each step of the tensile testing procedure is indicated below, broken into the required steps and how long each takes.

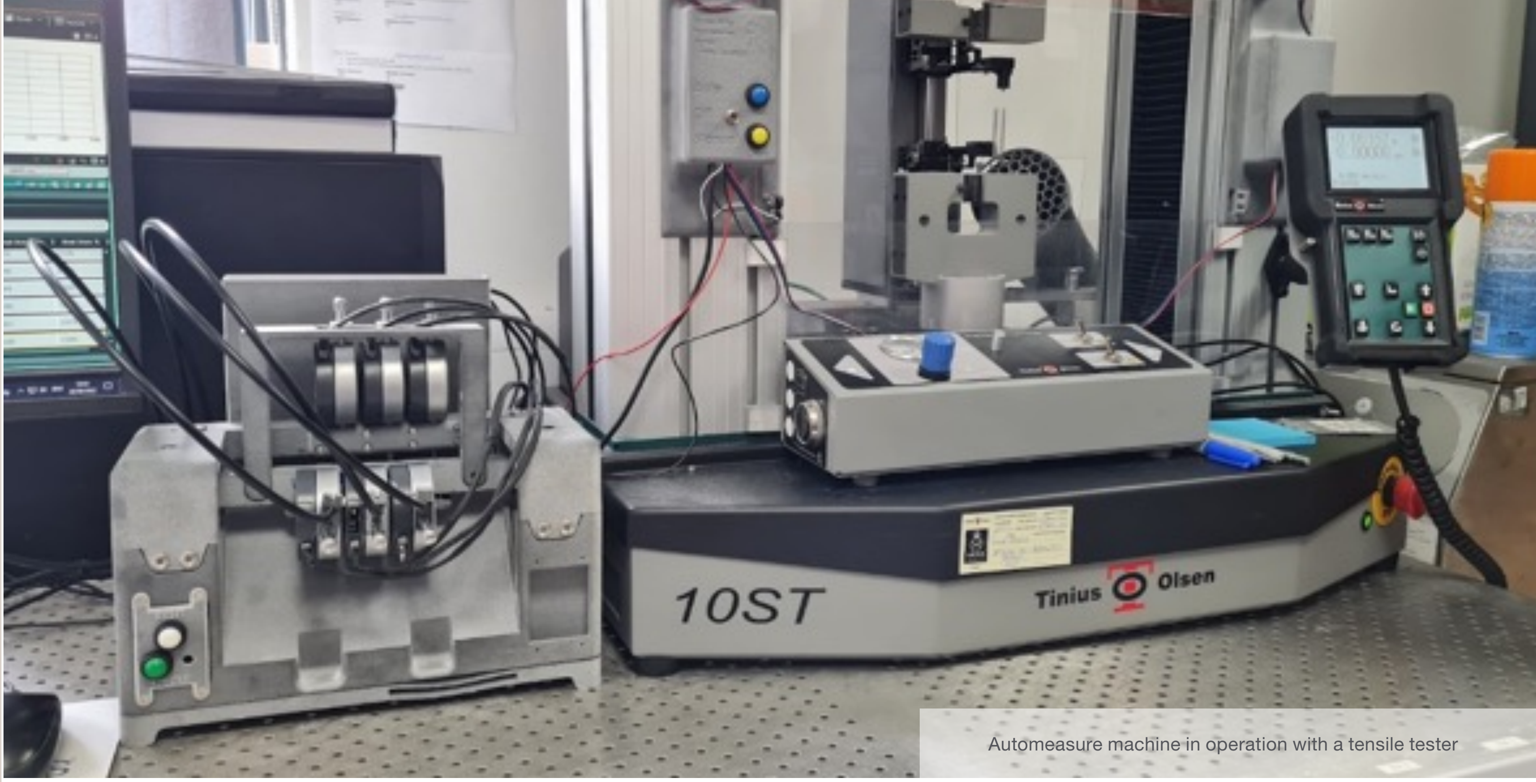
Considerations in finding a solution to cutting down the time taken in the testing process included:

- Loading and unloading the samples needed to be done safely and accurately.
- The minimum sample test time is dictated by standard practices. Increasing the number of test machines would be the only way to increase throughout, requiring significant capital and operational investment as well as long lead times for equipment.
- Measuring the cross-sectional area of the sample is performed manually, with vernier calipers, and 3 repeats. Cutting out the measurement process altogether or reducing the number of repeat measurements would reduce the quality of the testing and data.



An additional benefit of the AutoMeasure is an improvement in repreatability of measurements. Removing the variation of different operators removes the chances for differences in technique influencing measurement results.

The AutoMeasure reduces the process time and costs, delivers more data to steer R&D more quicky, improves measurement accuracy and frees operator time to perform other tasks.



Automeasure machine in operation with a tensile tester

High-quality H350 parts form the backbone of a high-volume testing machine

Industrial 3D printing QA technician Nyall David is the brainchild behind the AutoMeasure, which features 13 printed components, all of which are manufactured on the H350 using SAF™ PA12. The SAF printed components make up the entire structure of the AutoMeasure as well as a number of functional mechanical parts. These parts are designed specifically for manufacture with the H350 and take advantage of the high nesting capability of the machine. All 13 parts can be densely nested into a build slightly less than half of full Z height. This enables the build to complete in 5 hours, or alternatively for 2 AutoMeasure's worth of components to be built in a single build.

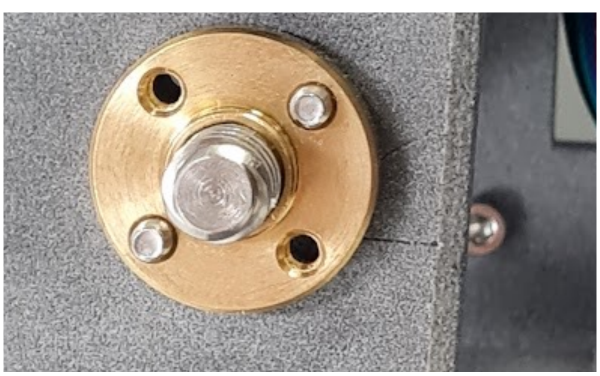
SAF technology engineers agree that without the H350 and SAF™ technology, the AutoMeasure could not have been developed. The following characteristics of the material allowed the machine to fulfil its intended purpose to perfection:

- SAF™ PA12 is an ideal choice for industrial machine components which require high accuracy. To function correctly, accurate parts are required for external parts such as bearings and screws to mount correctly so the parts sit as intended. The chassis comprises 2 large pieces which must assemble with screws holes located accurately so the chassis can be put together correctly.
- It allows quick turnaround of functional end use parts and the design freedom allowed by rapid design iterations and reduced development time. The high nesting capability of the SAF process was a further improvement, facilitating a print of all components in 5 hours (+24 hour cooldown), simply not possible with other 3D print processes.
- The accuracy of SAF™ PA12 allows for higher tolerance features such as bearing seats and adjustment screw holes to be printed directly into the part with no need for additional, post manufacture processes.

Further benefits of manufacturing with SAF™ PA12 using SAF technology

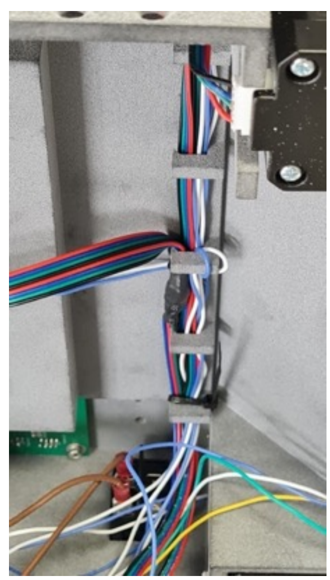
Track for adjustment screws. Working with M3 screws this track is very small and requires the high accuracy of SAF™ PA12 to operate in a linear and smooth manner.

Press fit bearing seat printed directly into the part for a lead screw. For bearings to be fit, these require a high level of accuracy delivered by SAF™ PA12.

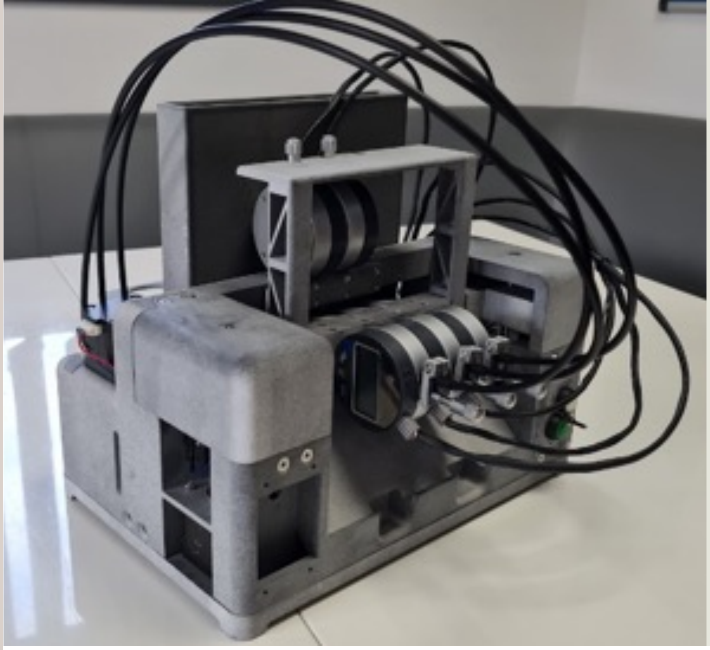


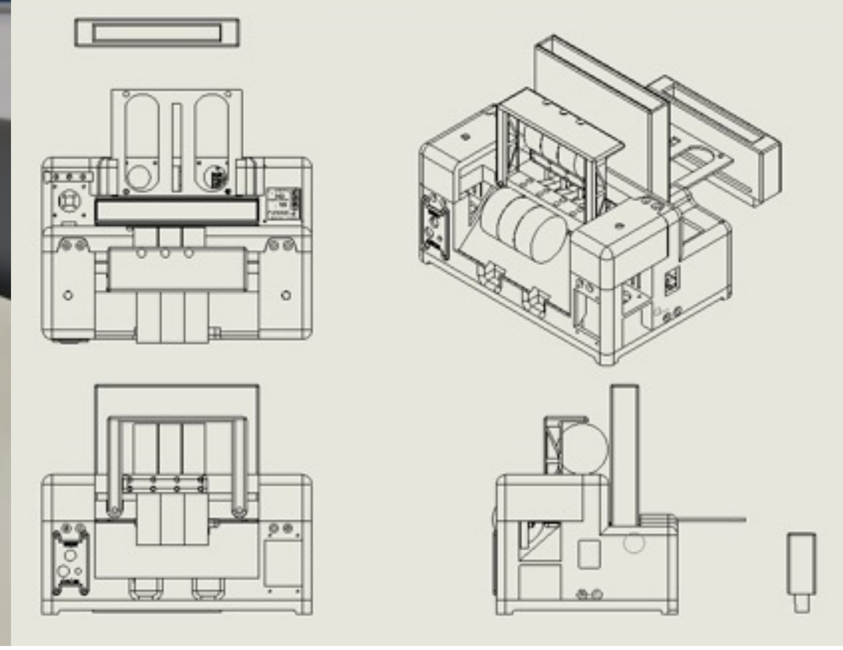
Lead screw nut bolt holes printed directly into the part. Slight misalignment of this part could cause issues in the operation of the lead screw, accuracy is critical making SAF™ PA12 the ideal material.

The fine feature resolution possible with the H350 and SAF™ PA12 allows for labels to be printed directly onto the part for clearly displaying the functions of buttons.



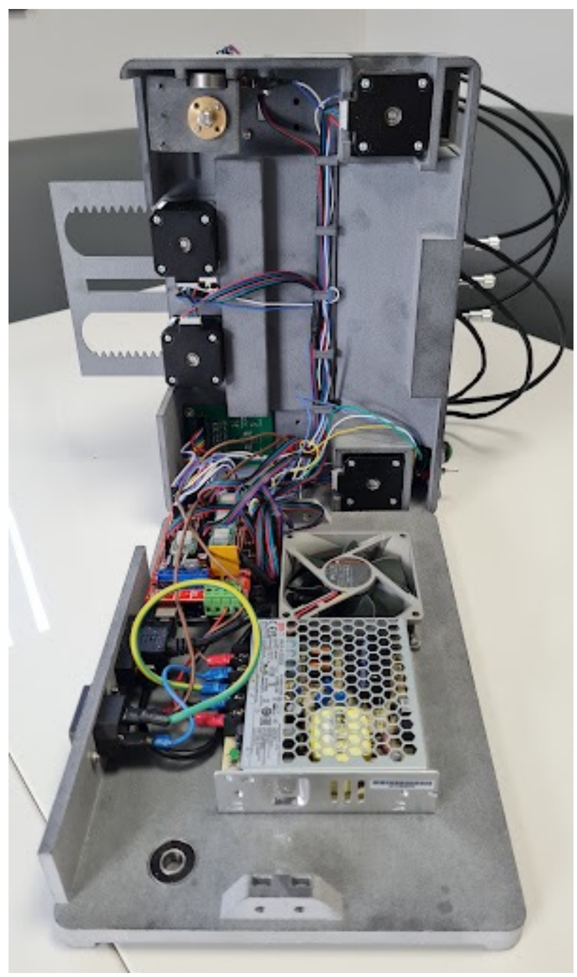
Design freedom of H350 and SAF technology allows for cable management to be printed directly onto the chassis, requiring no assembly after printing. Any modifications to the design in future can be made quickly and parts reprinted.





Operation and Design

The AutoMeasure is divided into several sections:



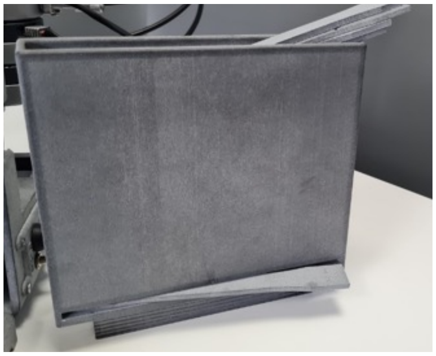
Chassis

The chassis of the AutoMeasure features mounting and bolt holes for assembly of components, cable management hooks and channels, press fit bearing seats and cooling vents for airflow and fans. The chassis also provides stiffness to ensure that measurements are accurate.

It is critical that the flat structural parts of the chassis, specifically the DTI gantry are accurate and free from warp, which does not present a problem for SAF™ PA12. Design freedom also allows weight and material to be removed from this part with no added difficulty in manufacturing.

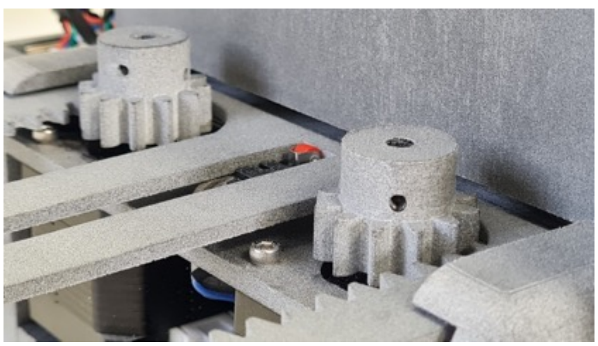
Dogbone storage magazine

Capable of storing 30, standard, ATSM D638, Type I dogbones stacked vertically. These are loaded into the open top of the magazine.



Dogbone feed mechanism

A pusher plate is actuated by a SAF printed rack and pinion system form SAF™ PA12. The mechanism is gravity fed dogbones from the storage magazine which pushes them, one by one, into the measurement bay.

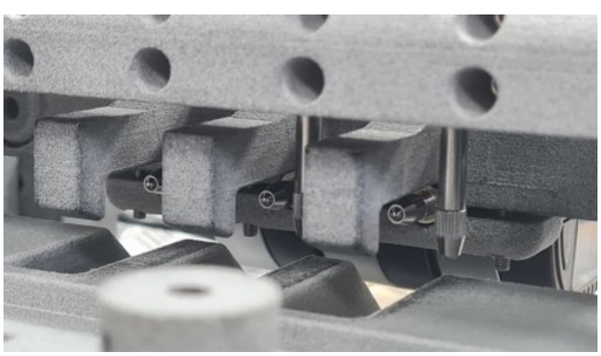


Measurement bay

Accepting a dogbone from the feed mechanism, the measurement bay houses 6 digital dial test indicators (DTIs), 3 for width, 3 for thickness evenly distributed along the gauge section of the dogbone. All 6 measurements are taken simultaneously.

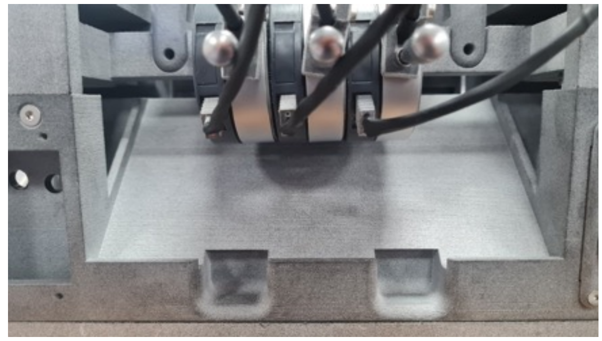
DTI Gantry

DTI gantry assembly printed without warp.

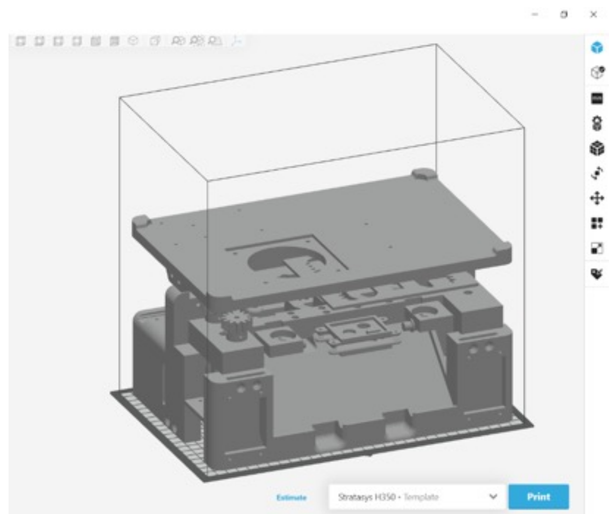


Operator delivery chute

Once the measurement is complete, the dogbone is ejected and fed down the chute for collection by the operator.



The measurements taken from the dogbone are fed instantaneously to the tensile testing software, ready for the dogbone to be pulled.



The printed parts are then assembled with a selection of standard, external, electrical and mechanical components. The control board is then loaded with code, written and developed in-house to produce a fully functional AutoMeasure. In this case, the SAF™ PA12 parts are left natural with no further post-processing, however, finishing options for a commercial product could include vapour smoothing, dyeing, spraying and many others.

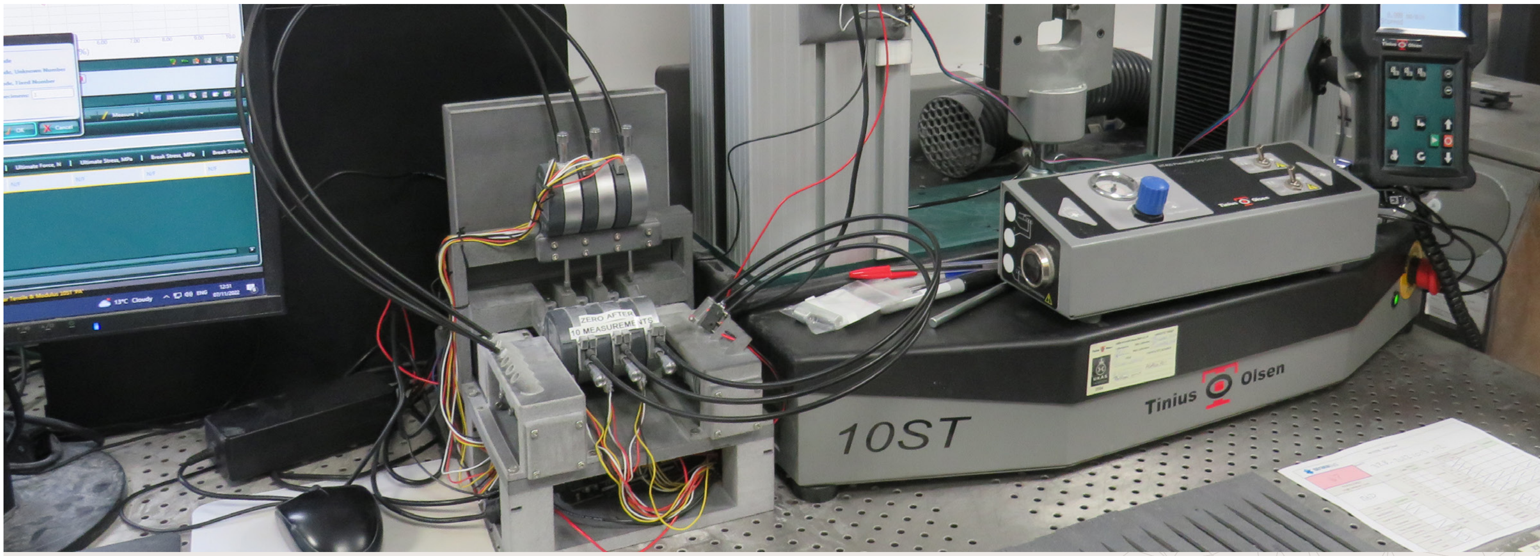
Lower costs and increased productivity with SAF™ PA12

As there are only 2 consumables (HAF and powder) and a simple, agile cooldown procedure, the cost per part with SAF is often lower than other technologies. The total assembled cost of the AutoMeasure was calculated to be $583 including printing and additional components.

The payback period for the AutoMeasure was calculated as 69 days, with an estimated annual saving of ~$4493 in operator time alone. In addition, operators save time to focus on other critical tasks.

Machine to machine consistency of the SAF process allows for this design to be instantly deployed anywhere in the world. The files can be shared electronically and printed with confidence that the resulting parts will be within spec. This means that transport costs and delays are eliminated and the time required to ramp up testing at another facility anywhere in the world is minimal.

As the design is modular and there is no tooling required for manufacture, the design is free to be modified in the future to accommodate testing of dogbones using different standards or other mechanical test pieces such as impact and flexural measurements.



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