How 3D Scanning Technology Can Benefit Refurbishment Projects

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Abstract

Three dimensional scanning technology has become increasingly accurate, portable and user friendly, thus enabling 3D scanning to be applied to many larger scale industrial applications such as refurbishment projects. Through the use of a handheld 3D scanner, there is no limit to the size of the objects that can be scanned, allowing the scanning of large parts such as turbine runners, drive shafts, and machinery foundations. Such benefits of having these scans include: the ability to compare with original tolerances and inspect localised wear of parts for replacement, replacement of complex geometric parts that would otherwise be difficult to measure, as well as the ability of measuring as-built components that may still be in service without the need of additional site visits and machine downtime.

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1 Introduction

Three-dimensional (3D) laser scanning is a modern tool capable of taking any physical object and replicating it digitally as a computer model. 3D laser scanning is an ideal way to measure and inspect contoured surfaces and complex geometries. Laser scanning technology also has the potential to streamline otherwise complex or time-consuming engineering tasks such as quality control, as-built documenting and reverse engineering.

Here at Vortex Group we have invested in laser scanning technology, namely through the use of the Creaform Hanyscan 300, and have applied its use within a number of current projects in the energy sector. The ability to be quickly setup and used on site, along with a multitude of inspection and post processing tools, allows 3D scanning to supplement almost any engineering application, including refurbishment projects.

2 How it Works

The most common 3D scanners on the market work using the same general principle: a laser light is emitted from the scanner onto an object's surface, the light is then reflected and then detected by a sensor. The time it takes for the reflected light to return, and angle of reflected light, can accurately determine the distance between the object and the scanner. Repeating this process thousands of times over an item's surface produces a "point cloud" of data that specific software can take, and within a few minutes, build a complete map of the objects viewable surface in 3D space (LaserDesign, T.M.).

Where 3D scanners differ comes down to the principles of imaging. Pulse-based and phase-shift scanners are able to scan objects 2 – 10 m away and form a complete 360° view around a central point. While this technique is less accurate for small-scale applications, it is suited to situations that require scanning of large and/or distant objects such as as-built surveying of buildings.

Another imaging principle used for 3D scanning is laser triangulation. Laser triangulation scanners use either a laser line or single laser point to scan across an object. This results in an accurate reading (up to 25 microns in some scanners) but the scanner has increasingly limited range with higher resolutions (EMS®, Inc.).

Figure 1: Handyscan 300 in action.

Laser triangulation will be the method referred to in this report, specifically the use of the Creaform Hanyscan 300

(*Figure 1*). This is a portable hand-held scanning device that is accurate up to 0.040 mm at a distance of 300 mm. Benefits of the Creaform Hanyscan 300 scanner include portability, ease of use and ability to scan large surfaces (Creaform).

In order to scan a surface, reflective targets must first be applied to the objects surface, in no particular order, as shown in *Figure 2*. The reflective stickers are detected by the two cameras built into the scanner, and are used as positional references. A positional reference is essential to track the location and orientation of the object, therefore, having many targets allows the scanned object to be repositioned and rotated as needed to fully scan all required surfaces.

As no two configurations of targets are similar, the scanner is able to recognise where on the object it is referencing. If further scanning is needed on the object at a later time, so long as the targets remain in situ, the scanning process can be continued through the application of additional targets.

Figure 2: Pelton wheel covered with reflective targets ready to be scanned.

Creaform has its own software, VXelements, that is used to view the scan in real-time as its created (*Figure 3)*. The software also has many post-processing and inspection features which allow for the retrieval of required dimensions directly from the scan, or the conversion of a scan into a CAD model.

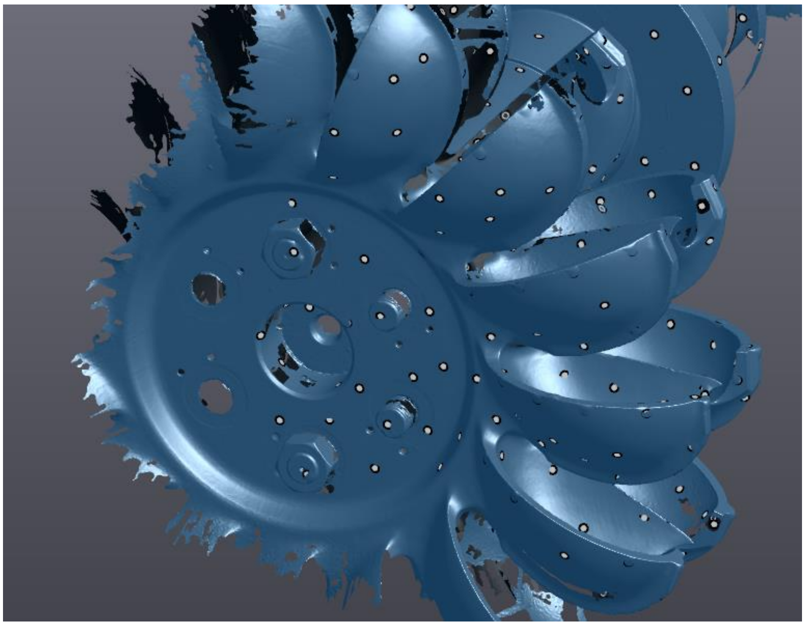

Figure 3: Pelton wheel scan in VX elements.

3 Applications in Engineering

The use of 3D scanning technology in the engineering industry can be a welcome tool to help simplify otherwise complex or time-consuming tasks.

At Vortex Group, we have incorporated this technology to assist with day-to-day tasks and are currently using it to aid with our current refurbishment works. Tasks include dimensioning of as-built plant equipment, inspection of worn or damaged parts in service, and reverse engineering or modification of complex replacement components.

The following sections contain examples of where we have used this technology in the past.

3.1 As-Built Dimensioning

Often critical components are not easily accessible, due to site locality or it is currently being used in service. If critical dimensions are required, a previously produced 3D scan of the component can provide an accurate substitute for any non-intrusive future dimensional inspection. For example, a current refurbishment project required an electric generator replacement that was to use the original mounting foundations. Along with traditional measurements, a 3D scan of the generator bed was taken, as seen in *Figure 4*.

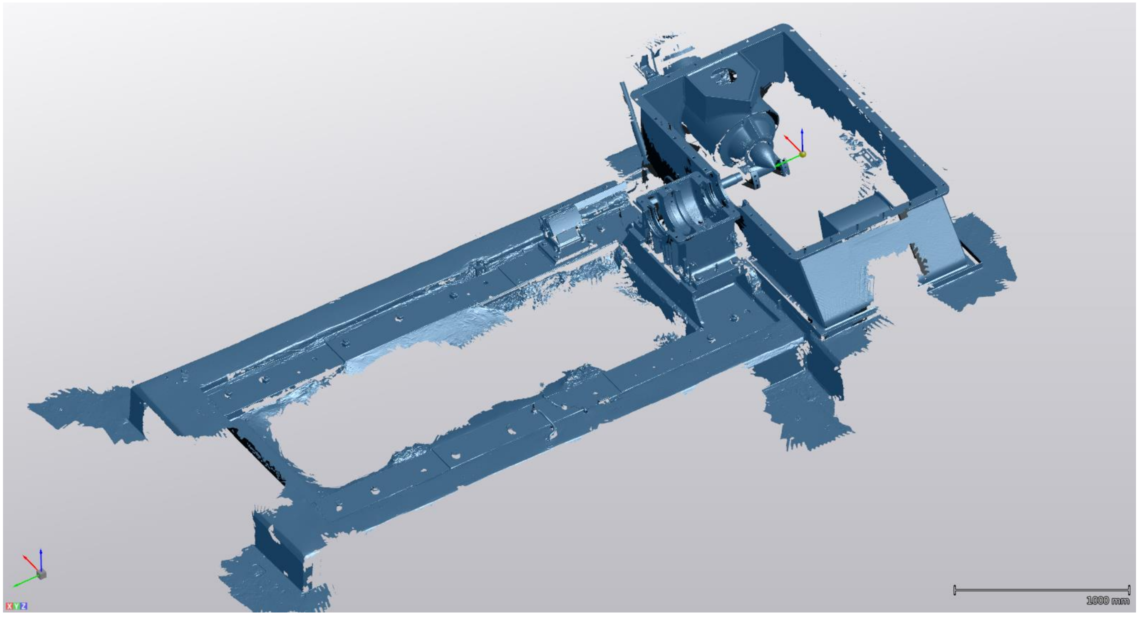

Figure 4: 3D scan of the generator bed with surrounding equipment.

This scan allowed for accurate dimensions to be taken without the need for repeated site visits. Additionally, the scan provided the location relative to the bearing pedestal and turbine lower housing as a reference for later alignment. So long as all the areas of interest are scanned, all information is readily available when needed.

3.2 Tolerance Inspection

A scan was taken of a large spherical bearing housing for a Ø280 mm shaft shown in *Figure 5*. This consisted of four parts: the two top and bottom cast steel outer casings and two halves of the spherical inner unit.

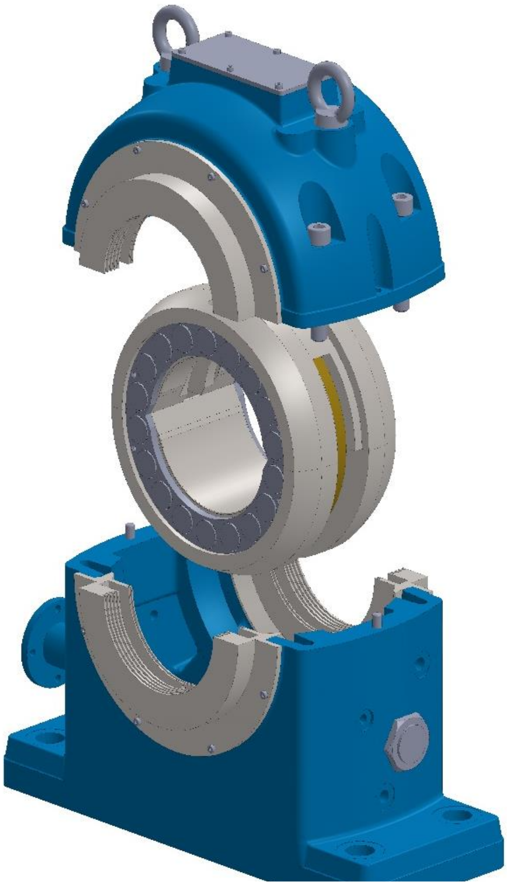

Figure 5: Exploded view of bearing assembly.

The 3D scan of the housing was taken to provide an indication of the level of deterioration the spherical surface had sustained in service. Additionally, the scan allowed for determining whether replacement or repair was necessary. The interface function is for self-alignment of the shaft, which if loose enough to move freely, could cause ceasing of the surface and potential further complications to the operation of the entire system.

Using the 3D scanning software tools available, a colourmap was created over the surfaces for inspection. This colourmap was set to show the recommended transition fit with required allowable clearance for operation. *Figure 6* shows the colourmap for the bottom casing, while *Figure 7* shows the colourmap for the bottom spherical unit.

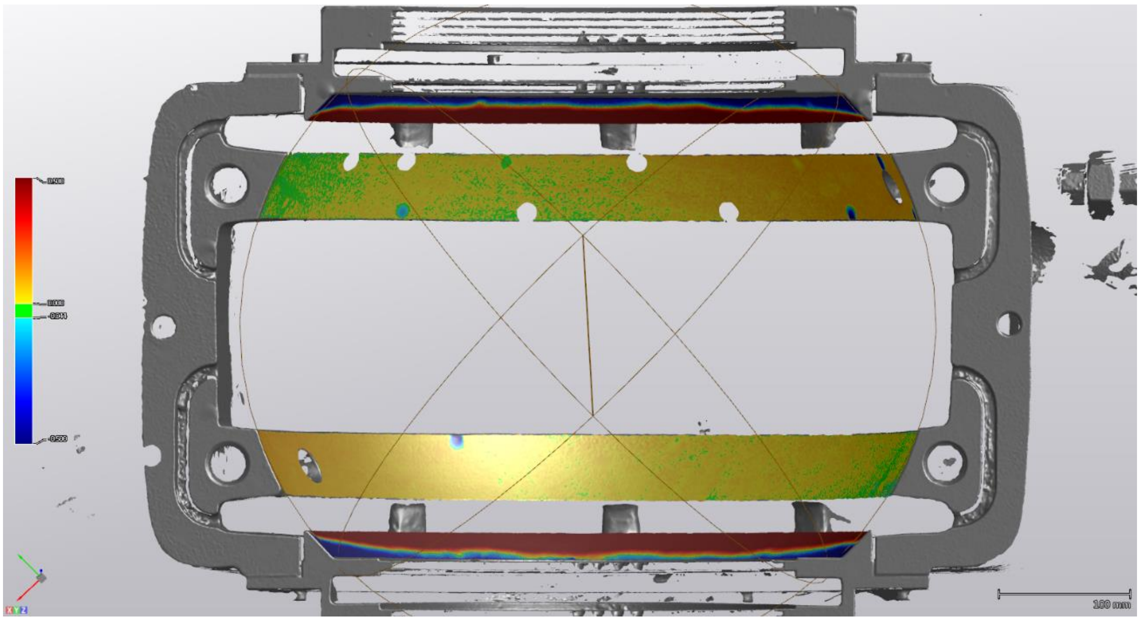

Figure 6: Colourmap of bottom casing spherical face.

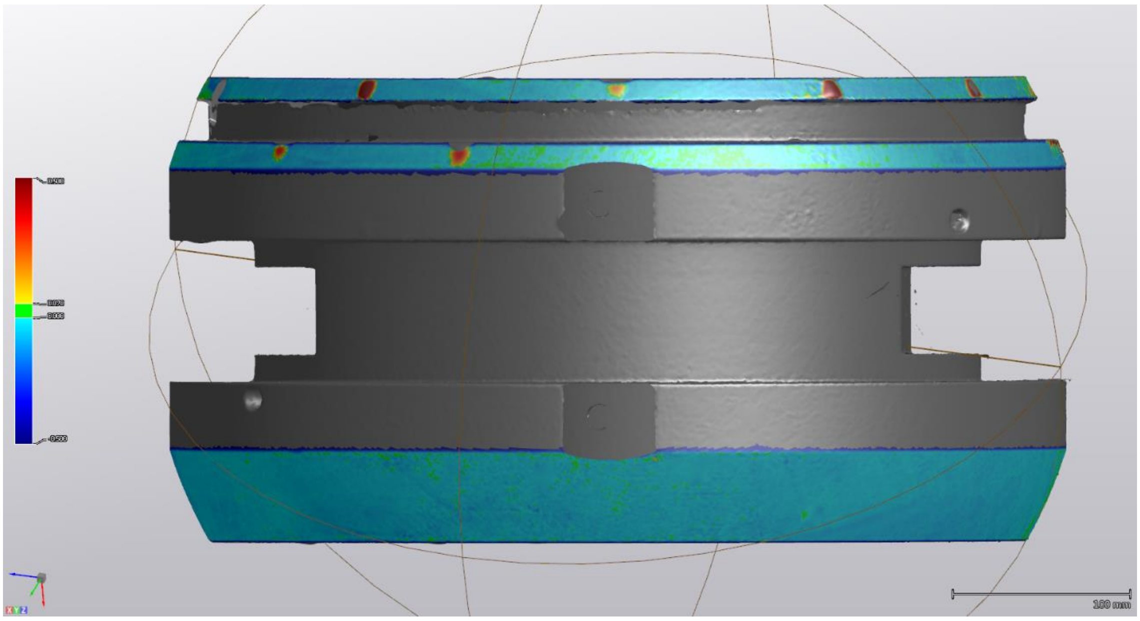

Figure 7: Colourmap of bottom bearing unit spherical face.

In this example, it can be seen that the combination of wear and fretting of the surface of the housing has resulted in it being largely oversized (up to 0.3 mm). Again, for the spherical unit, majority of the surface is undersized from wear and fretting (up to -0.1 mm). Together a maximum of 0.4 mm clearance exists between the two units clearly showing either replacement or repair is needed.

3.3 Reverse Engineering

A series of centrifugal pumps carrying fluid with abrasive solids can cause accelerated wear of the pump impellers, as can be seen in the 3D scan in *Figure 8*. These often require frequent replacement and can prove difficult and expensive to source.

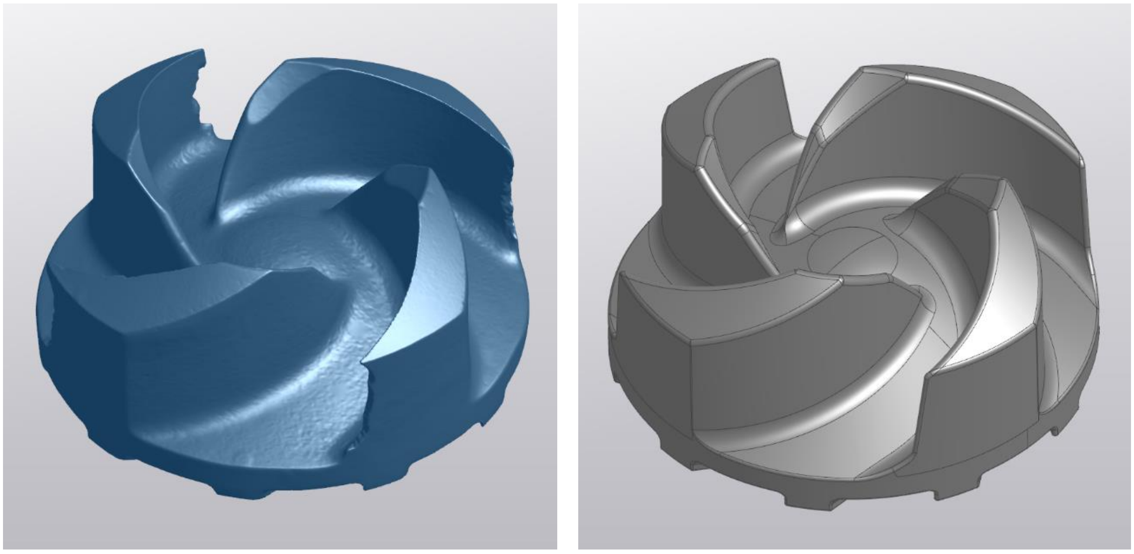

Figure 8: Pump Impeller mesh in current condition(Left) and CAD model of original part (Right).

A 3D scan can be used to create a CAD model which is accurate to the original part. The 3D mesh can then be overlapped with the CAD model as a visual guide to see how the two compare. A colour map is created to show where on the CAD model these two differ, shown in *Figure 9*, which can be set to any required tolerance. This allows areas that require modification to be identified in the CAD model, which can be modified to achieve a required accuracy. The CAD model can be used to create engineering drawings and a machining programs for manufacture of the replacement parts such as the pump impellor mentioned above.

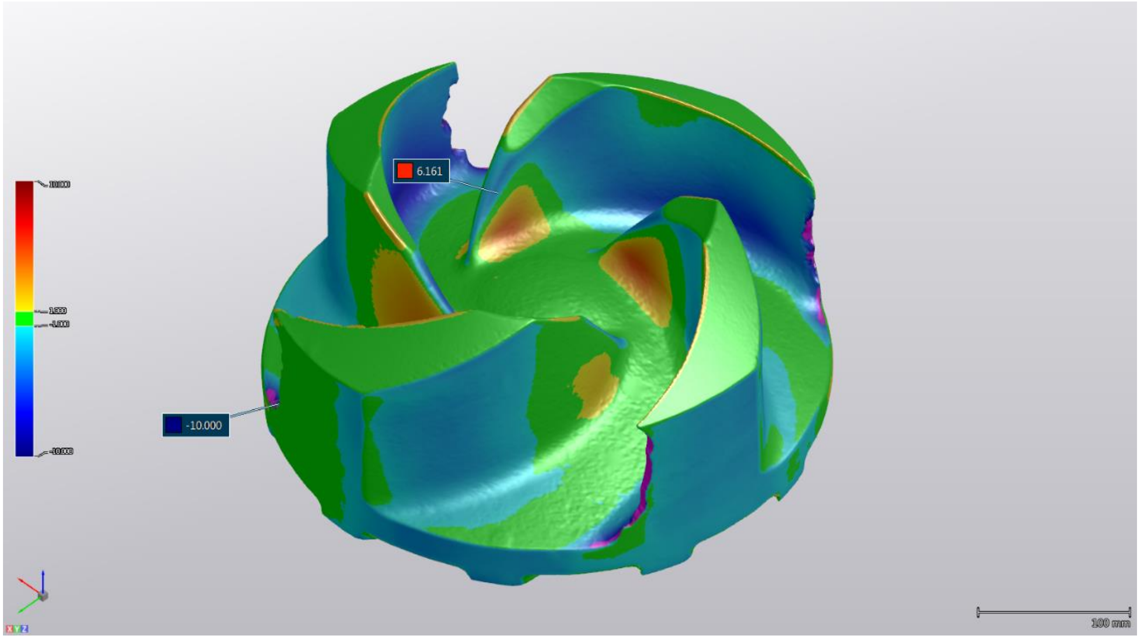

Figure 9: Colourmap of comparison between impellor mesh and CAD model.

3.4 Erosion Inspection of In Service Parts

It may be beneficial to know at what rate a component is eroding, such as in the following case of a gas turbine diaphragm in *Figure 10*Figure 10. To estimate the remaining service life of the component, it was necessary to know the rate at which the internal walls of the gas turbine were wearing-down in service.

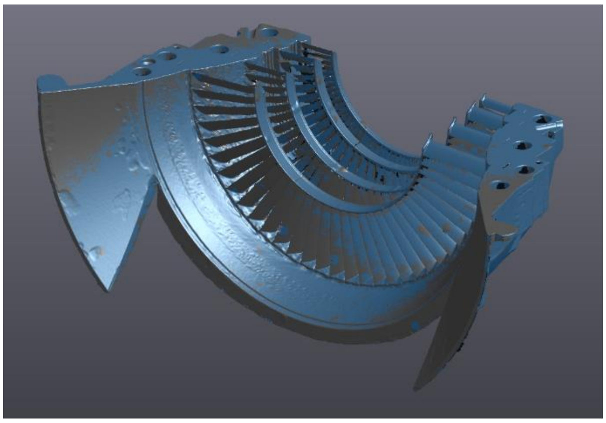

Figure 10: Two aligned scans of a gas turbine diaphragm.

During an annual maintenance shut,
the diaphragm of the gas turbine was removed and an initial scan taken. Twelve months later, the same component was removed again to allow for a secondary scan to be taken. Using the parting face as a reference, the two scans could be overlapped and any discrepancy between the two could be inspected via a colourmap, seen in *Figure 11*.

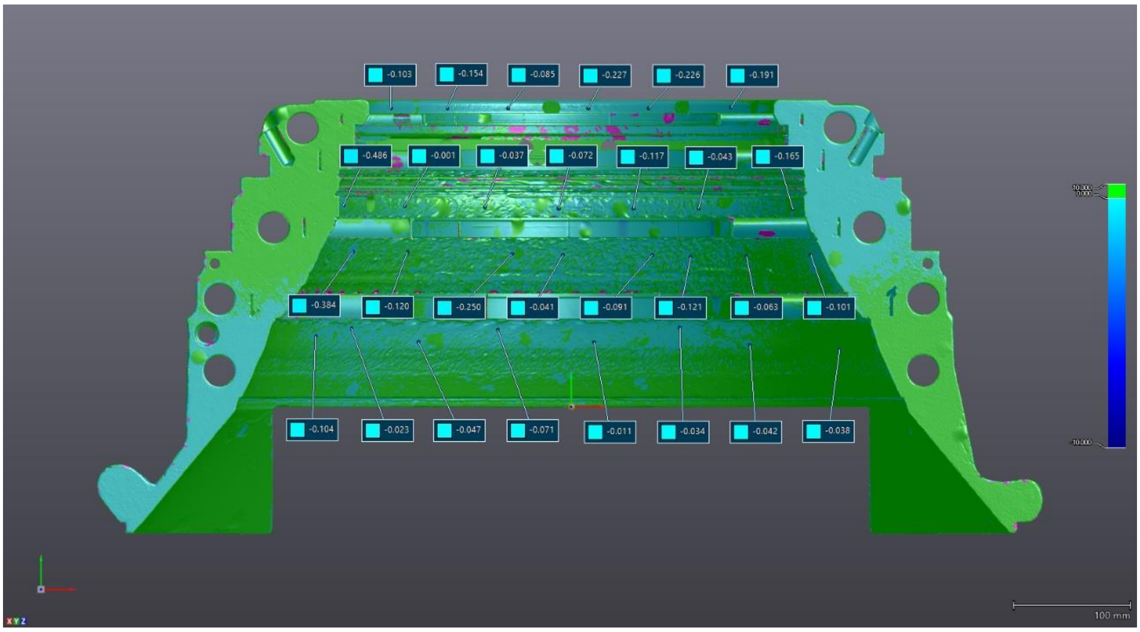

Figure 11: Colourmap of gas turbine diaphragm.

As can be seen from the overall colourmap, the light blue areas show a slight evenly distributed wear up to 0.2 mm on both inlet and outlet side as predicted. Points between the blade carrier sections show more concentrated points of wear up to 0.4 mm, yet the distribution of wear in these sections is smaller compared to the inlet and outlet sides.

4 Conclusion

The addition of 3D scanning technology has presented many possibilities for its use in engineering. 3D scanning has the ability to streamline otherwise difficult or time-consuming tasks with a high level of accuracy, such as as-built dimensioning, quality control inspection and reverse engineering. These skills greatly aid in such tasks as refurbishment projects where new parts must work in unison with existing machinery.

At Vortex Group, we have adopted this technology and use it in many day-to-day tasks. It is a welcome tool that we have available in our workshop and on hand when conducting site visits. We continue to apply this technology to new and specialised applications to work towards obtaining faster, more accurate results.

5 References

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