Performance Prediction of Pump under Age-Related Deterioration using AI Pump, CAESES, and CFX

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Introduction of DMWCorporation

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Background 1

Most of Current infrastructures in Japan was established in 1960s and 70s. They are still used because the budget to renew them is not enough. As a result, they are getting older and older.

Pump performance characteristics are predicted to become lower but we don’t know how performance is. Because a measurement system on site is poor in order to estimate the current pump performance. In addition, it is almost impossible to conduct experimental tests in accordance with a standard, such as Japan Industrial Standard (JIS) B 8327 “Testing methods for performance of pump using model pump”.

Recently, a handy-type 3D scanner having high accuracy is released. So, in order to solve these issued, it is tried to make a workflow using 3D Scanner, AIPump, CAESES, and ANSYS CFX.

Background 2

Quality of casting is sometimes not good. Geometry of a casting product, especially an impeller blade, is different from a design drawing.

In this case, a designer has to decide to re-cast it or to improve it. However, that decision depends on experts knowledge, skill, and experience.

By making a CFD model using a handy-type 3D scanner data, it is possible to predict the pump performance. In addition, by optimizing it by CAESES, it is possible to consider re-casting it or improving it quantitatively. (This is a future work.)

3D Scanner

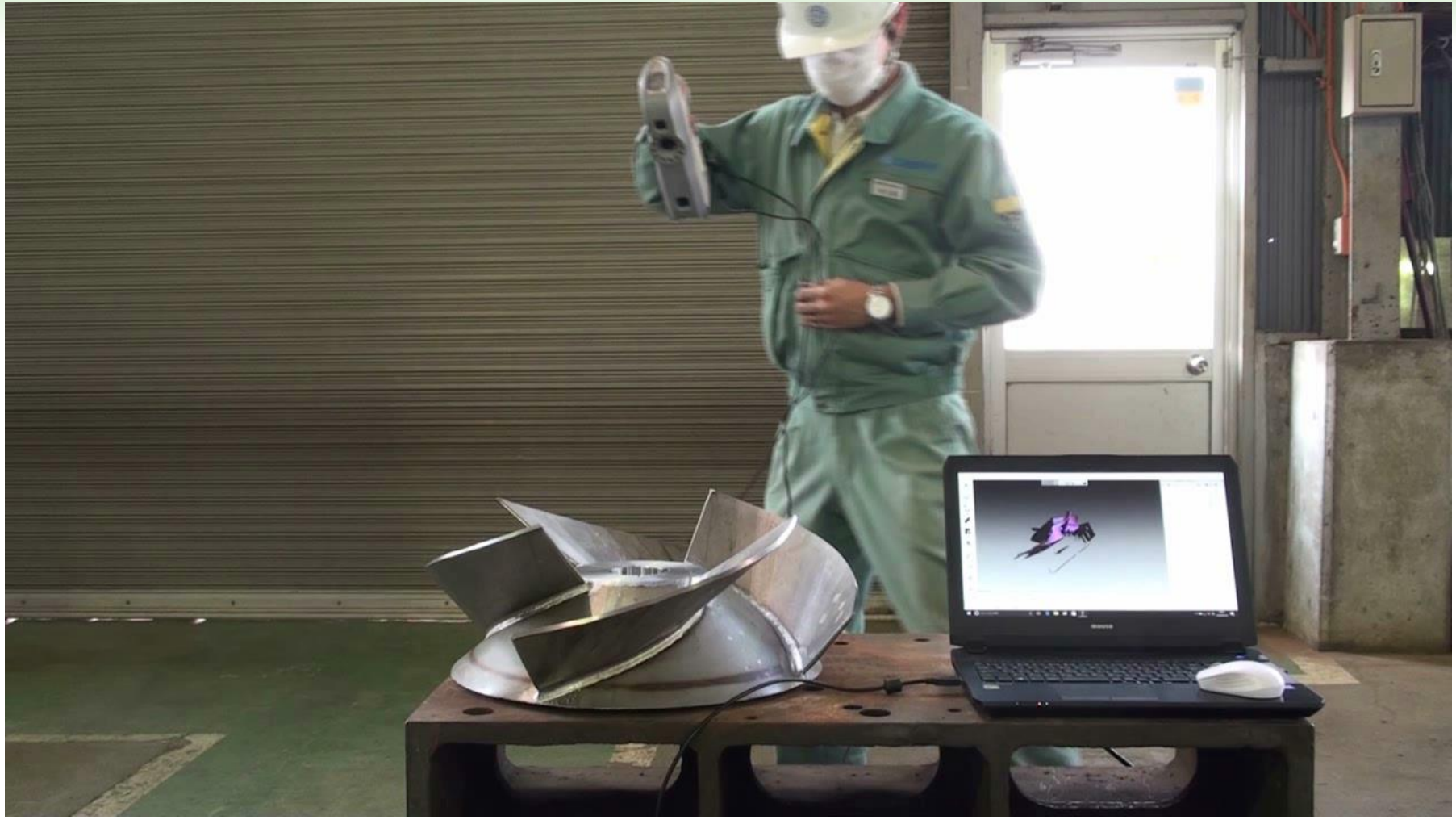
Specifications

3D Accuracy	0.1mm
Working Distance	0.4～1m
Angular field of view, HxW	30 x 21°
Weight	0.85kg
Dimensions, HxDxW	262 x 158 x 63 mm
3D Formats	OBJ, PLY, WRL, STL, AOP, ASCII, Disney PTEX, E57, XYZRGB
Formats for measurements	CSV, DXF, XML

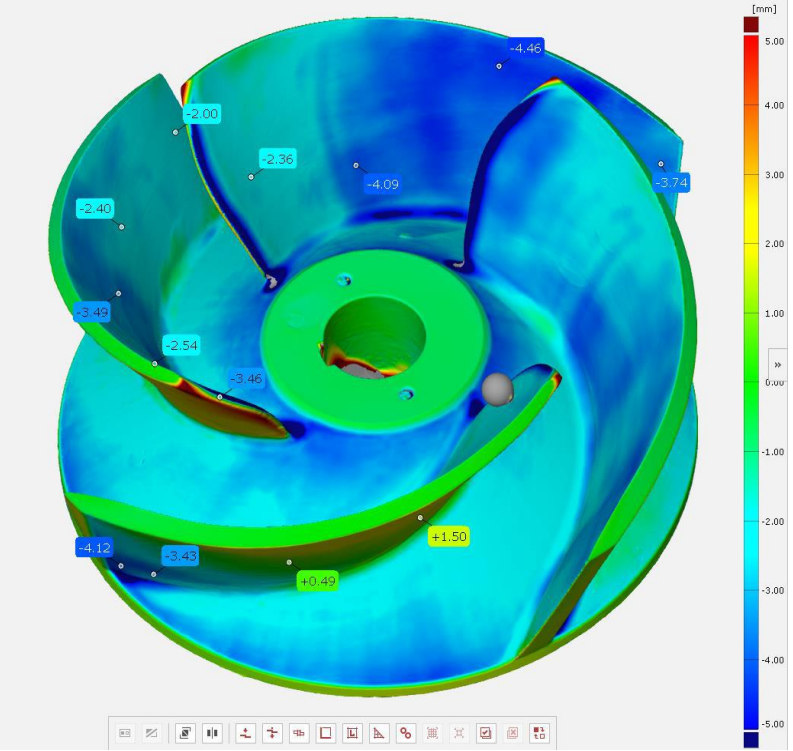
How to connect to ANSYS CFX?
Challenge of this project!

Artec 3D (https://www.artec3d.com/ja)

How to Use 3D Scanner



Data Coming in from 3D Scanner



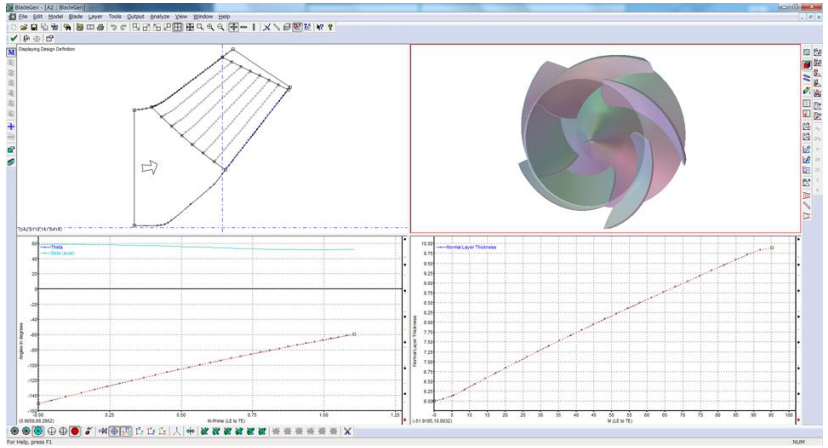
Geometry Data Derived by 3D Scanner

In this approach, it is possible to scan an open-typed impeller. However, it is impossible to scan a close-typed impeller, such as a centrifugal pump impeller, a diffuser vane, and so on.

In this approach, we focus on a rotating open-typed impeller, such as a mixed flow pump, an axial flow pump, and so on.
As shown in the picture on the left, it is possible to compare the geometry obtained by 3D scanning with the geometry of the original 3D CAD data.

Conventional Design Workflow using CFD

Coordinate data → Modeling → Meshing → CFD



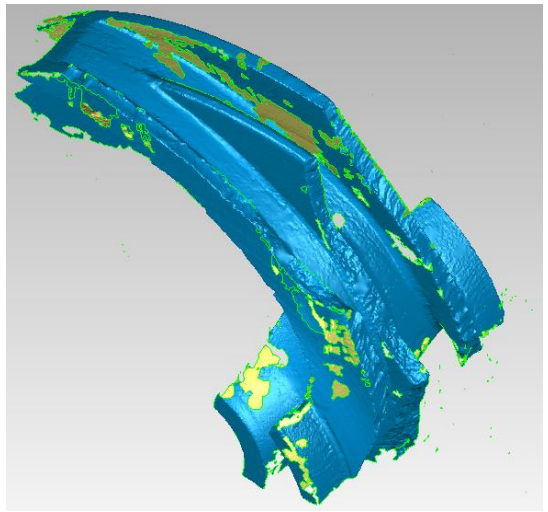
Modeled by CFX Blade Modeler

Meshed by CFX-Mesh

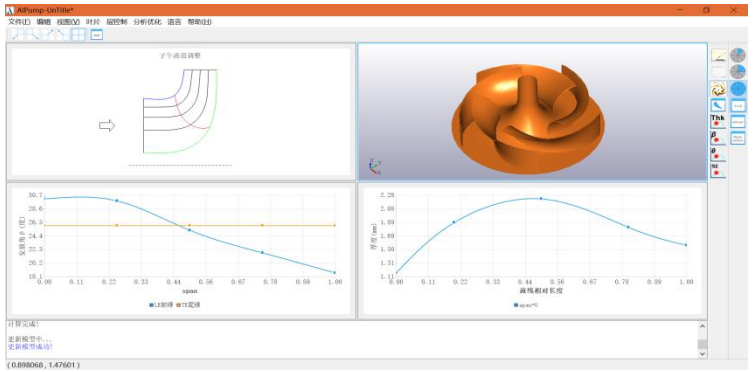
In the case of the conventional design, the coordinate data is formatted with a pattern of ordered arrangement.

Workflow of reverse engineering

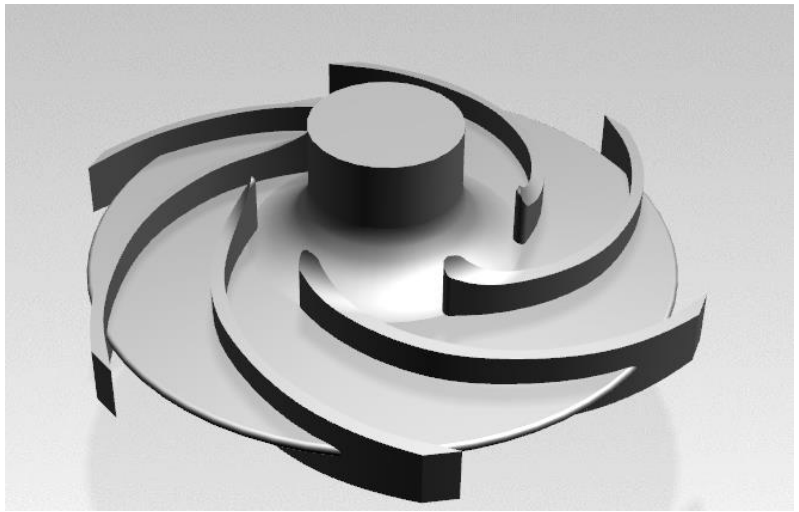
3D Scaning → Data cleansing → Coordinate data → Modeling → Meshing → CFD



3D scanned data



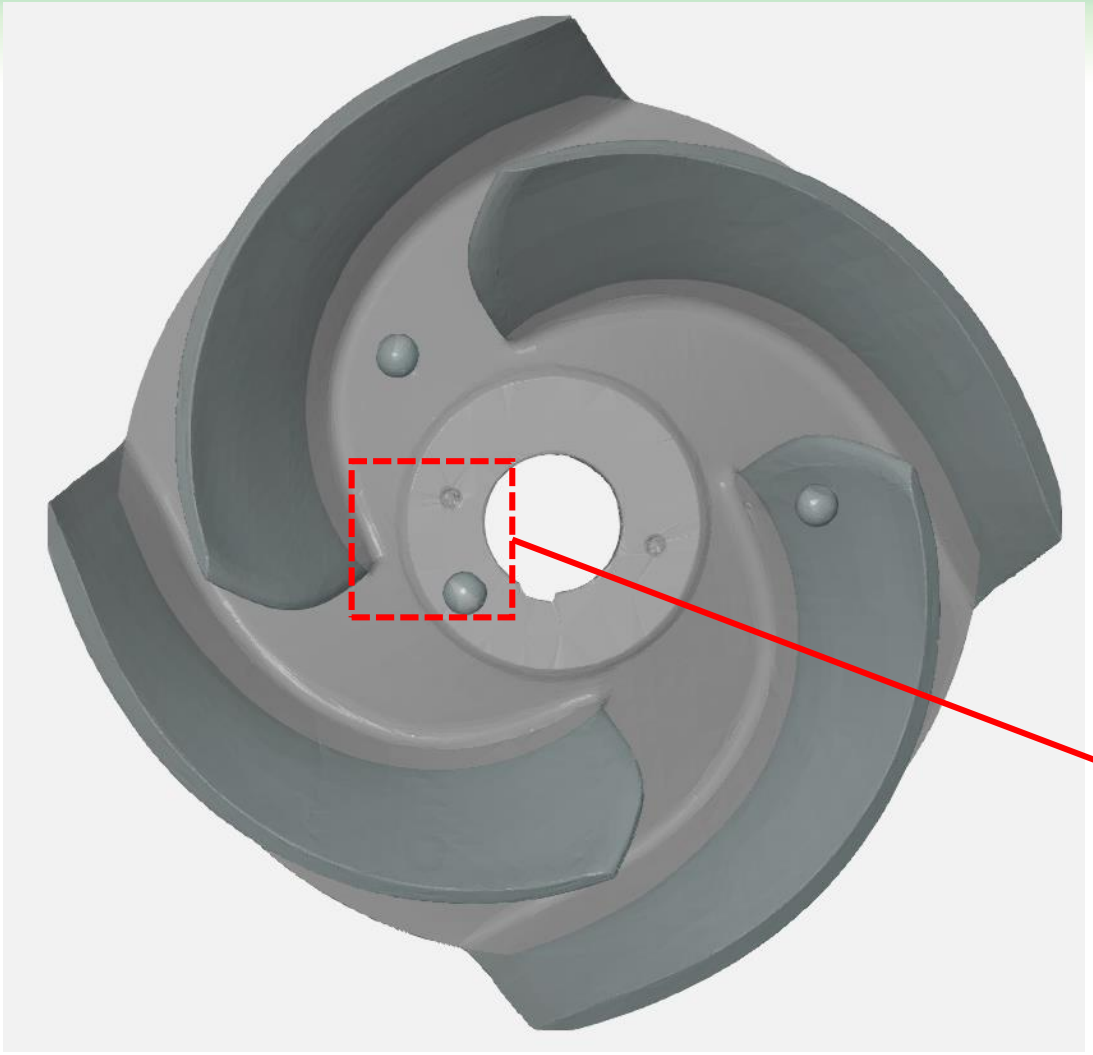
AIPump



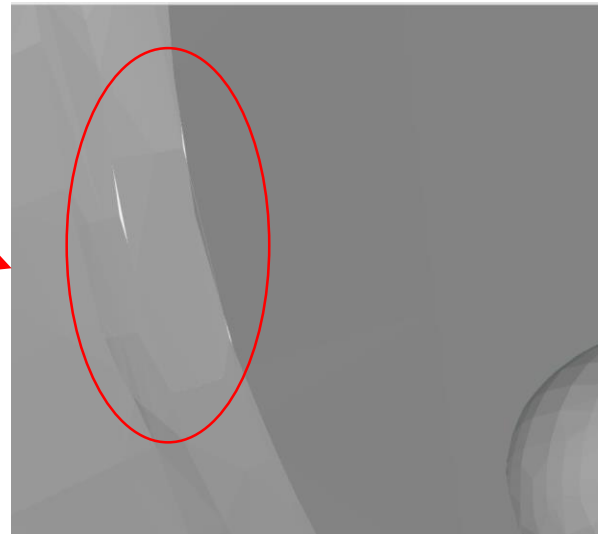
Impeller model

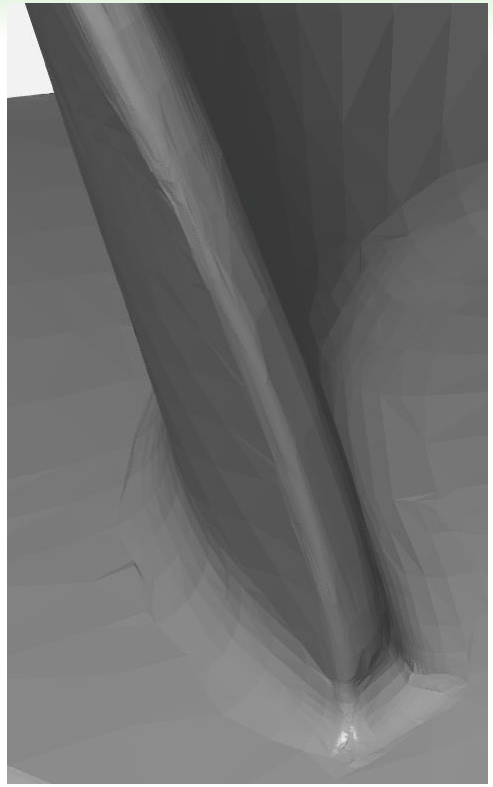
It spends much time to repair a model made by 3D scanned data.

Native Data (stl) of 3D Scanner

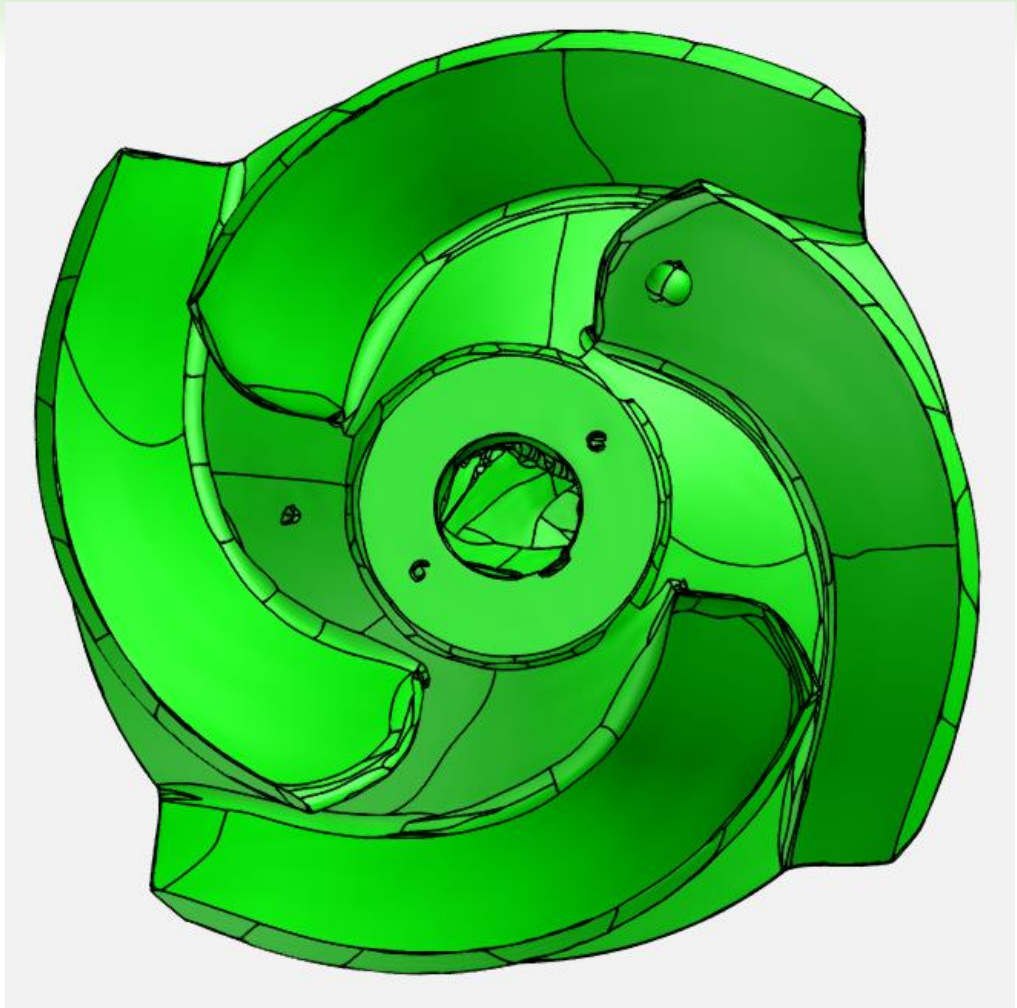


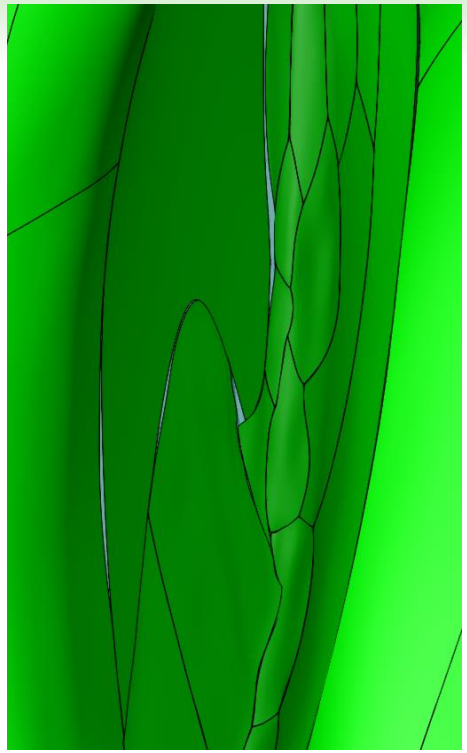
There are many gaps in a model.





Conversion to IGES by Other Model Converter

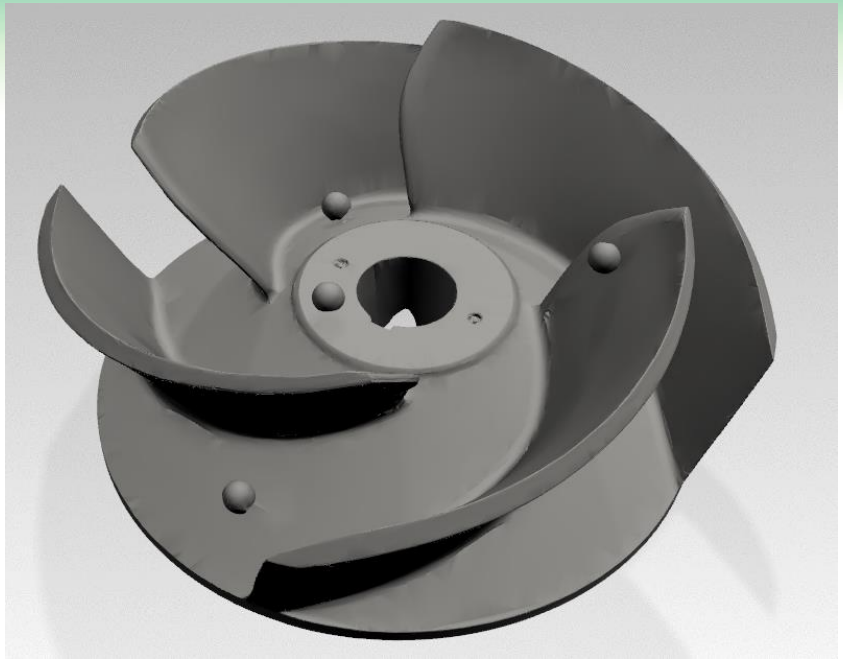




- ✓ Gaps are getting worse.
- ✓ There are many surfaces.

It is very difficult to make a mesh model using a geometry file like this. And it spends much time to repair them.

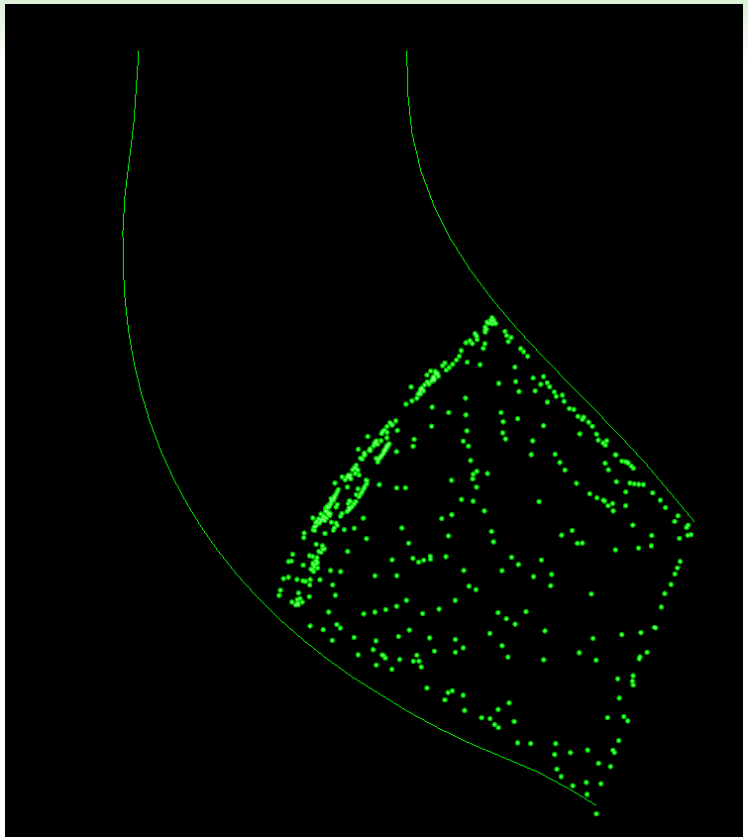
Conversion by AIPump



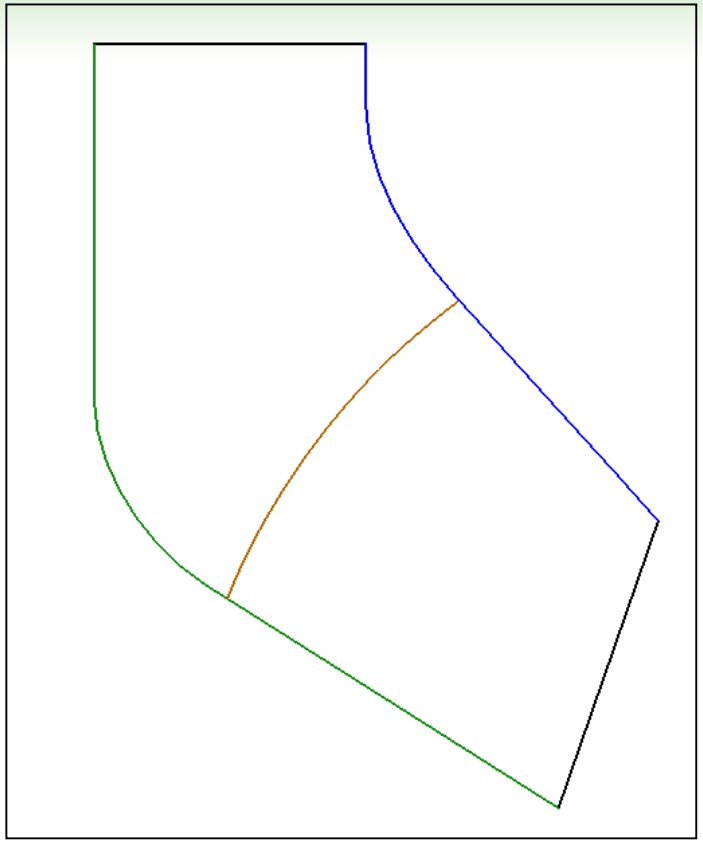
Scanned data of the impeller

- shroud.STL
- hub.STL
- blade.STL

Meridional Flow Passage

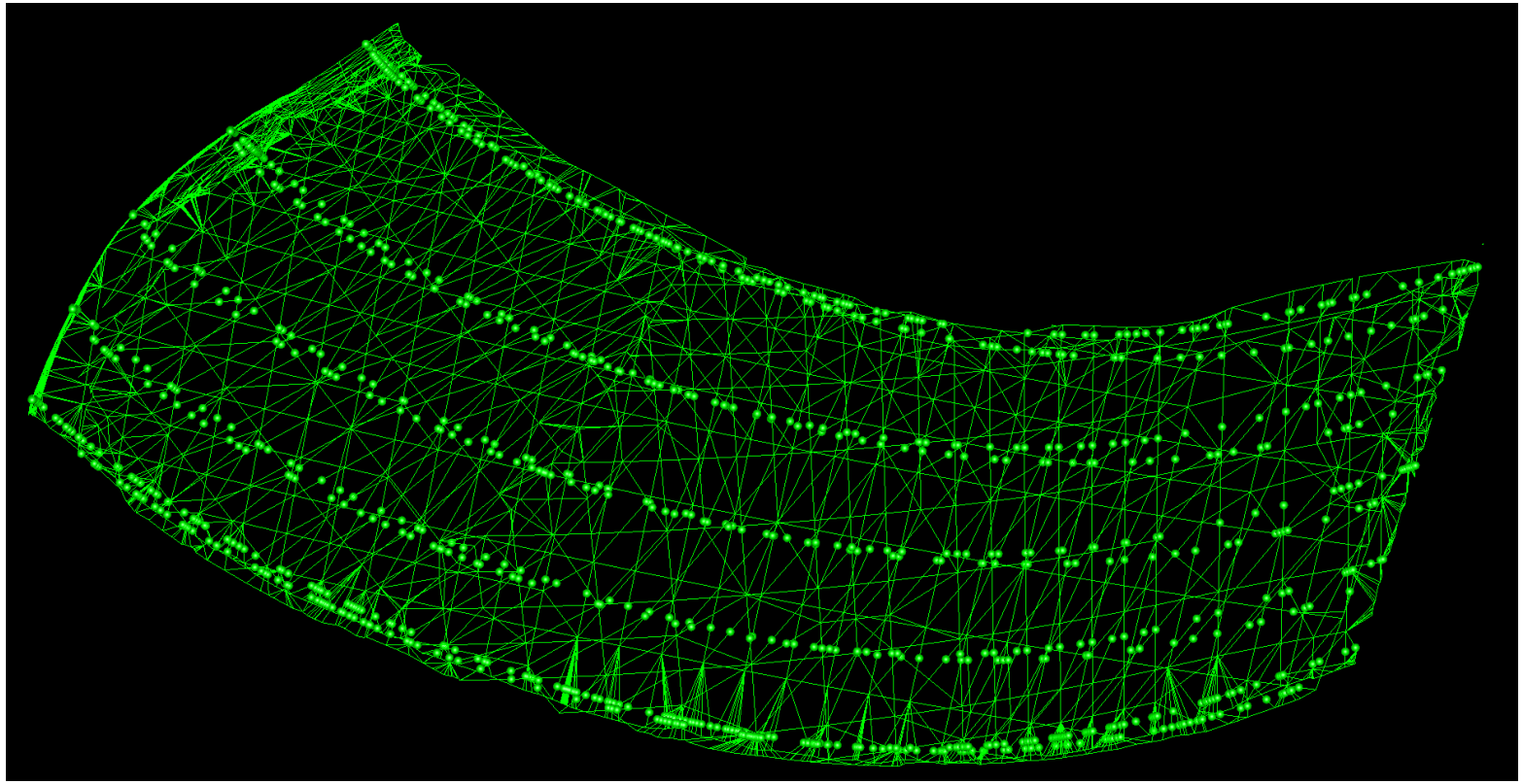


Point data projection



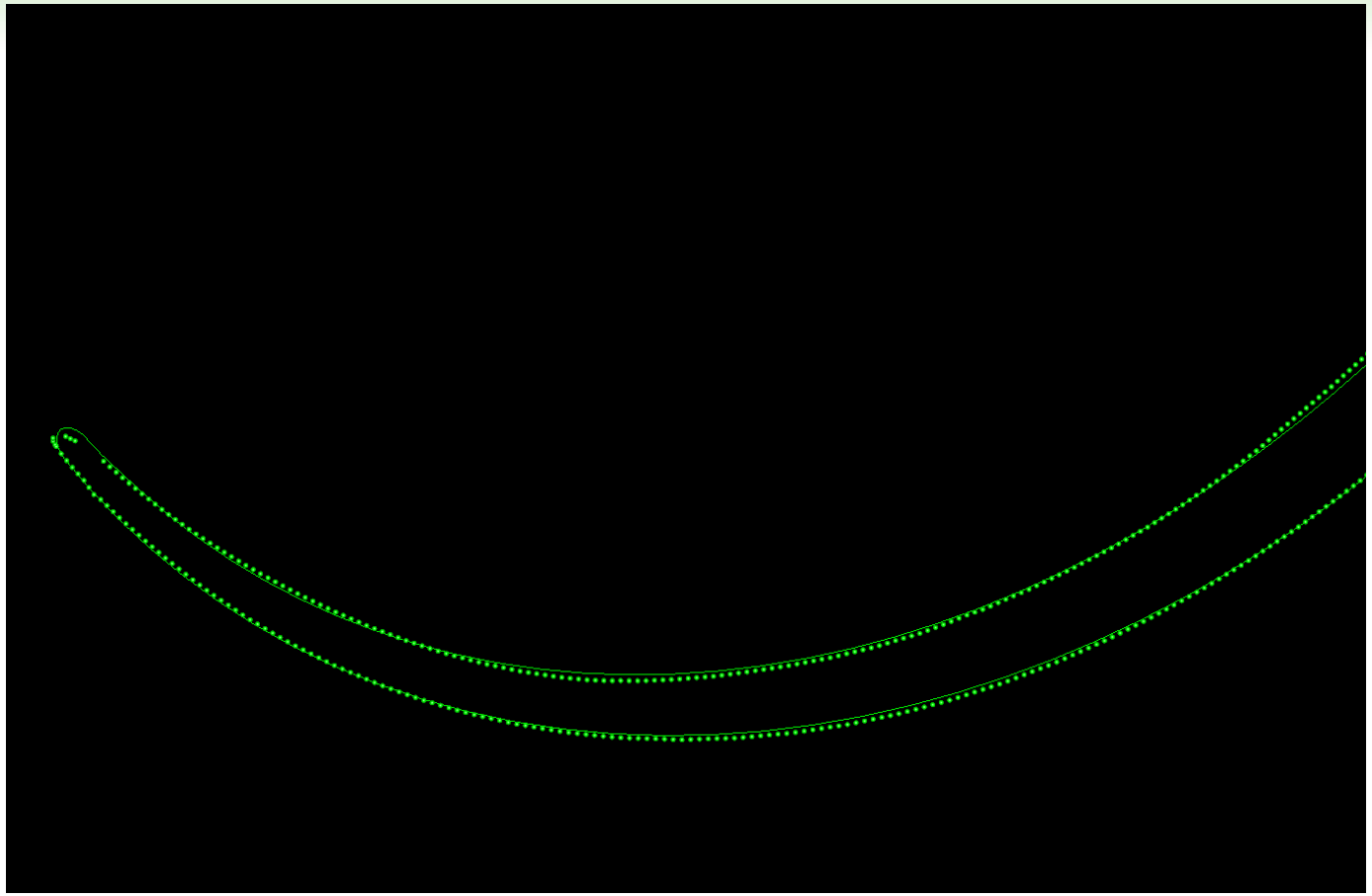
Meridional plane

Blade Profile



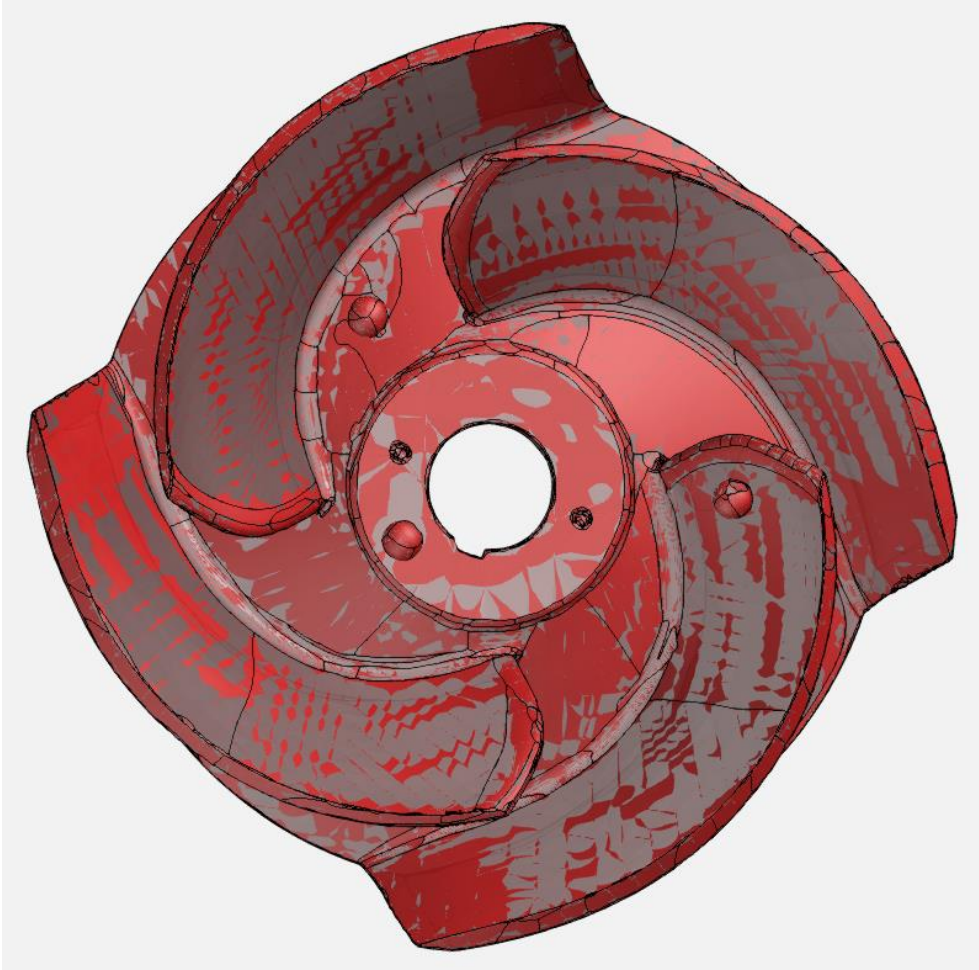
The characteristic data extracted from STL file

Blade Profile



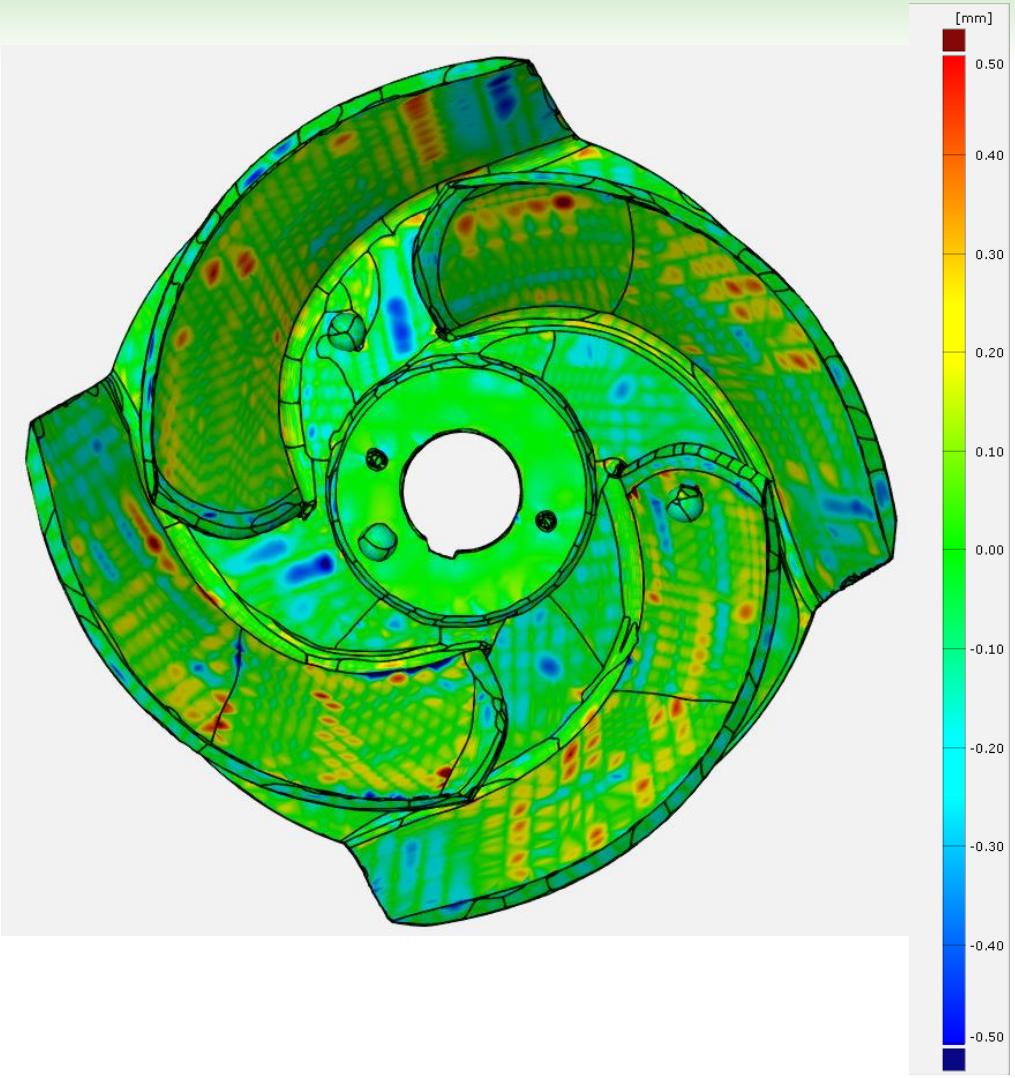
The parameterized curve and original points

Comparison before and after Conversion



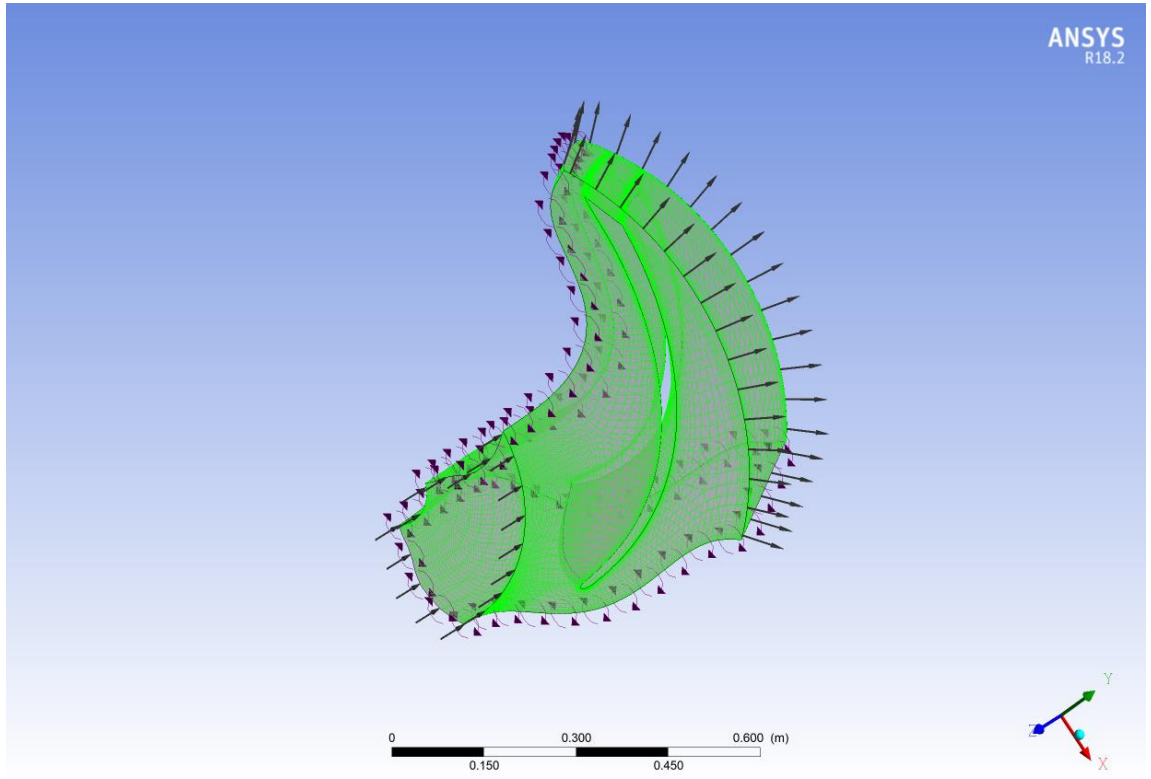
Gray: Original Data (Input)
Red: AIPump Data (Output)

Accuracy of Modeling



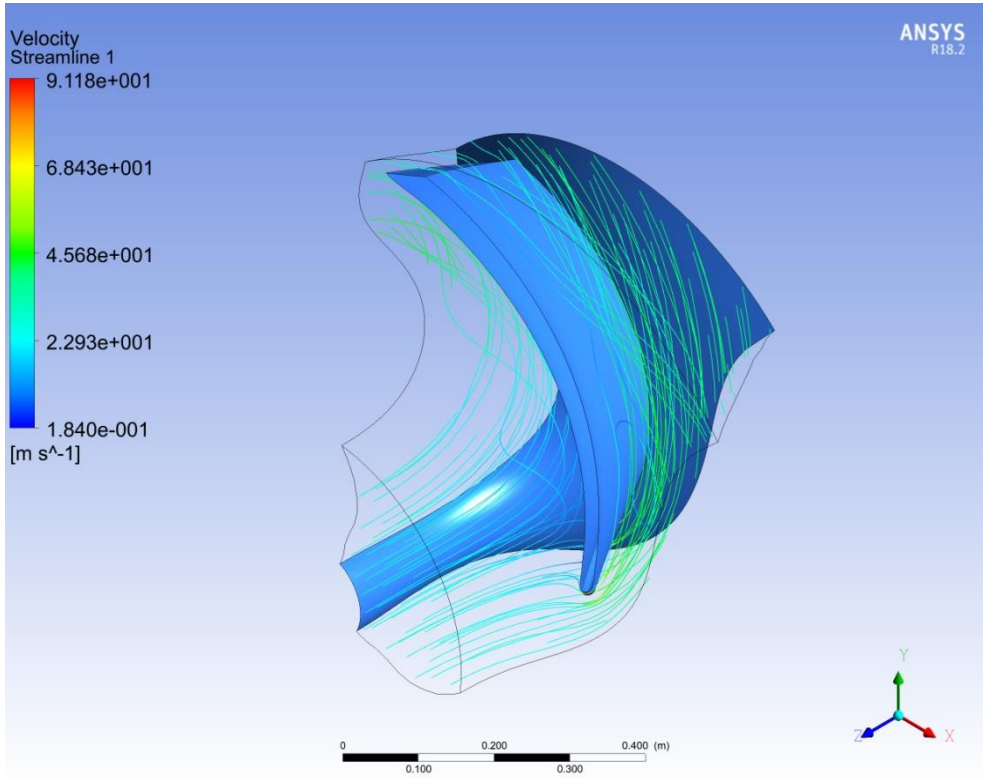
Approximately ±0.5 mm

Meshing and CFD



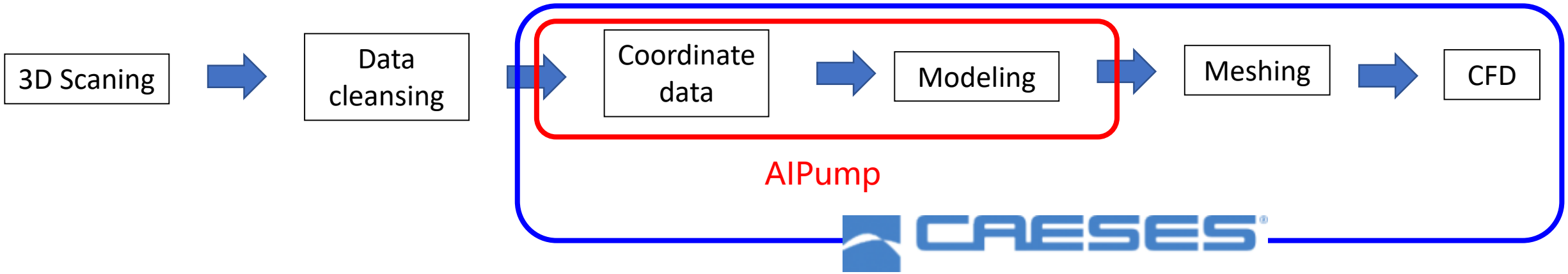
Meshed by ANSYS Turbo Grid

AIPump can make a single flow path model.



Streamline
Analyzed by ANSYS CFX

Future Work



These phases can be controlled by CAESES.

It will be able to be improved operational efficiency.

In addition, optimization will be able to be conducted by morphing between modeling and meshing.
This approach will be useful in case of casting error.

Conclusion

The workflow of the performance prediction of the mixed flow pump under age-related deterioration using AI Pump, CAESES, and CFX is considered.

- CFD modeling is conducted by using AIPump and the 3D scanned data. The modeling using 3D scanned data was manually conducted, so it spent much time. However, it will be able to reduce working hours by using AIPump.

- The difference between the geometry of 3D scanned data and the one modeled by AIPump is approximately 0.5 mm in maximum.

- It is possible to a single flow path model of an opened-typed impeller using 3D scanned data and AIPump. This approach will be useful in case of casting error.

Future Work

By controlling this operation by CAESES, this workflow will be more efficient and effective.