Customer:				Document Number:			
Bedford Pumps Ltd.				**BPL 0019**			
Originator:	Issued:	Issued For:	Revision:	Revison Date:	Checked By:	Approved By:	No. of Pages
RNK	**03/10/18**	**Publication**	**1**	**03/10/18**	**RNK**	**LO**	**13**

BEDFORD PUMPS LTD.

Analytical tools used by Bedford Pumps Engineering team

REPORT NO: BPL 0019

CONTENTS

1 ABSTRACT 3
1.1 SCOPE of CFD and FEA analysis 4
2 Analysis Case Studies CFD 5
2.1 Pump performance validation 5
2.1.1 Summary 6
2.2 Modelling the effects of surface finish and blade passages on pump performance 7
2.2.1 Summary 8
3 Analysis Case Studies FEA 8
3.1 Motor stool static structural analysis and Discharge bend static structural analysis 8
3.2 The analytical process 8
3.3 Motor Stool and Discharge bend results 11
3.4 Summary of FEA analysis on the 2 stage pump design 11
4 Additional FEA analysis supporting BPL Pump designs 12
4.1 Summary of FEA analysis on a test frame used during testing of a 2 stage pump 12
Conclusion 13

1 ABSTRACT

Due to the increasing complexity of Bedford Pumps designs and bespoke market requirements, the BPL Technical Design department is challenged to deliver robust product designs into increasingly challenging and complex applications. This report is a summary of some of the tools and analysis the Bedford Engineering team have recently conducted and gives a summary of some of the case studies recently conducted.

To meet these challenges BPL has made significant investment in Finite Element Analysis (FEA) using Inventor, Solidworks and ANSYS FEA packages & Computational Fluid Dynamics ANSYS 19.0 to validate the structural suitability of mechanical designs and validate hydraulic designs.

A typical 2 stage pump layout is shown below is DB 70.47.08. and shows a typical pump unit where both CDF and FEA analysis has been completed. A more detailed description of the type of analysis conducted will be summarised in the report.

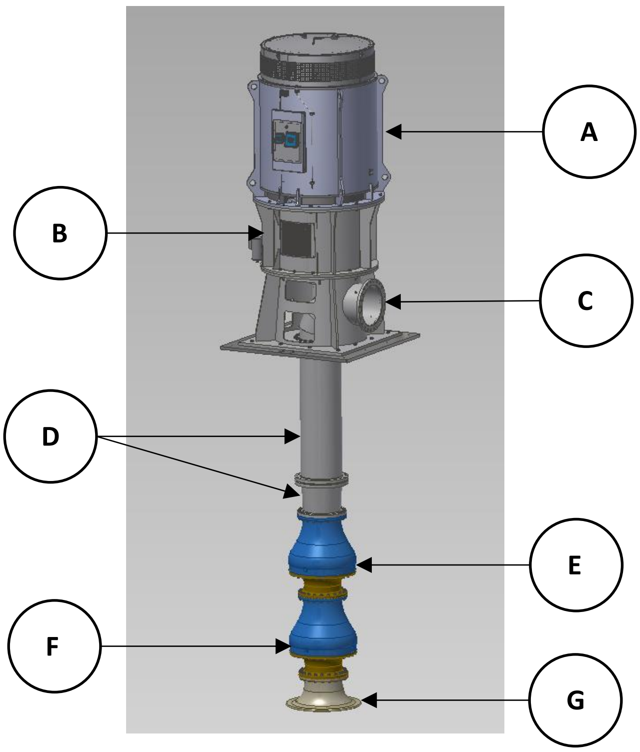


Figure 1: Typical 2 stage BPL DB design

A	Motor	**B**	Motor Stool	**C**	Discharge Bend
D	Riser Sections	**E**	Stage 2	**F**	Stage 1
G	Bellmouth				

1.1 SCOPE of CFD and FEA analysis

This report will outline some of the areas where the Technical team has used FEA and CFD to demonstrate our capabilities and is a summary of the typical analysis that we routinely conduct on our newer designs.

Examples of CFD analysis conducted in ANSYS: -

- Comparison of High Lift Pump Performance Test Results using CFD with initial ANSYS analysis.
- Validation and optimisation of test data against predicted data.
- Analysis of tests data to determine the effects of surface finish of casting on pump performance.
- Predict and optimise new pump casing designs to enable us to develop a new pump range.

Examples of FEA analysis: -

- Structural analysis of safety critical components.
- Analysis of lifting beams and lifting aids.
- Assessment of static and dynamic loads on pump components.
- Analysis of key test components such as test frames.

2 Analysis Case Studies CFD

2.1 Pump performance validation

In this case study we used ANSYS CFD to validate analytical test results against known test data results. This exercise has confirmed that the data from ANSYS can be used to help us develop new pump designs using historical test data in new design applications.

For impeller vane and bowl vane performance validation BPL use Bladegen and Turbo-grid within Ansys Workbench.

Fig 2 and 3 show a Bladegen set-up, vane angles and vane thickness of the impeller and bowl vanes.

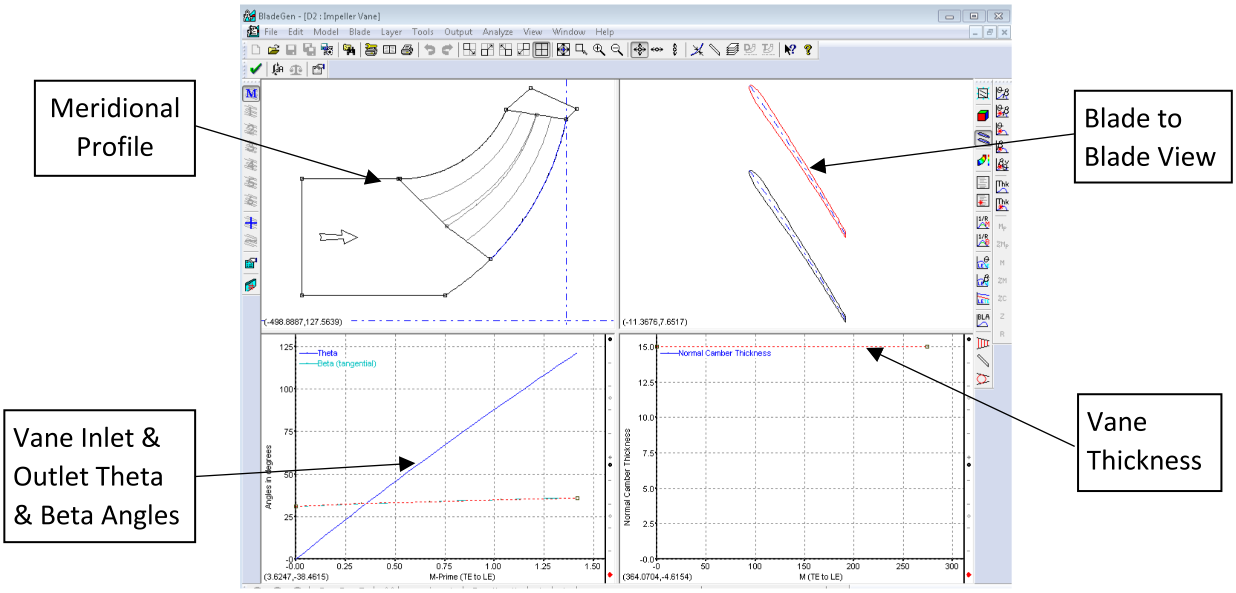


Figure 2: Bladegen. The impeller vane profile

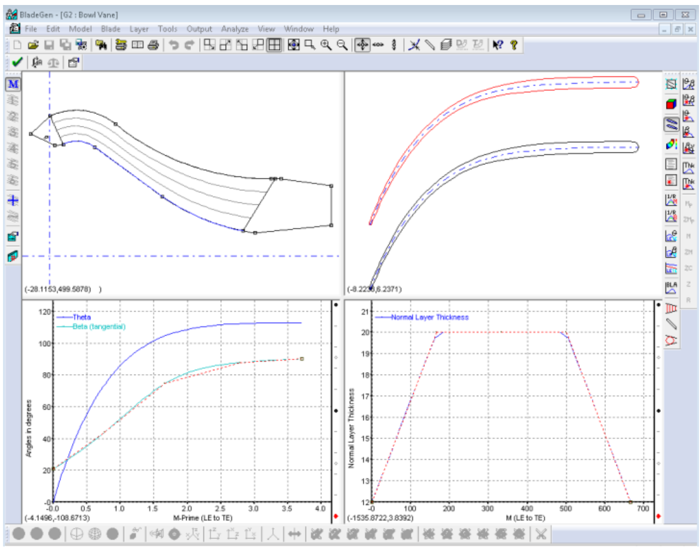
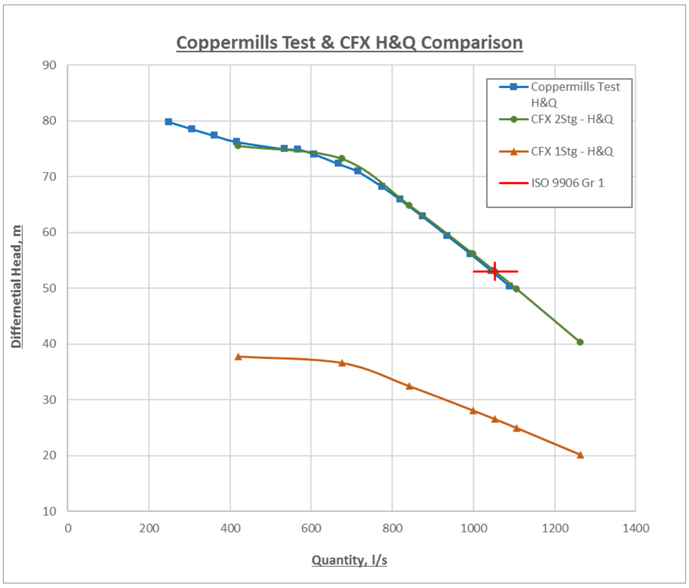
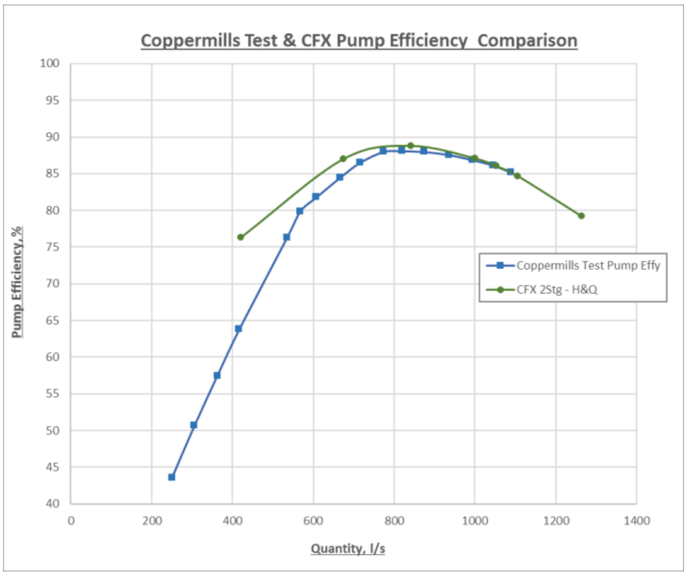


Figure 3: Bladegen. The bowl vane profile

Figs 4 and 5 show typical ANSYS CFX results against recorded test results for a 2 stage pump.





2.1.1 Summary

The results of this analysis showed that pump efficiency has a good correlation between test performance data and CFD results which is consistent through the majority of the assessed flow rates. This is particularly relevant with pump efficiency near the pumps best efficiency point (BEP) which is pertinent to nearly all pump applications.

The results of this exercise have enabled the design team to develop new hydraulic pump applications using modern analytical techniques rather than relying on traditional hand calculations, spreadsheets and historical data. These tools have also led to a reduction in our hydraulic leadtimes and as already stated the output is validated in the physical test.

2.2 Modelling the effects of surface finish and blade passages on pump performance

In this case study we have conducted an analysis using Ansys CFX to validate the hydraulic performance effects associated with added paint thickness and surface roughness within a pump bowl casing. This has enabled us to determine the impact of casting roughness and material surface finished and the impact this has on the overall unit predicted efficiency.

The pump designation used for the analysis was a Submersible Bowl type pump. The figures show measured paint thickness and surface finish used for the analysis.

Fig6 applied paint thickness and Figure 7 surface finish

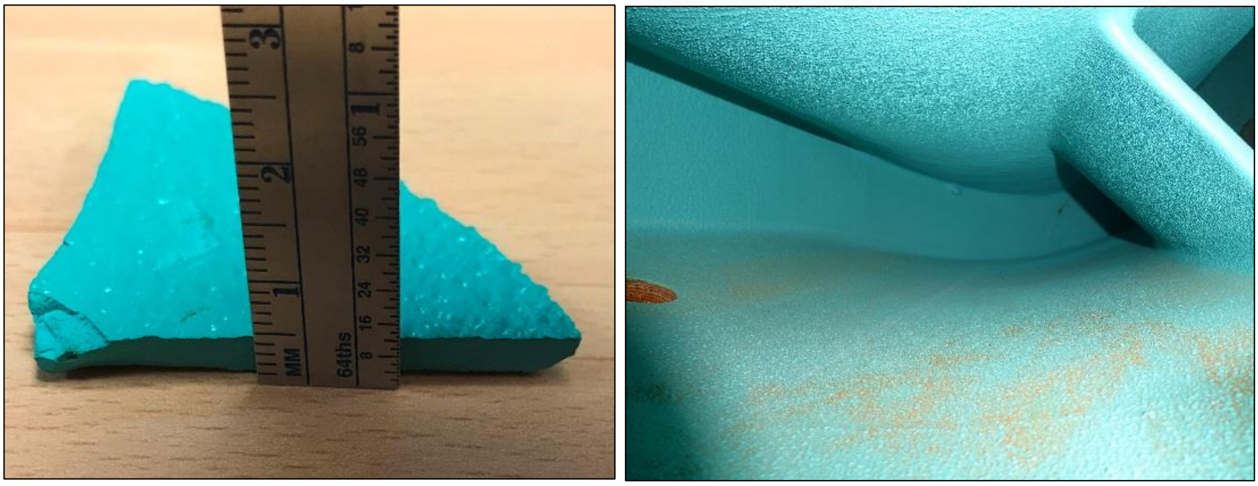
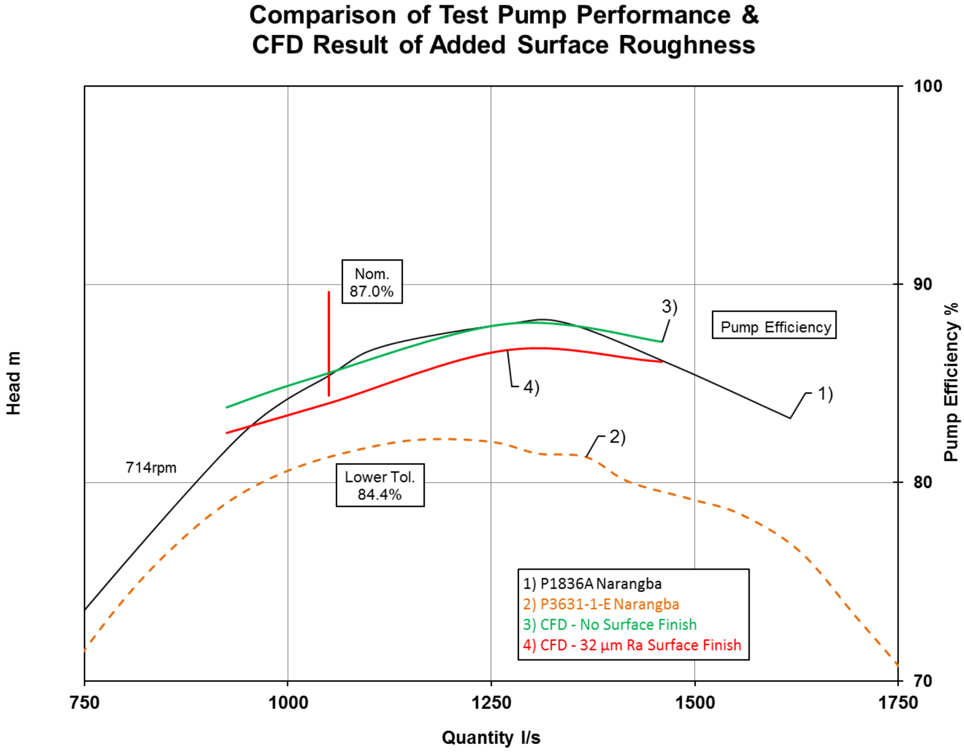


Figure 8: Effects of 32µm Ra surface roughness from ANSYS CFX



2.2.1 Summary

In this case study, the ANSYS CFD results confirmed that paint thickness and surface roughness increased the pump power absorbed. This has a detrimental effect on the overall efficiency of the pump and will impact true life costs of a unit in the field.

Through analysis we are now able to predict and address areas that can lead to poor hydraulic performance, this helps us to reduce our development leadtimes, reduce our costs on traditional Research and Development and focus on product quality and process techniques, additionally we are able to demonstrate to our customers our focus on pump efficiency and their through life costs.

3 Analysis Case Studies FEA

3.1 Motor stool static structural analysis and Discharge bend static structural analysis

This study outlines structural assessment using Finite Element Analysis (FEA) in ANSYS 19.0 to validate the structural suitability of the motor stool & discharge bend fabrications for a two stage pump design, reference Fig 1. ANSYS FEA was utilised due to the complexity of the discharge bend assembly. Note our default FEA package is either Autodesk Inventor or Solidworks FEA, but in more complex cases our preferred tool is ANSYS FEA.

Due to the nature of the design, we needed to consider the motor stool and discharge bend operational loads on the structure and the pumping station and the impact of the remedial stresses induced within the fabrications. The aim of this report was to analyse the suitability of the design methodology for the fabrications, and to determine if any design changes were required to meet the design loads.

3.2 The analytical process

An initial assessment of the motor stool boundary conditions was conducted. See Figure 9.

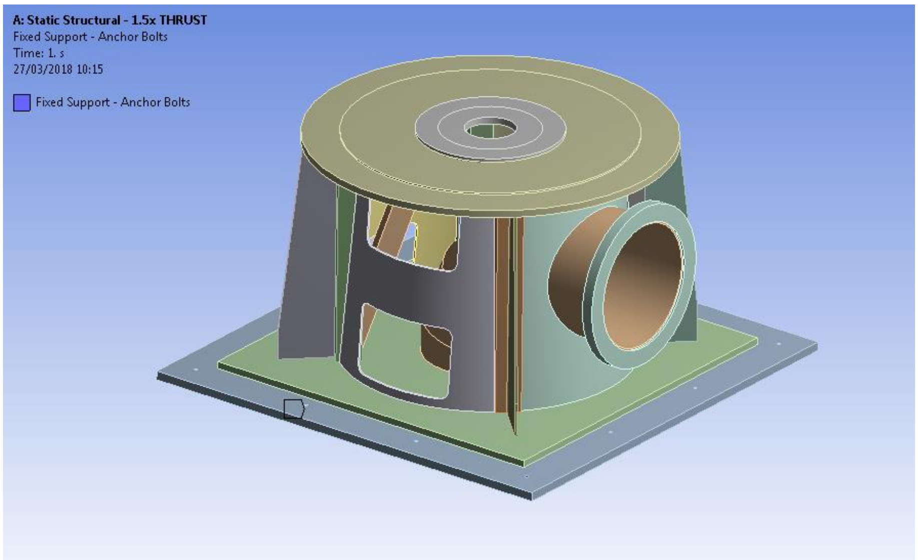


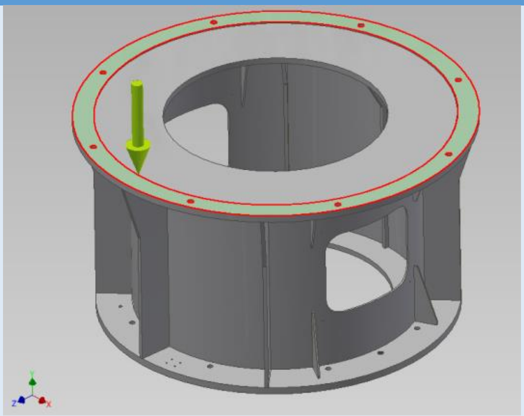
Figure 9 Establishing boundary conditions

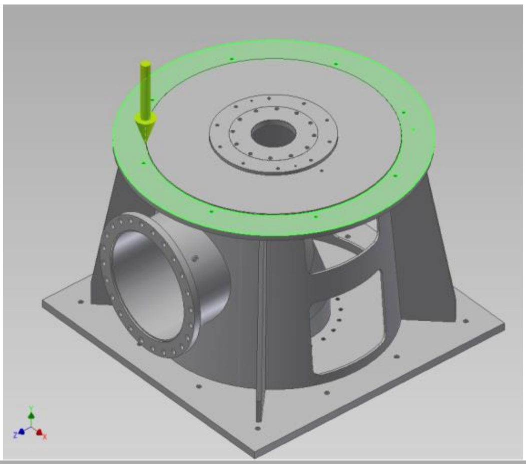
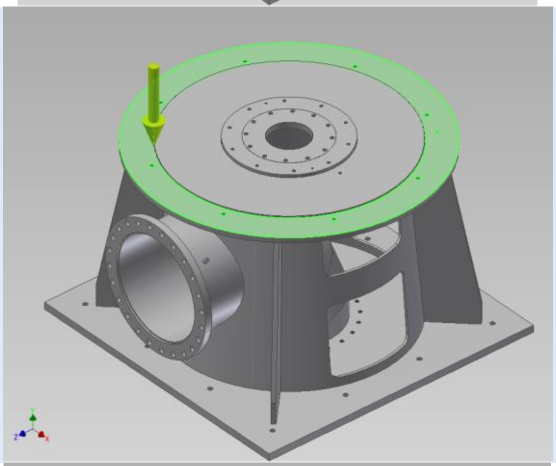
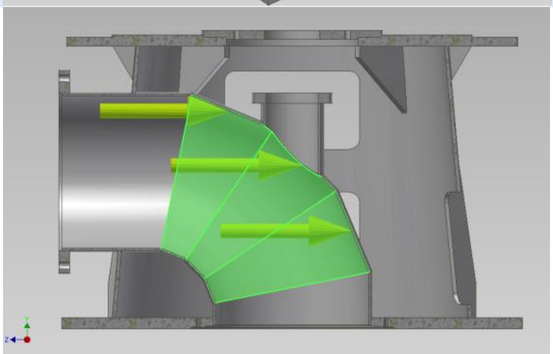
From this we determined the load applications: -

- Motor breakdown torque
- Motor weight
- Motor Bearing Loads
- Motor & motor Stool weight
- Fluid Force on Bends
- Pump Components Weights

The loads were applied as follows:

Figure 10 - Motor Stool Fabrication Applied Loads

Load	Description	Location	Magnitude	Direction
1	Motor weight		104746 N	-Y- axis

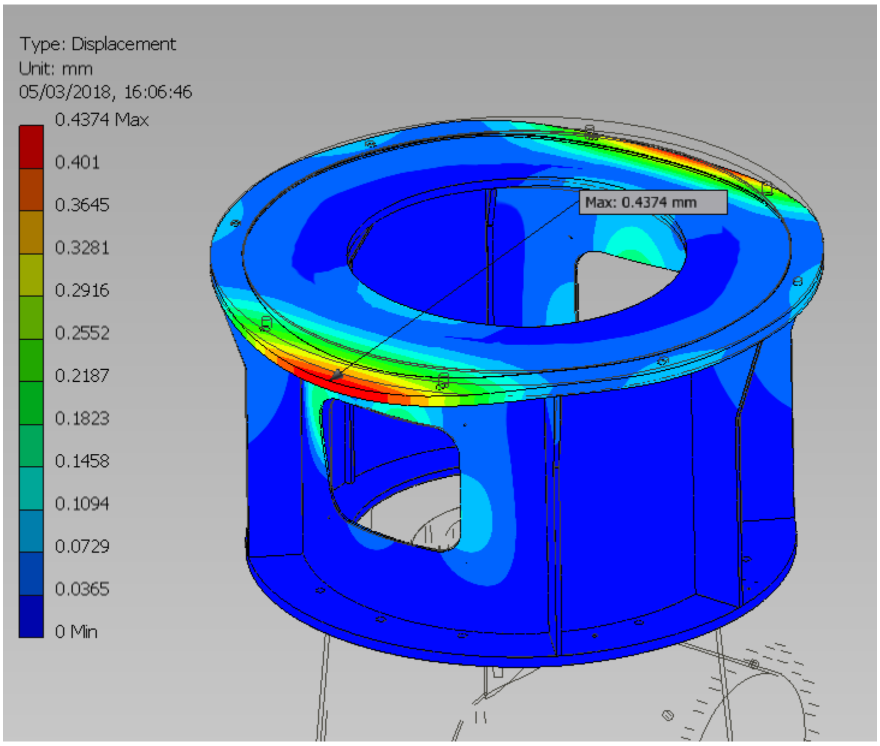
2	Motor & motor Stool weight		125288 N	-Y- axis
3	Motor & motor Stool weight		125288 N	-Y- axis
4	Fluid force on bend		350000 N	-Z- axis

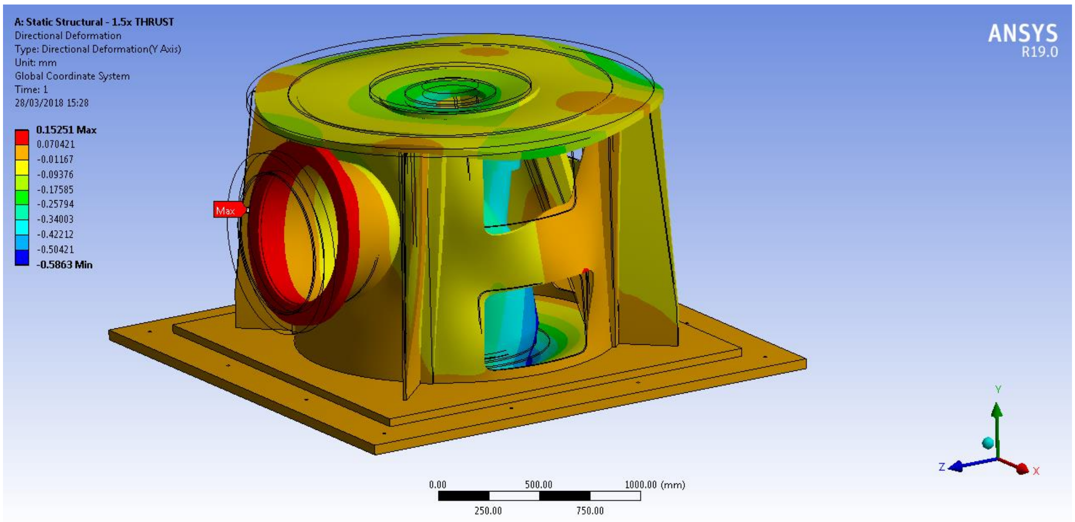
In ANSYS, a basic mesh was applied to the models of the key components and this was continually refined until the mesh converged. The material properties were then applied to the loads and the corresponding results were analysed.

Fig 11 Material Properties & Allowable Stress and test results

Component	Material	Yield Strength	Safety Factor	Allowable Stress
Motor Stool	BS EN 10025-1:2004 - S275	265 MPa	1.5	176 MPa
Discharge Bend	BS EN 10025-1:2004 - S275	265 MPa	1.5	176 MPa

3.3 Motor Stool and Discharge bend results





3.4 Summary of FEA analysis on the 2 stage pump design

From the FEA simulations conducted we have proven the suitability of the motor stool and discharge bend designs for the 2 stage pump designs.

All stresses are within allowable limits and all motor stool deflections are negligible and will not affect performance of the unit.

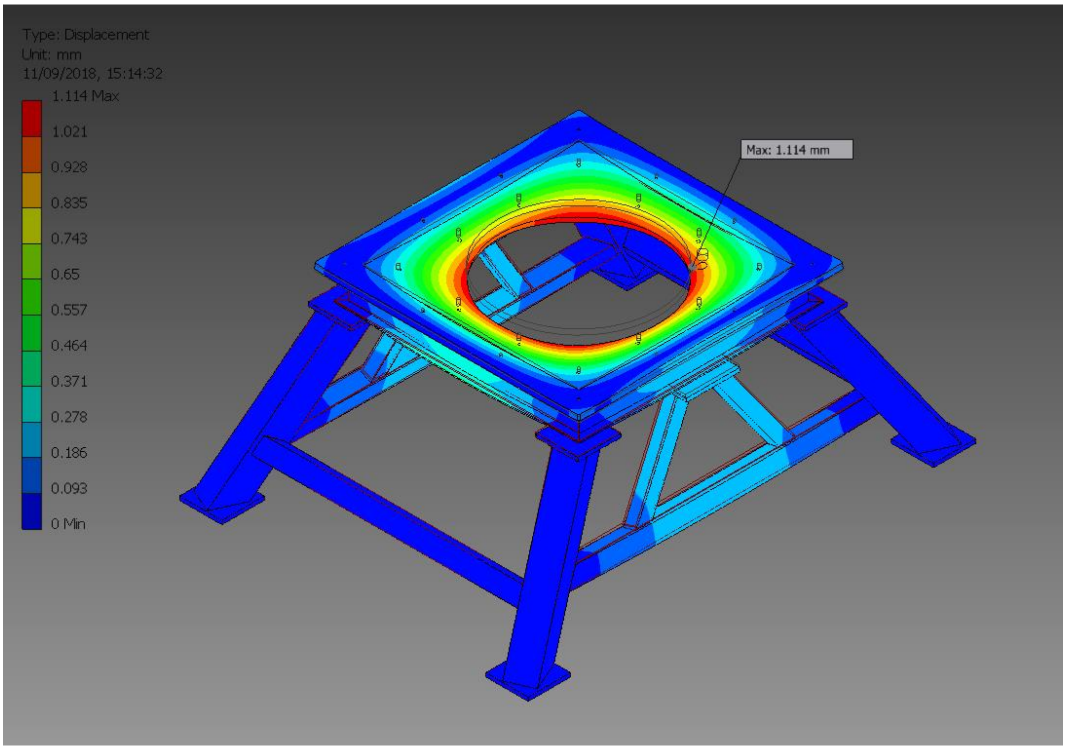
4 Additional FEA analysis supporting BPL Pump designs

4.1 Summary of FEA analysis on a test frame used during testing of a 2 stage pump

The purpose of this study was to validate the structural suitability of the test frame under load conditions using Autodesk Inventor Professional 2014.

The test frame fabrication consists of steel I-beams and hollow rectangular sections. Four legs contact the ground and allow the pump to be held at the required height while tests are being conducted. The pump is connected to the frame by bolting the delivery bend fabrication onto the sole plate, with the sole plate being bolted directly onto the support frame. The sole plate was included in the FEA model as the pump's static and dynamic loads are directly applied to this component.

Figure 12 test results during the analysis.



The results of the analysis concluded that the allowable stress of the test frame were well below the yield strength. We have successfully used this test frame for testing of the pump.

5.0 Conclusion

This document is a snapshot demonstrating some of the analytical capabilities of Bedford Pumps Engineering Team. All new designs are reviewed and where relevant ANSYS CFD or FEA analysis is conducted to ensure delivery of a compliant and structurally sound product that meets the requirements of our customers.

More information is available on request.