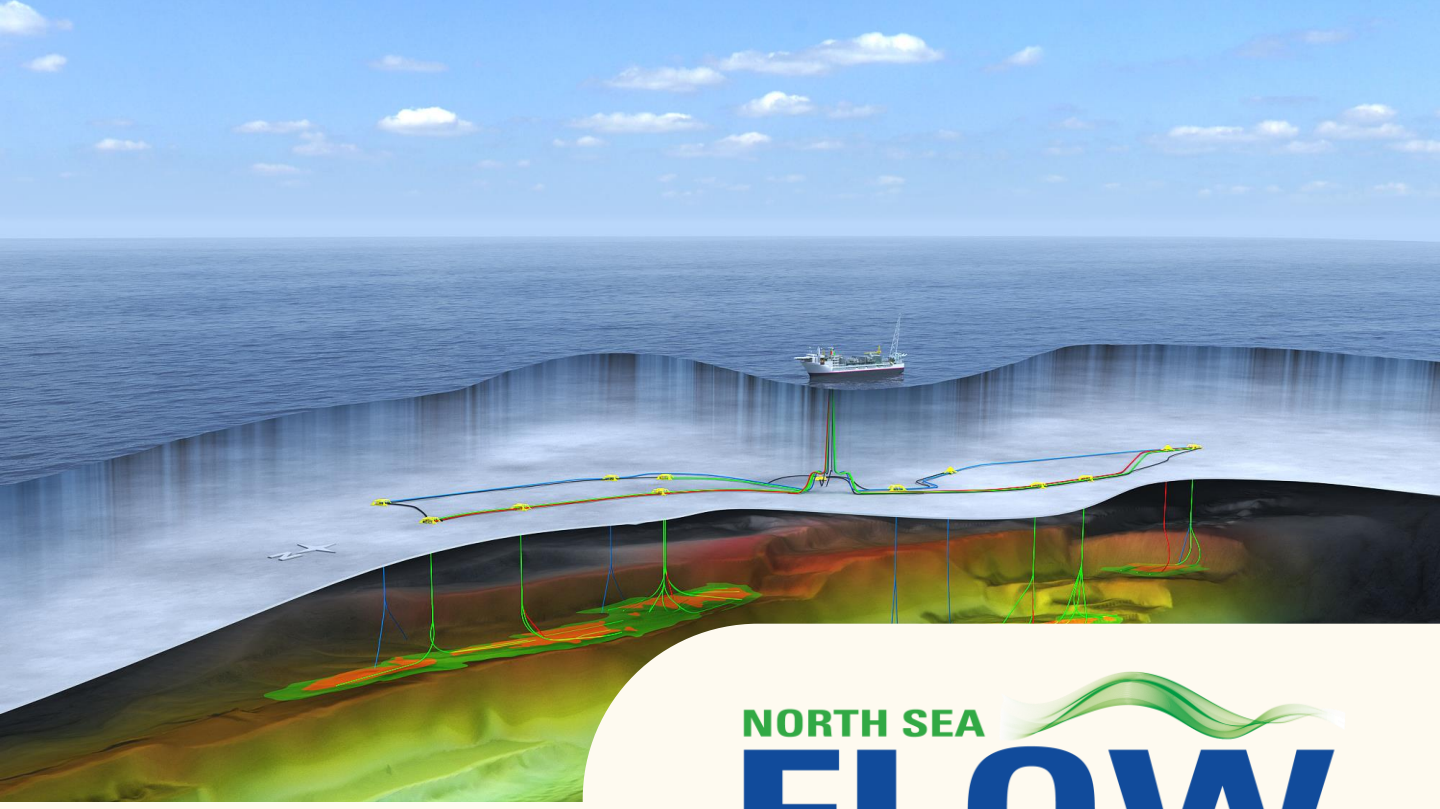

NORTH SEA
FLOW
MEASUREMENT WORKSHOP
measuring for the energy transition

Poster 2021

Tekna

TÜV SÜD NEL

NFOGM
NORWEGIAN SOCIETY FOR OIL AND GAS MEASUREMENT

NORTH SEA FLOW MEASUREMENT WORKSHOP
measuring for the energy transition

Enhanced Quadrature Design for Chordal Ultrasonic Flowmeters

Patrick Arnould, Robert Gordon University p.arnould@rgu.ac.uk **Dr. M. G. Droubi, Dr. S. Z. Islam**

In addition to his regulatory role, Patrick is a part time research student in the department of Engineering at RGU Aberdeen. Patrick's research is examining design changes to ultrasonic flowmeters to increase the uptake of condition-based monitoring with special emphasis on resilience to velocity profile effects.

Introduction

Some previous work has proposed tailoring designs to *specific* profiles to reduce integration errors due to axial distortion. This work instead aims to improve resilience across a *range* of axial profiles.

We propose a change to the method used for calculating Legendre 4 chord weighting factors which improves performance in axial distortion.

Can new 4 & 5 chord quadrature designs be found which outperform Chebyshev & OWICS designs?

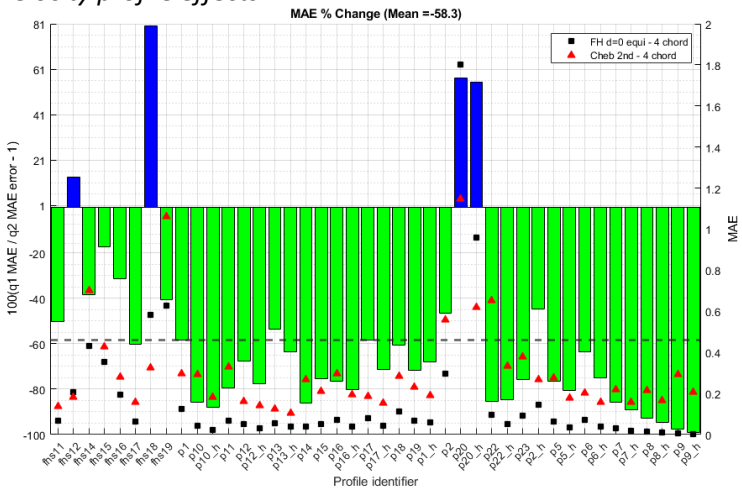

Fig 2 – Change in MAE across a range of distorted axial profiles comparing new 4 chord design with common Gauss-Chebyshev 4 chord design

Methodology

Mathematical model developed which allows testing of an integration scheme across 42 disturbed axial profiles. High order Chebyshev interpolants used to model path velocity measurements [1].

36 different orientations for each profile are used, increasing the dataset. Results used to calculate three metrics for each profile: Mean Absolute Error (MAE), Root Mean Square error (RMS) and error span (max-min).

Proposed design compared using the above metrics against an appropriate benchmark.

Results

New method of correcting 4 chord Legendre for a circular domain reduces MAE on average by ~26% across a range of profiles (Fig. 1). Improvement in RMS and error span also seen.

New 4 & 5 chord path positions tested with weights calculated using rational interpolant [2]. Average reduction in MAE of ~58% observed for our 4 chord design when compared with Gauss-Chebyshev 4 chord (Fig. 2). Improvement in RMS and error span also seen. New 5 chord design also an improvement compared with Gauss-Chebyshev 5 chord.

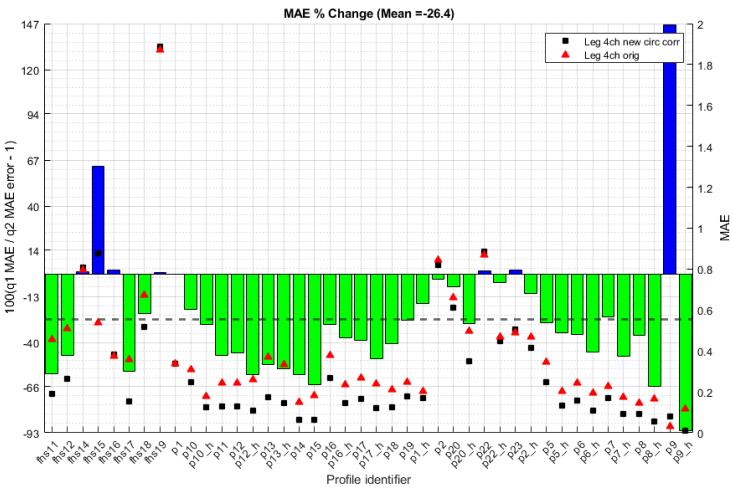

Fig 1 – Change in MAE across a range of distorted axial profiles comparing new circular domain correction to the existing method (Legendre 4 chord)

Conclusions

The change to Legendre reduces errors due to axial distortion by improving the fit of the interpolant to the area flow function. New 4 & 5 chord quadrature designs appear to reduce errors due to axial distortion. Initial analysis indicates this is due to cancelling of errors between paths with those near the wall for the 4 chord, and improved fit between paths for the 5 chord.

Further work will test conclusions on profiles with more realistic near wall behaviour.

References

[1] BATTLES, Z. and TREFETHEN, L.N., 2004. An extension of matlab to continuous functions and operators. *SIAM Journal on Scientific Computing*, 25(5), pp. 1743-1770.

[2] FLOATER, M.S., HORMANN, K., 2007. Barycentric rational interpolation with no poles and high rates of approximation. *Numer. Math.* 107, pp. 315–331.