ANALYSIS of 2" 3 SEGMENT CLAMP

PREPARED BY:	ON BEHALF OF:
WILDE FEA LTD BRINDLEY LODGE ADCROFT STREET STOCKPORT SK1 3HS	ADVANCED COUPLINGS STATION HOUSE THWAITES BRIDGE KEIGHLEY WEST YORKS BD21 4NQ

ANALYSIS of 2" 3 SEGMENT CLAMP

REPORT APPROVAL COVER SHEET

Prepared by: M. Kempton   Date: December 2003

Checked by: J. L. Dennis   Date: December 2003

Approved by: J. L. Dennis   Date: December 2003

REVISION	DESCRIPTION	BY	CHECKED	APPROVED	DATE
A	First Issue				
B	Clarification comments				

Wilde

Contents

1.0 Introduction

1.1 Advanced Couplings Ltd are investigating the contact pressure distributions developed in their range of piping clamps.

1.2 As part of this investigation, Advanced Couplings Ltd have asked Wilde FEA to perform a finite element analysis of a 2" 3 segment clamp in order to gain an insight into its clamping efficiency.

1.3 The ANSYS Workbench version 8.0 finite element program has been used for this study.

2.0 Method

2.1 A finite element model has been developed to represent the clamp and a mating ferrule in order to investigate the contact stress distribution between the components.

2.2 The finite element analysis uses two planes of symmetry to reduce the size of the model. This simplification does not affect the accuracy of the results. The model is shown in figure 1 (Model 1).

2.3 It was noted that there was a small gap between the clamp and the ferrule when the clamp bolting lugs were parallel. This means that when the clamp is closed to create initial contact between the clamp and the ferrule, the clamp will not be perfectly circular. This condition will tend to accentuate localised contact areas between the components.

2.4 Initially the actual ferrule geometry was not available and therefore Wilde FEA produced a simplified ferrule piece. This contact face of this component was generated to exactly follow the geometry of the clamp compression face (i.e. curved). Although it is now known that the geometry of the ferrule has a different profile, the geometry created by Wilde FEA is a perfect fit inside the clamp when the clamp is in the 'exact round condition' i.e. the bolt lugs are parallel at the start of ferrule compression. This study therefore gives an indication of the pressure distribution which would be achieved in this ideal situation, and provides an interesting comparison condition. This model is shown in figure 2 (Model 2).

2.3 For each configuration of ferrule geometry, the clamp model was the same. The key features of the model are as follows:-

> (a) Frictionless pins between the three clamp segments.

The Wilde logo appears in the top right corner of the page.

(b) Contact surface elements between the clamp and the ferrule. These elements will allow separation of the bodies, but will form a compression interface when the components come into contact.

(c) Two planes of symmetry assumed, reducing the size of the finite element model.

(d) Bolt clamp load applied as a force on the inside surface of the rivet hole.

(e) A single load case representing a bolt clamp load of 1000 N. was applied.

(f) The Young's Modulus (material property) of the clamp and ferrule was taken as 200,000 N/mm^2.

(g) The loading and restraints applied to the two models are shown in figures 3 & 4.

3.0 Results

3.1 The results for the case of the actual ferrule geometry (Model1) are shown in figures 5 & 6. Localised contact stresses can be seen at the 'ten to' and 'ten past' locations, and also at the 6 o'clock position. Some distribution of loading away from these locations can be seen, but the concentration of loading at these positions is very apparent.

3.2 The results for the artificial ferrule created by Wilde FEA are shown in figures 7 & 8. These generally tend to show a more even loading distribution around the ring, but highly localised concentration of contact pressure occurs close to the pins, and local to the clamp bolt.

4.0 Conclusions

4.1 Two finite element models have been developed, with the objective of establishing the contact stress distribution between the coupling and the ferrule. The first model (Model 1) includes a ferrule geometry which replicates the actual item, whereas the second model (Model 2) includes an artificial ferrule where the contact surface geometry exactly matches that of the clamp contact surface geometry.

4.2 Model 2 shows a more even contact pressure distribution around the circumference of the clamp and ferrule.

4.3 The following observations are made with reference to the behaviour of this clamp.

(a) The contact pressure distribution will be very dependent on the roundness of the clamp, at the point when significant load starts to be transmitted across the interface into the ferrule.

(b) The pressure distribution is very dependent on the ferrule/gasket stiffness, because these affect roundness of the clamp at closure.

(c) The pressure distribution will be sensitive to component tolerances, because the actual contact between the angled ferrule and the curved clamp face will alter the effective contact diameter, and also the initial roundness of the clamp.

(d) Clearances in the pins will allow different segments of the clamp to bed down more evenly. The model is very intolerant in this respect for two reasons.

(i) The axis of symmetry perpendicular to the pipe axis is infinitely rigid, and will hold all three segments on that plane. In reality there will be a small amount of relative axial movement possible between the components.

(ii) There are no pin clearances in the model which might allow potential load re-distribution for the out of round condition.

(e) The model does not include the effects of friction at the contact interface or the link pins.

(f) The model does not include material plasticity which could assist in load redistribution.
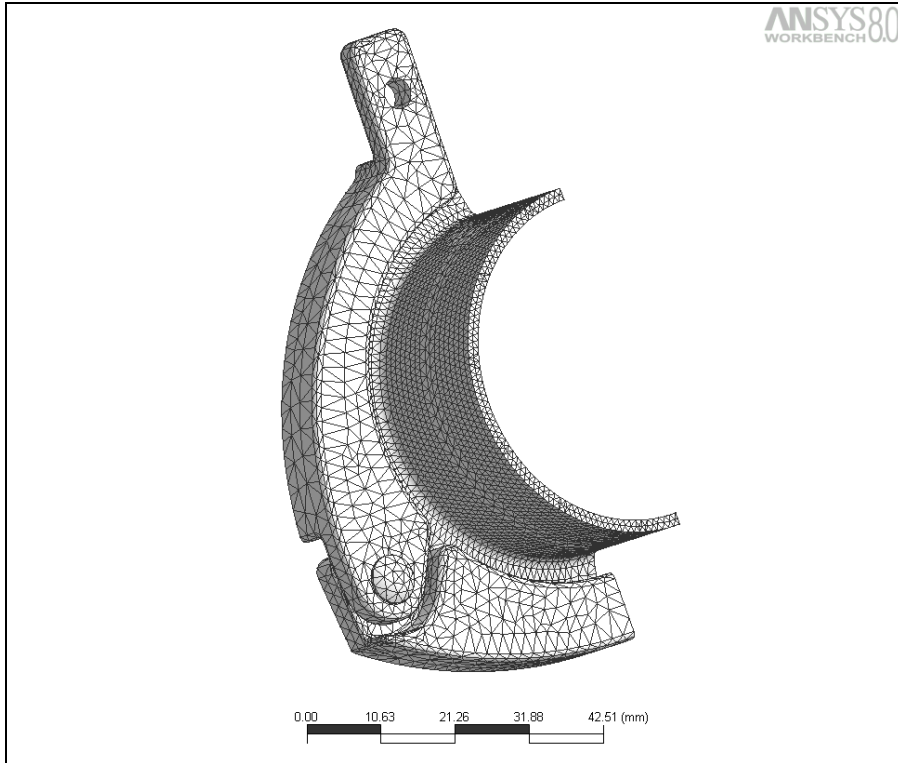
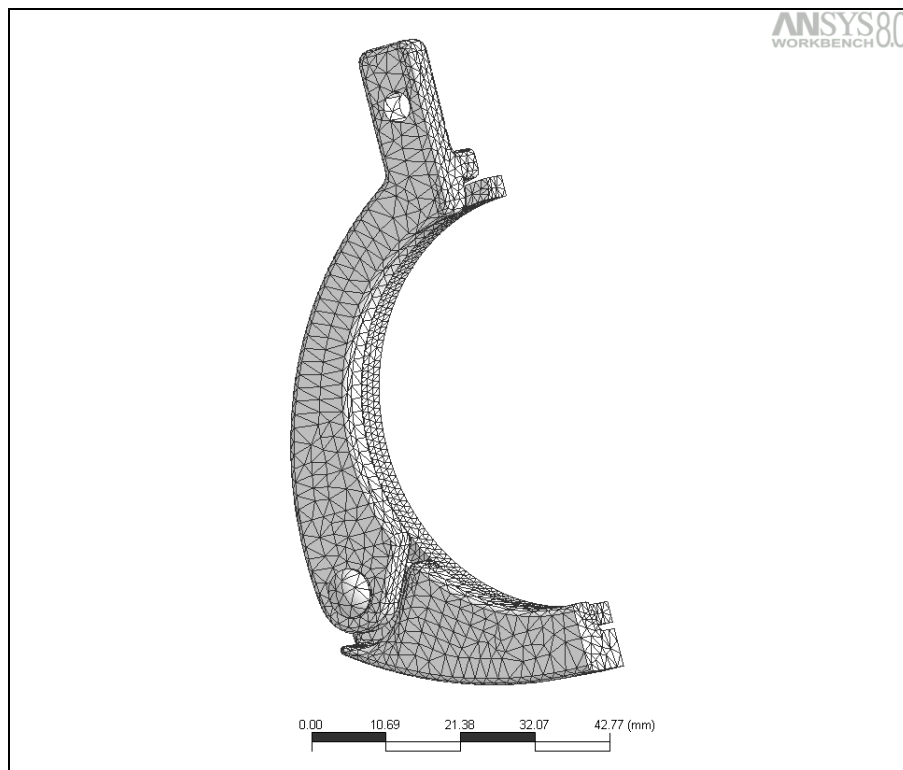Figure 1 - Illustration of the Finite Element Mesh for Model 1

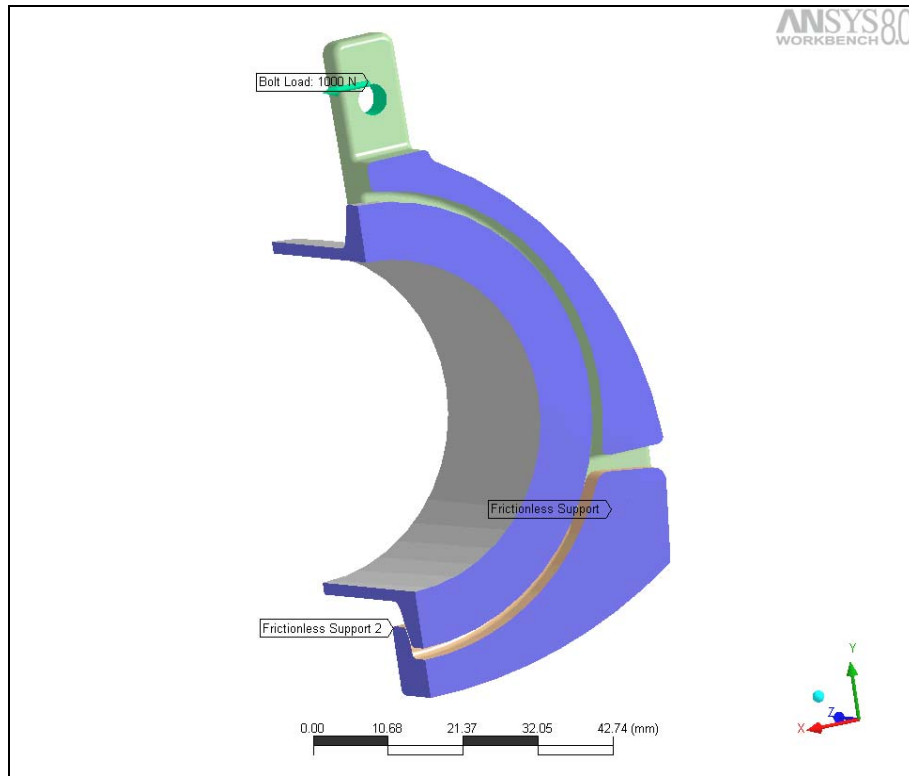Figure 2 - Illustration of the Finite Element Mesh for Model 2

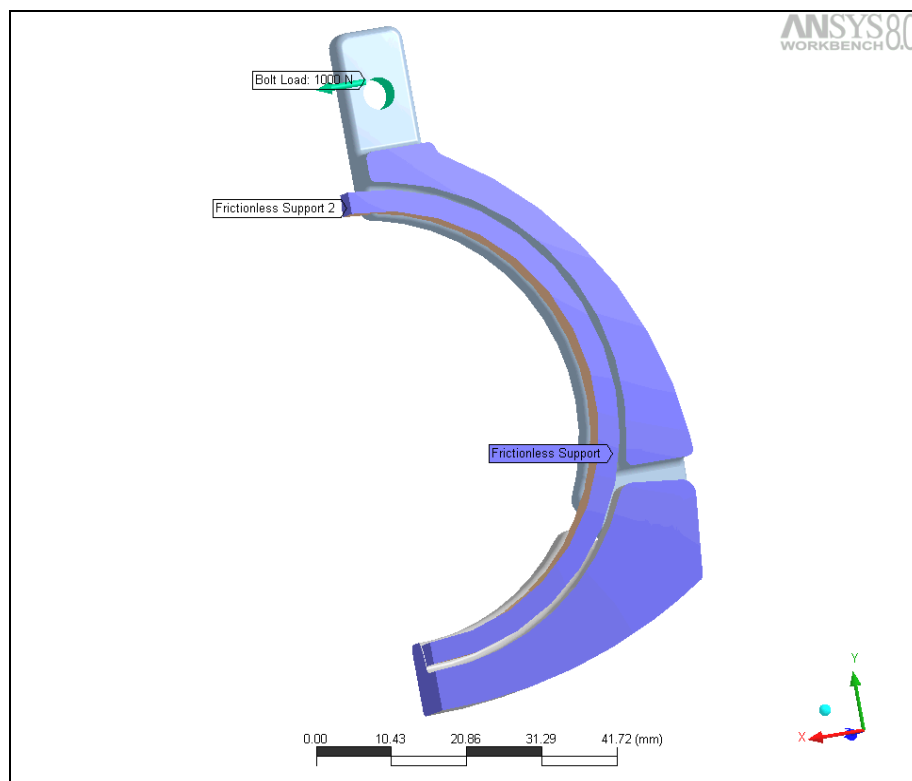Figure 3 – Loading Environment for Model 1
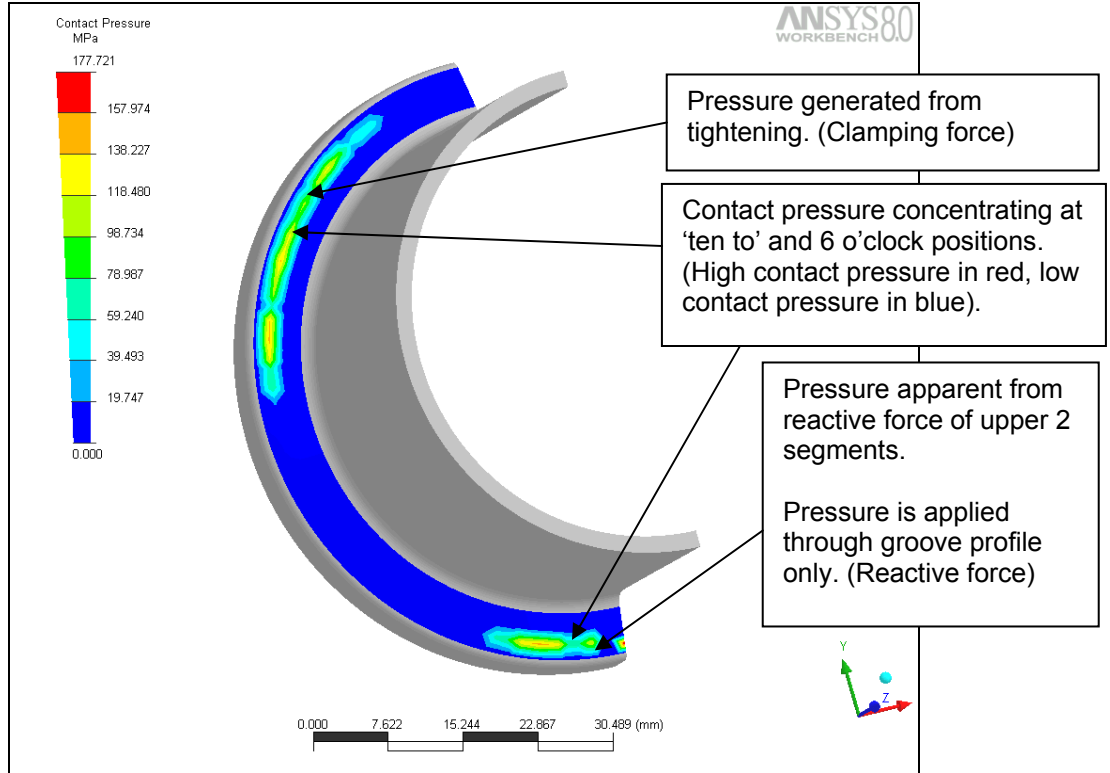

Figure 4 – Loading Environment for Model 2

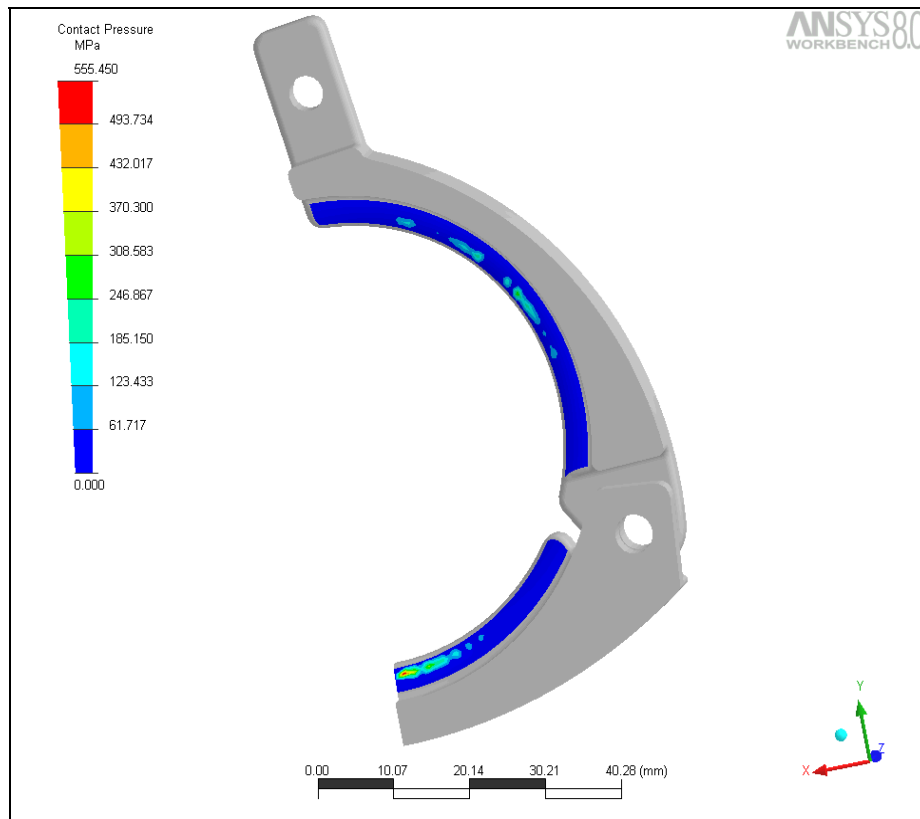Figure 5 – Contact Pressure on Ferrule Surface for Model 1

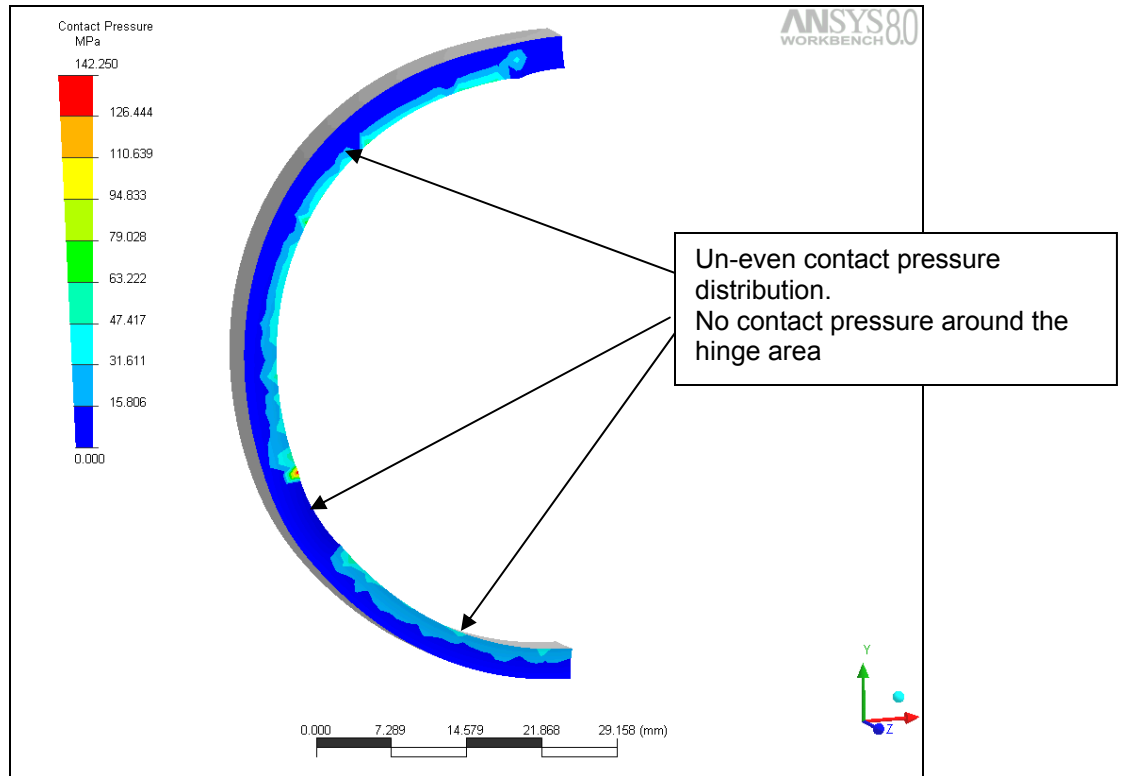Figure 6 – Contact Pressure on Clamp Surfaces for Model 1
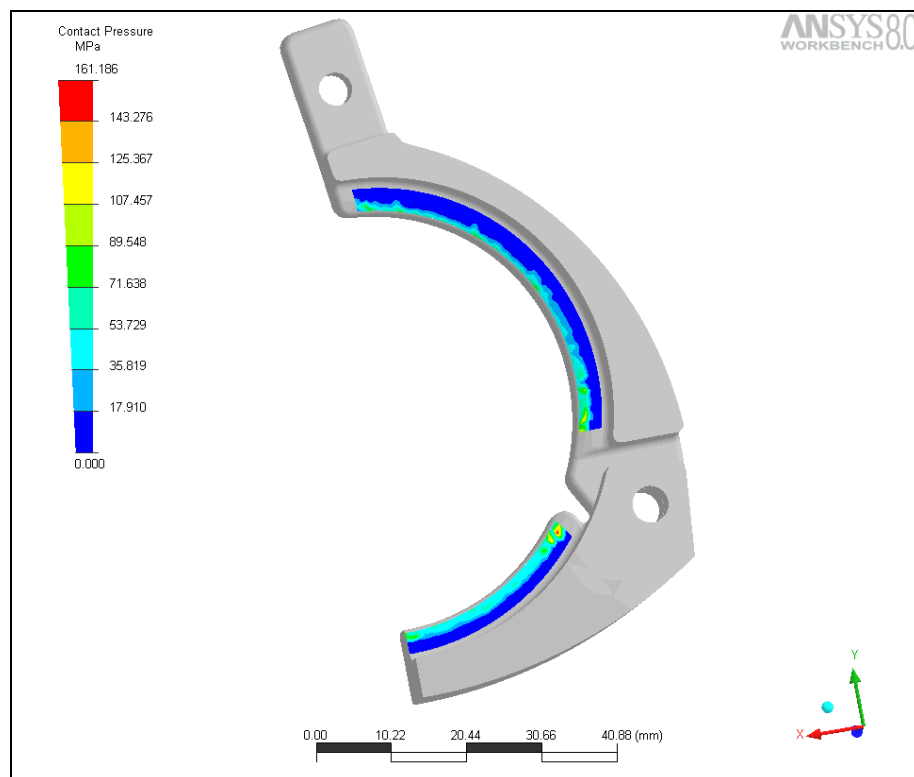
Figure 7 – Contact Pressure on Ferrule Surface for Model 2

Figure 8 – Contact Pressure on Clamp Surfaces for Model 2