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INSTALLATION OF SERRATED METAL CORE WITHOUT FULL DISASSEMBLY OF A HEAT EXCHANGER

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Abstract

Problem

The problem faced was to provide a sealing solution on a heat exchanger where certain restrictions were in place. Several years had passed since the bundle was last pulled, the concern over the service was that corrosion may be present on the flanges inspection had not been determined. The sit e had become congested since it was first installed which reduced the available movement of the bundle. Shutdown would be extended if floors had to be cut out, the exchanger dropped and rerouted to the edge of the platform. There were several unknowns; documentation on what had been done last time was sketchy, along with its location in the North Sea with climatic issues. The platform itself had replaced a facility which is remembered in history for major loss of life.

Investigation

The initial review of the documentary evidence, along with site visit provided invaluable fact finding. The geometry of the exchanger, the operating conditions, and the availability of skills, men and equipment were taken into the initial review. Following initial discussions a proposal was prepared and presented to the key decision makers. At the initial review several unknowns were still present so a contingency plan was required to anticipate the possible issues.

The development of the procedure for the, pulling, inspection review and the subsequent installation of a Sigma faced Kammprofile gasket on the Shell /Tube sheet position without pulling the tube bundle full out of shell was carried out in conjunction with Ross Offshore, Wood Group, Talisman and Flexitallic.

This was refined on land by the use of life size models, using out of service equipment to refine procedures, proving the system of operation, site testing and then subsequent off site testing of welds, and destructive testing of the sealing elements

In previous situations the geometry of bundles would allow metallic components to be manipulated in the cold state to pull over the

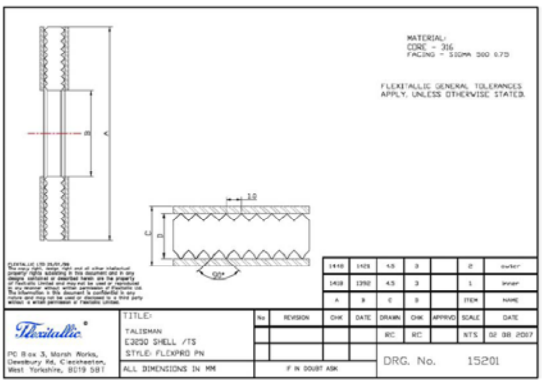
bundle. Through the bundle stud bolting in this case didn't allow this to be used.

Planning

The procedure commences with the manufacture of the core in 1 piece at the Flexitallic facility. Facing material to match the core sizes were cut and cleaned. The relevant dimensions were made in accordance with the Flexitallic drawing specifications.

The dimensions of the gasket were based on the operating conditions, the available bolting and gasket style. The current gasket used in the system utilized a solid metal core which utilized a stress raise nubbin on the shell side to generate sufficient stress to deform the metallic core. The use of solid metal gasket s on many heat exchangers has been replaced using serrated metal core on land. This was the option taken here to replace 1 solid metal gasket with 2 Kammprofile gaskets.

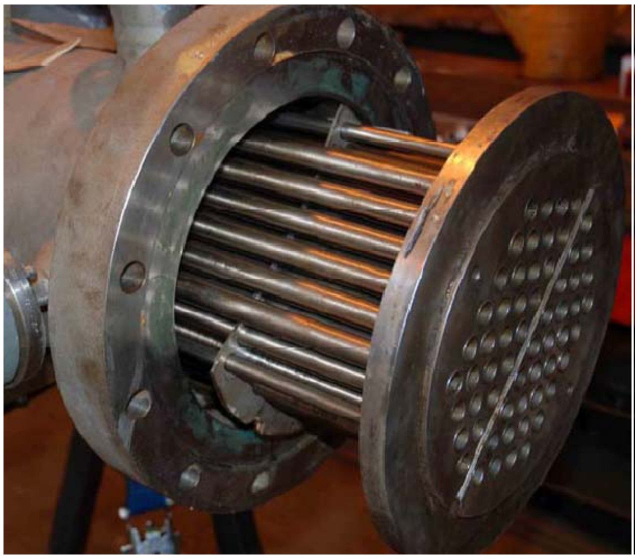
The Kammprofile gasket offers a low stress sealing solution over the solid metal product, utilizes a soft material deformation and not relying on deformation of metal, this feature of soft deformation of material is well established with significant growth worldwide on this product.



The gasket core is cut by guillotine action in a perpendicular cut. This action does not remove metal and provides edge prep for the welding. The tube sheet needs to be pulled to a significant distance to allow ease of access. The decision to remove or utilize the previous gasket is made following inspection and the necessary materials are cleaned and removed. The sealing faces are cleaned free from debris and surface condition noted.

The replacement by two gaskets could be an issue of the gasket already has a low maintenance factor and low minimum seating stress.

Photo of trial exchanger



Distance apart required for operations

Once the channel section was removed the bundle was pulled sufficiently to allow inspection and determination of the sealing faces. The pre split core is fed onto the back of the tube sheet and cleaned before any welding is considered. The tubes are cleaned and suitable protection of them is carried out to prevent damage or product contamination. (Not Shown)

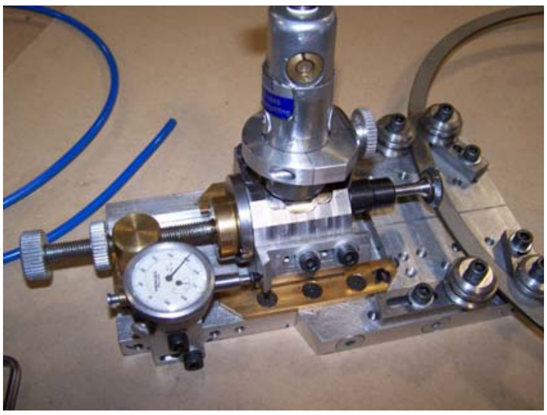
Site inspection of previously used shell to tubesheet gasket

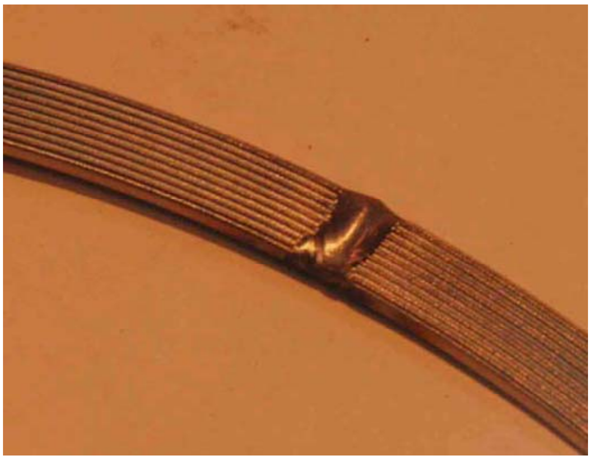
The core is positioned to allow ease of access for the weld to be carried out.

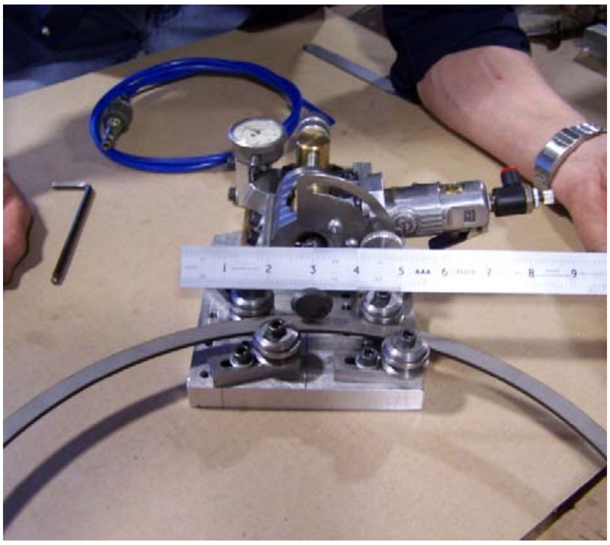
The core is aligned using wide jaw clamps and supporting sacrificial backing rings, these are stainless rings which are sized as the sealing element. This backing ring provides support for clamps to the exchanger baffles , they are utilized to hold the metal in alignment before welding and also used to hold the sealing face material onto the metallic core in climatic conditions. Trial run on sample pieces set out to set up welding machine and account for local conditions carried out in horizontal mode. This is accordance with the weld procedure.

A practice of using dressing tool also to give feel for conditions is recommended. This is to allow the operator a feel for the job in the

environment. A purpose designed compressed tool was developed. The serration depth, spacing is key to a successful seal. Groove alignment is achieved from clamping the rings prior to welding. Groove depth and spacing is determined by the tool, using a cam machined in the bush depth is controlled, spacing determined using a micrometer.







It is essential to have good lighting in the area as each of the individual kammprofile grooves will be dressed. The initial weld is removed using an orbital sander with a coarse wheel; the milling tool is used to dress the weld.

The individual serrations are re-cut using a custom manufactured portable milling tool. The prepared ring is located and fixed in place using four guides. The guides are adjustable to accommodate rings of varying width and thickness.

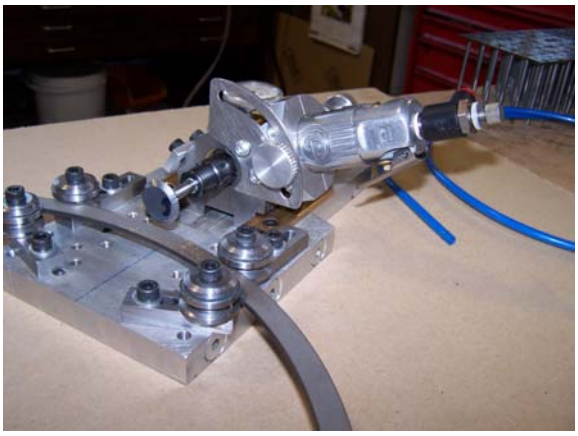
The cutting tool is initially positioned and set for depth by indexing the ring to a clean adjacent to the weld area. Depth is set by lowering the cutter head into the groove and tensioning the cutter against the bottom of the groove. This locates the cutting tool in-line with the groove. This position is used to zero the gauge associated with the linear index control of the milling tool. The linear indexing screw is then locked in place.

Once adjusted, the motor is initiated using the paddle trigger. The ring is then indexed, passing the welded section and cutting the groove in alignment with the balance of the groove.

After the initial groove is re-machined, the cutting tool is raised to a level sufficient to clear the surface of the ring. The cutting tool is then indexed inward based upon the factory machining specifications of the ring. Alternately, the same procedure used to set the initial groove location may be used.

Each ring is machined and a final cleanup is performed on the weld area if necessary to remove any small burrs or improve final flatness.

Once the re-machining is completed, the portable equipment is removed and the process for facing the ring quadrant is initiated.



The cleaning and bonding process is a three stage operation

Stage 1 use a citric based degreaser can label

Stage 2 uses either clean distilled water or an alcohol wipe to remove any residue of degreaser

Stage 3 contact adhesive applied to metallic and sigma sparingly

Example:
Citrus Based
Cleaner

Example:

Adhesive

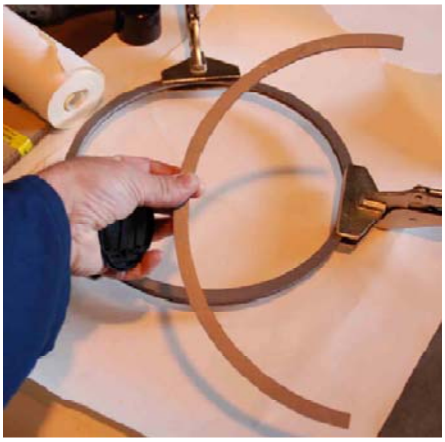
The cleaner is to be removed with a damp lint free cloth wetted with either clean water or white solvent material so as to remove all traces of the degreaser. The adhesive is applied to both sealing surfaces to be bonded. The minimal amount of contact adhesive is to be used to ensure bonding.

Both bonding surfaces – the serrated metal and the gasket facing are treated with the adhesive. The example shown is one option for facing in-place. The facing is provided in pre-cut arcs to suite the width and diameter of the ring. As shown in the example photograph, these segments are installed and then fixed in place using standard welding clamps. Larger diameters will necessitate more frequent clamping along with backing rings may be employed.

For high temperature facing materials such as Thermiculite, the facing may be bonded in advance of cutting, installation and welding, with only a small segment of the facing removed for the procedure. Mating arcs of Thermiculite are provided to re-face the bare segment. These facing sections are placed over the bare metal and extend beyond the coated face. The existing facing and segment facing are then match cut on a 45 degree angle using a razor knife at each end. The bonded facing, extending beyond the cut is then removed and the exposed surface is cleaned per the previous direction. The existing facing is protected against overspray while the bonding agent is applied to the bare metal and new facing segment.

In all cases, the joint should be clamped for a period of time which will insure setting of the bonding agent.

After removal of the clamps or backing, the entire gasket surface is then inspected and cleaned as necessary. The equipment may now be reassembled. Bolting up may begin.



Customer Approval

On certain exchangers where the flange bolts are separate the pulling over of the kammprofile from the channel side onto the tubeside can be carried out by manipulation of the solid 1 piece gasket into position by forming an ellipse and guidance. As with this case with the tubesheet with the intergral bolt holes this technique is not possible. To offer confidence to the customer several steps were taken

1. Trial using a full scale wooden mock up of the tubesheet to show and demonstrate the principle
2. A demonstration showing the technique on a smaller exchanger onshore to show the step by step method used
3. A weld carried out in situation on the smaller exchanger, dressed and manufactured. This was done on several occasions to allow the gaskets to be subsequently examined using NDE techniques and then subjected to compression loading, gas sealing test

3.1.1 Test 1, this involves a simple compression recovery test to determine the mechanical properties of the gasket. This test involves the placement of a refaced, welded used gasket between plates and loading and unloading at a predetermined rate of 100kN/min. Rig set to maximum 3MN which equates to gasket surface stress of 290MPa..

3.2 Test 2 , this involves a series of compression , recovery unloading tests on the gasket in a cyclic manner, up to a surface stress of 290MPa in 50 MPa steps.

3.3 Test 3, this involves loading the gasket to 290MPa, then pressurising the system to 180Bar with gas. The load is then unloaded in a series of steps with pauses every 500KN. The steps halt when 1 bubble of Nitrogen gas is collected in the gas jar. A visual record of sealing pressure is made when 1 bubble leaks.

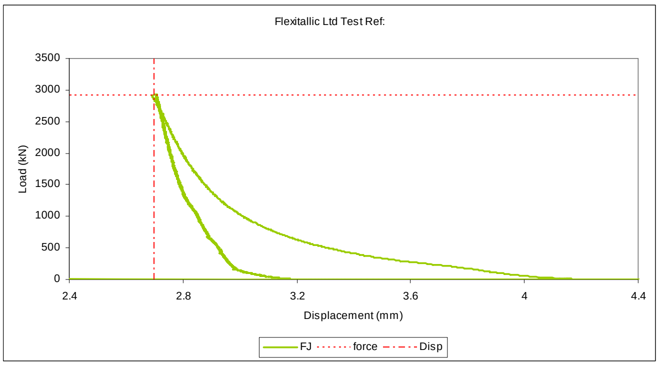
3.4 visual examination of sealing faces

Test Scope

Test Gasket dimensions = 325.2mm OD x 304.8mm ID

Area = 10093.9 mm2

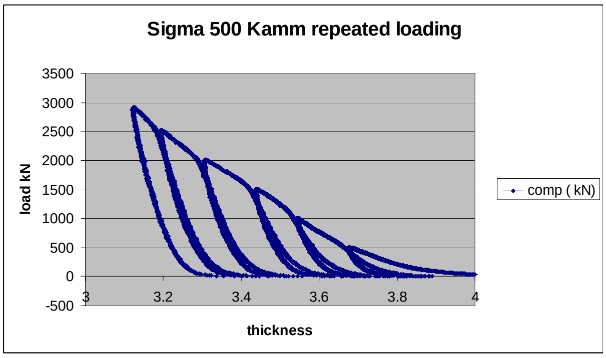
Test Results



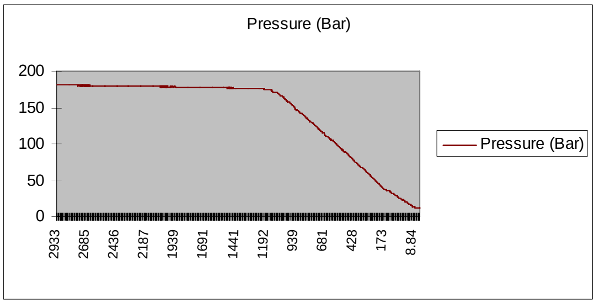
3.1 Test 1 Compression test on gasket, load unload characteristic

Cyclic	Load	Gasket Stress MPa	Rate
1	504.5	50	100kN/min
2	100.9	100	100kN/min
3	1514	150	100kN/min
4	2018	200	100kN/min
5	2523	250	100kN/min
6	2926	290	100kN/min

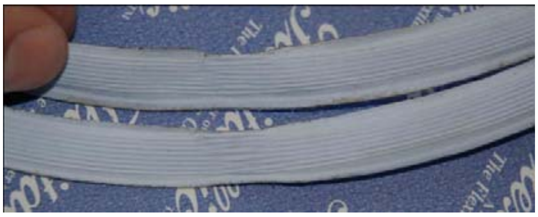
3.2 Test 2 Loading limits and stress value



3.2 Test 2 cyclic compression test characteristics

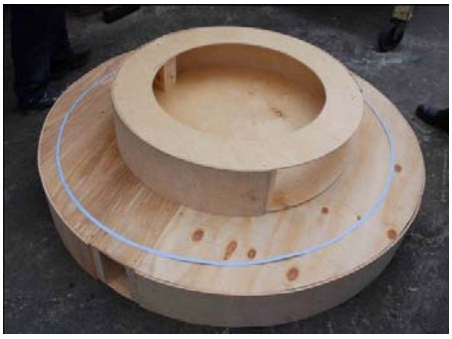


3.3 Test 3, Gas sealing test Pressure v Load
at 180Bar , unload until 1 Nitrogen gas bubble leak, at Gasket stress



3.4 Test 4 The underside surface of the gasket was removed and examined for damage after each compression test, the core was refaced before the sealing test.

1. Gasket welds were intact after 1 site test, 1 compression test, 6 cyclic loads and 1 sealing pressure test
2. the facing of the gaskets were not penetrated by the kammprofile core under a loading of 290MPa , therefore isolation of the core from the flange is intact
3. The gasket sealing width sealed 180 Bar without leakage



Full scale wooden model of the heat exchanger showing gasket position

Logistics

Once the procedure was finalized the unknown had to be anticipated in the plan. Duplication of cores, sealing faces and cleaning bonding materials were prepared

Climatic conditions could affect the soft face bonding to the metallic core so an effective mechanism for holding the material in situ using clamps and sacrificial support strips was used.

Oversized facing material to allow on site trimming on the cores

All of the materials were packaged, organized and shipped to site prior to shutdown commencement.

Conclusion

The bundle was pulled early in the shutdown, surface condition was such that a 2 part sealing element was used which was faced each side with single piece sealing face following the joining and the weld dressing. The shutdown was not delayed due to this critical component and returned into service following pressure testing.

Further work using this procedure is expected allowing troublesome exchangers with limited access to have the kammprofile gasket fitted.

end