NEW WELLHEAD SEALING TECHNOLOGY HARBISON-FISCHER INJECTABLE STUFFING BOX (INJECTA-BOX™) AND ALIGNMENT TOOL (PRO-ALIGN™)

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ABSTRACT AND SCOPE

The patented Harbison-Fischer Injectable Stuffing Box (Injecta-Box™) fitted in combination with the patented Harbison-Fischer Alignment Tool (Pro-Align™), was field tested from mid-2002 through to mid-2003 before being sold commercially. Four field tests were chosen to ensure that diverse conditions were considered and that the results were reflective of different regional requirements. This paper will review the testing program, the lessons learned and the resulting product that is now commercially available.

INTRODUCTION AND BACKGROUND

Pumping Unit Alignment and the Pro-Align™

The industry has known and accepted for many years that the alignment between the pumping unit and the well head is critically important to the effectiveness of the stuffing box and pollution control equipment that is fitted to the well head. The Harbison-Fischer Pro-Align™ was developed specifically to highlight any disparity in the alignment between the two pieces of equipment and ensure that perfect alignment is achieved and then maintained. See figure 1.

The Pro-Align™ tool is basically a flexible joint that connects the stuffing box to the production tee (or flow tee). The tool is designed to allow a fixed amount of movement that then highlights misalignment between the stuffing box and the production tee (or more importantly, between the pumping unit and the well-bore). The concept is to bring the misalignment to the attention of the maintenance crew so that they can correct the problem using the white alignment gauge fitted to the Pro-Align™.

The tool is made up of several parts that are held together inside the main body by means of an adjustable lower nut. A bushing inside the tool stops metal-to-metal contact with the polished rod.

The main benefits of using the Pro-Align™ tool are as follows:

- The tool offers a clear indication of both the direction and amount of misalignment between the pumping unit and the production tee without the need to necessarily kill the well. ***Previously, the crew would often need to fill the tubing with a hydrostatic head in order to open up the ratigan B.O.P., this would then allow them to look at the rod hanging freely through the production tee and make the appropriate adjustments. This method of establishing alignment does not allow the crew to look at the alignment issues at both ends of the stroke, nor does it guarantee that the sucker rods are in tension and in fact indicating the true working position.***
- Automatically adjusts and compensates for any angles that may be present in the wellhead. Often it is found that the well was completed at an angle or there may be a bad connecting thread between the wellhead components or the pipe work is pulled into a bind due to bad plumbing. These conditions cause a conflict between the stuffing box and the polished rod regardless of other alignment issues.
- The built in indicator gauge offers a direct visual link between what is happening to the polished rod throughout the stroke. If the gauge shows movement during the stroke, there is a definite geometry problem within the pumping unit. The pumping unit is designed to pull the polished rod directly upwards; any sideways movement indicates a problem. The problem may be a bad bearing or an incorrectly set horse head or a twisted walking beam etc.
- The tool offers the production crew the ability to identify and monitor problems as they occur. If a pumping unit starts to "crater" or move, the tool may well offer an early warning before the major damage occurs. If the pumping unit breaks loose from the tie downs, the operator may notice before the polished rod snaps.
- The tool will allow enough tolerance for seasonal ground shifts. Often the tool will indicate a different position in summer than in winter. This depends on the severity of the temperature difference and if the ground freezes and thaws.

Injectable Packing Materials

There are basically two types of seals used in stuffing boxes, pressure actuated seals such as chevron packing, or friction seals such as compression rings or cone packing. The 3-1/2" diameter cone packing is by far the most widely used stuffing box seal in the oil industry due largely to the fact that its bulk is more forgiving to misalignment than other available options. The cone seal is manufactured from various grades of rubber with enhancing additives to suit particular conditions.

The limitations of rubber cone seals are well known even when good alignment exists, therefore Harbison-Fischer began to explore alternatives that would offer the end user the following benefits:

- A system and material that would provide a secure and reliable seal without the need for constant adjustment
- A system that would alert the operator to add packing material before a leak occurs
- A seal that would not burn out if the well pumped off or if high rod speeds were encountered
- A system that does not require an operator to be exposed to the well contents while replenishing the packing material
- Less friction and drag on the polished rod

Harbison-Fischer concluded that an injectable packing material would provide the desired results.

Injectable packing material has been used successfully in rotary applications for many years sealing various materials such as chemicals, slurry and hydrocarbons. The injectable material is manufactured basically from compression seals (rope packing) that are broken down into fibers with binders and lubricants added to allow the material to be somewhat fluid. Materials such as Kevlar, Graphite and Teflon are often used as the base materials. The problem with using a non-rubber material such as this is that the material must be adjusted constantly to maintain a seal. At Harbison-Fischer we felt that we could design a stuffing box that could be live loaded using the well pressure to directly self-adjust the seals and when coupled to the Pro-Align™ tool would be suitable for use in the oil industry.

Injecta-Box™ design and features

The Injecta-Box™ has a built in mechanism that automatically adjusts the packing material by transferring the well pressure to packing pressure at a pre-determined ratio. When the internal mechanism automatically adjusts the packing, there are two vertical pins that clearly show the material usage to the operator and therefore pre-warns the operator that the stuffing box requires more material before a leak occurs. See figures 2 & 3.

The packing material has a very low coefficient of friction and therefore does not put any significant drag on to the polished rod. This feature should offer the end user a significant power saving and also reduce wear and tear on other associated parts.

THEORY

When the pumping unit is aligned perfectly to the well bore by using the integrated Pro-Align™ tool, the Injecta-Box™ will provide a secure seal that can be monitored and maintained before a leak occurs and without the need to open up the stuffing box to change the seals.

For the design to be successful H-F needed to test different applications to determine the optimal pressure differential between the well fluids and the Injecta-Pak™. Another critical factor was to establish and test the best means of containing the Injecta-Pak™ within the stuffing box.

FIELD TESTS

Four prototype tools were installed around June of 2002. The installations took place in East Texas, West Texas, Alberta-Canada and California.

East Texas

Harbison-Fischer with the help and cooperation of Devon Energy started testing an early prototype of an injectable stuffing box in April of 2002. The early prototype relied on our ability to move injectable packing material from one area to another through a check valve using the available casing pressure on a high-pressure gas/water well. It was quickly found that the more force applied to the injectable material to try and flow it through valves, the more back pressure and resistance was encountered. Using this information a tool was developed that used a piston to apply direct pressure to the injectable material

that was contained inside the stuffing box. This methodology proved quickly to be a superior way of energizing the packing material.

The test well had a residual pressure ranging from 150 psi up to 350 psi and tended to pump off on a regular basis. The prototype Injecta-Box™ provided a secure seal but tended to use more packing material than was expected or acceptable. At this time we had other test results flowing in and we knew that another prototype was running competently at 110 psi. We decided that a lower pressure differential was required to reduce the pressure that was being applied to the injectable packing. A third prototype was built that provide about half as much pressure differential as the first unit and once installed provided an immediate improvement to the run time.

The lower pressure differential unit ran until recently and required packing to be injected about every 45-days. The well continued to pump off occasionally over the duration of the test and the Injecta-Box™ always sealed once the fluid returned. The well produced only brine water and a wick-type lubricator provided extra lubrication. The test was considered successful and concluded after twelve months.

Alberta – Canada

A trial unit was set up for Conoco in Alberta during June of 2002. The test well had a history of unpredictably pumping off followed by an oil spill. The well fluid was 99% oil and was produced at 6 SPM on a 168" (14') stroke.

Once the prototype was fitted and the pumping unit started up, it was noted that the indicator pins raised and lowered about 1/16" as the polished rod passed through the stuffing box. The polished rod was then measured and found to be –0.035" at the mid point. The movement of the pins was a result of the Injecta-Pak™ expanding and contracting to suit the polished rod. The Injecta-Box™ did not leak but a new polished rod was fitted to avoid any confusion with the performance and results of the test.

When the crew arrived to change the polished rod they also changed the down hole pump as a change had been scheduled. The crew pressure tested the tubing to 900psi once the work was completed and the Injecta-Box™ sealed without incident.

The prototype Injecta-Box™ ran for a year before the test was completed and packing was injected once after a run time of 8-months. The tool ran through the Canadian winter without incident even though the well pumped off a number of times and ran dry.

West Texas

A prototype was installed for OXY-Permian at Denver City in the C02 flood field. The well was considered to be a chronic leaker and produced mostly brine water.

Unfortunately, this test did not run through to a conclusion due to various pumping well conditions not considered to be critical to the test program.

California

A prototype Injecta-Box was installed on a long stroke Dyna-Pump unit for Oxy in Elk Hills West California in July of 2002. The well had a 21ft stroke and pumped about 760BPD of brine water and heavy iron sulfide. The well fluid temperature was around 180 deg F.

The Dyna-Pump was badly aligned and had to be re set using the Pro-Align™ tool. Once this work was completed the Injecta-Box™ sealed securely. The well had previously needed attention on a daily basis but ran for about 60-days before needing additional Injecta-Pak™. Due to the electronic monitoring equipment that Oxy use in this field, we were able to note a significant drop in power usage from the Cone-type seals that were used previously to the Injecta-Pak™. The non-rubber based Injecta-Pak™ material showed a consistent 30% power reduction to the peak power consumption of the rubber Cone seals that had been used previously. The test continued for several months providing good results and data.

SUMMARY

The test program provided the following information:

Injecta-Pak™ Characteristics

Several injectable packing materials are available and are currently being tested to determine their applicability to specific well conditions. The initial packing material continues to give good service in its applicable temperature and pressure ranges.

The anti-extrusion rings that are used to contain the Injecta-Pak™ are critically important particularly during the first few days of operation. Once the material loses the added liquid lubricants, the packing solidifies and becomes more solid and less likely to extrude from the stuffing box. The binders that are used in the Injecta-Pak™ material are important because certain binders tend to allow the material to over stiffen during use causing difficulty in sealing gasses.

The design of the Injecta-Box™ uses a pressure differential based on the residual well pressure that provides the live loading for the Injecta-Pak™. Harbison Fischer has developed two differentials to cope with high (≥ 180psi) and low (≤ 180psi) pressure applications however, both ratio's have been hydrostatically tested to 5,000psi and are rated to a working pressure of 2,500psi from a structural point of view.

Injecta-Box™ Design

The Injecta-Box™ design has proven to be simple to get to grips with from an operational point of view. Operators and crews have no influence over the performance of the stuffing box and therefore the test results are accurate and untainted by undocumented adjustments.

Benefits of the Pro-Align™

During testing, we specifically asked for wells that had a history of constant leakage. The Pro-Align™ highlighted the alignment issues in two of the four test wells that would have otherwise interfered with the performance and results of the test program.

Strength and Robustness of the Design

One of the tests was concluded early due to a failure in the pumping unit that caused the rod string to fall and then stopped by a safety clamp hitting the top of the Injecta-Box™. The tool was examined for structural damage at the H-F manufacturing plant and only superficial impact damage was found.

Efficiency

Many of the Injecta-Box™ tools that have been installed during and post test phase have recorded outstanding results in terms of performance and ease of operation.

Diagnostics

The Injecta-Box™/Pro-Align™ tool has proved useful to diagnose problems such as:

- Misaligned pumping units
- Crooked well heads
- Pumping unit geometry and structural problems
- Tapered polished rods
- Uneven polished rods
- Potential power savings

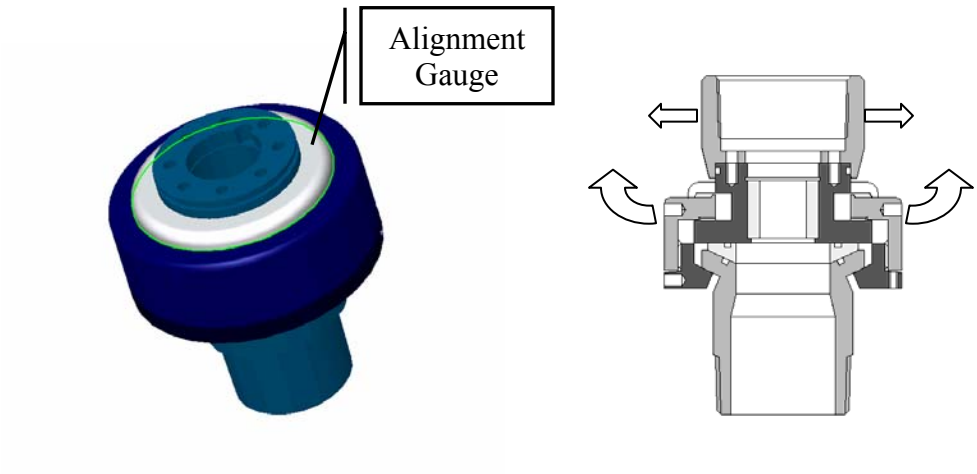
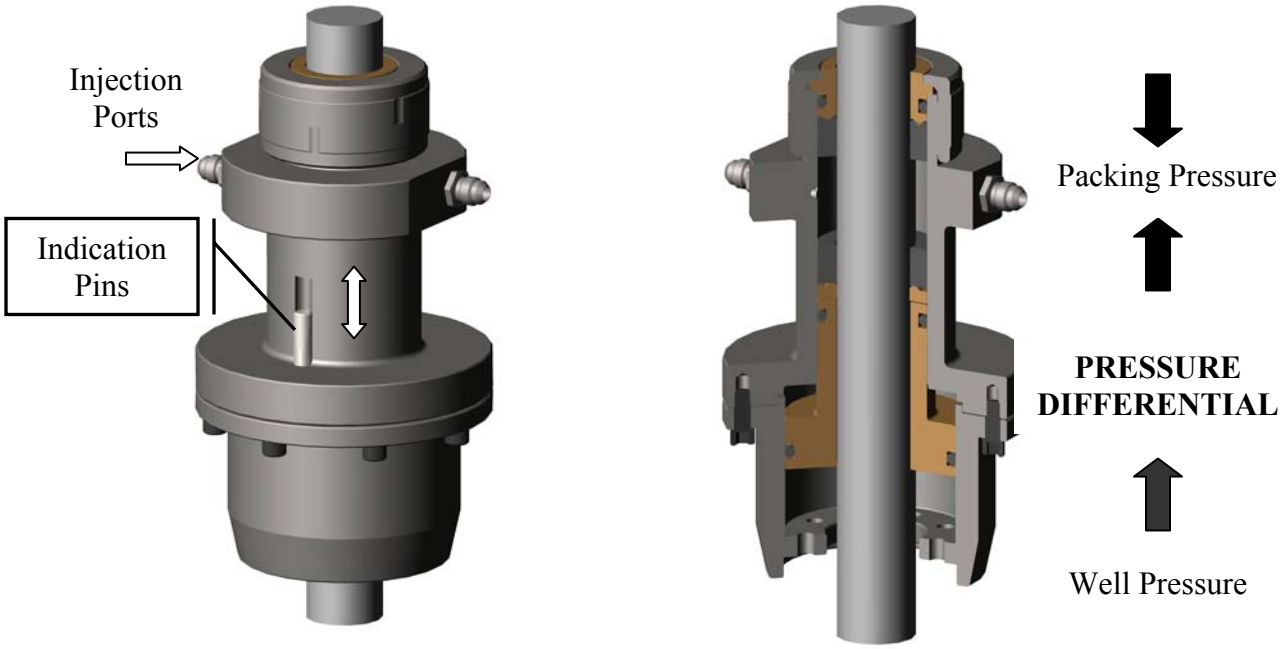


Figure 1



Figures 2 & 3