New generation of welding and inspection systems

Throughout the pipeline industry, and particularly in offshore and spool base production, welding requirements are shifting toward higher quality, greater accuracy and more precision. At the same time, everyone is concerned with pushing productivity levels beyond the old ideas of normal. Only new technology could address both of these needs, and developing an engineering solution is a complex process. CRC-Evans Automatic Welding is in a unique position to achieve a breakthrough in technology that establishes a new category of welding and inspection equipment.

Now, CRC-Evans is introducing the Vision Welding System, a welding system line incorporating advanced laser vision technology in every step of the welding process. The Vision Welding System includes the external welding machine – V Weld; Bevel inspection – V Bevel; Root inspection – V Root; fully automated purge control system – V Purge and a post weld inspection system V Cap. All have laser vision.

**Principle:**
You cannot manage what you cannot measure. With this in mind CRC Evans has introduced a line of laser inspection systems to measure quality and laser assisted weld systems for offshore and spool base industry to enhance quality and productivity in focus.

Specifically, this new technology process allows:

– Inspection, digital record and reporting of the bevel measurement to ensure the tolerances required for the root welding process are satisfied.

– For CRA and CMn materials higher speed mechanized external root pass welding without the need for copper backup.

– Inspection, digital record and reporting of the root bead immediately after completion. Should the root be rejected it can be corrected before any of the remainder of the weld is complete minimizing downtime.

– All external pass, high productivity, dual torch, welding system with real-time thru-the-arc and vision based tracking technology. Resulting in faster welding speeds than previously possible.
The vision system measures the weld joint volume. The joint information is used for adaptive welding by making adjustments to travel speed, oscillation width and wire feed speed. In this way each pass can have a level fill ratio around the pipe circumference optimizing the number of fill passes for a specific wall thickness. Ultimately, increasing the process efficiency and the overall productivity.

–Post weld inspection system to measure, digital record and report weld Hi Lo and Cap weld height.

**Development**

Always on a quest for solutions, CRC-Evans saw the need to create laser vision technology for higher speed welding in the harsh environments typical of pipeline construction, offshore and onshore. Standard, off-the-shelf laser systems typically are used with robots or in-plant applications, but these systems have a dedicated computer system for image and process control that makes them inherently expensive.

Through-the-arc technology featured in current CRC-Evans single and dual torch welding systems provides vertical and horizontal arc positioning. This technology has made possible more aggressive joint designs and welding procedures, while simultaneously reducing weld repair rates. However, it cannot be used for horizontal positioning in the root or cap pass. In addition, there is a limit on maximum welding speed for horizontal tracking. The arc must be oscillated to generate the arc data used for tracking.

Recognizing these problems, CRC-Evans developed a robust laser vision sensor able to handle the work environment of the pipeline industry. It has no moving parts, and the key embedded electronic circuitry is integrated into the laser vision sensor for image processing.

The laser vision sensor was developed to provide (A) weld productivity enhancements when welding in narrow groove pipe joints and (B) quality assurance in pre-weld and post-weld inspection. The new laser vision sensor meets these specific challenges, and its components permit remarkable flexibility at work in the field.

**Specifications**
The Vision Welding System’s laser vision sensor has a high resolution camera fitted with a high-speed digital signal processor and a large, very high speed gate array for intensive data calculations. It also has an industry standard communication backbone built in – Ethernet and controller area networking (CAN bus) make the sensor very flexible in configuring and extracting relevant information at a high speed. The sensor is built with a 50mm field of view that will comfortably scan a bevel and extract joint profile information up to 35mm in width. It has a 65mm nominal standoff distance to place it well above the pipe surface and maintain a horizontal resolution of 50 microns. The special camera optics doubles the height resolution that the sensor can achieve for the same package size. Unlike commercially available systems, the sensor is rated for handling industrial temperature swings (–40 degrees C to +60 degrees C). It senses electronically the ambient temperature and controls the temperature of the laser inside. It is also fitted with cooling ports that can use air or water.

Applications

**Bevel inspection**: This system V Bevel with laser vision, first in the industry can be used to measure the joint dimensions directly after beveling, allowing a “go or no go” decision. Unlike hand-held gauging, in which narrow gap levels are difficult to measure, the laser vision sensor is precise. The V Bevel machine is placed in the pipe end, and the laser vision system V Bevel is driven around the pipe end using a stepper motor, an accelerometer to provide a reference to a start/stop position for the measurement data. The start/stop positions and the rate at which the measurement is taken are fully programmable.

The process sounds complicated, but the system is actually simple to use (Figure 1). It is a self-contained intelligent bevel inspection system that includes a laptop computer to record data permanently.
Once the pipe is beveled, the pipe facing machine (PFM) operator inserts the system (Figure 2) into the pipe end and runs the inspection tool around the pipe. The measurement can be continuous or segmented into a variable number of fixed positions. If the bevel fails to meet the specifications, it can be re-beveled immediately. Typically, beveling is not in the critical path, so no loss in production results from re-beveling. However, once in the firing line, non-specification bevels that are found just prior to root pass welding can have a dramatic effect on production because the pipe has to be re-beveled in the critical path. Other problems that can be prevented are root pass defects resulting from non-specification bevels. In offshore and spool base applications where repairs to the weld are in the critical path, this can have significant effects on productivity and operating costs.

**Purge control:** When the pipe is a corrosion-resistant alloy (CRA) material, bevels and root quality take on further importance as the root and hot pass must be back-purged to prevent oxidation of the parent material. Often the root must be free of defects to ensure full in-service performance. To handle this stringent back-purge requirement, CRC-Evans offers a fully automated pressure based (Fist in the pipeline industry) close loop purge control system with laser vision, called V Purge, (Figure 3) to control and monitor the purge chamber parameters and the inline inspection to go along with it.

**External Root weld CMT (Cold Metal Transfer) process**

As the offshore industry explores and brings on stream fields that extend far below the ocean floor, the need for high-integrity, high-quality root weld process increases. Over the last few years we have investigated and developed the use of the Cold Metal Transfer (CMT) process for use on pipeline applications. CMT is a modified GMAW process that uses a new method of droplet detachment based on short circuit welding.
Originally intended as a method of joining thin-gauged materials in the automotive industry, this technology became the subject of our research to find if it was suitable for root pass deposition on pipeline girth welds. The result is our P450 CMT platform. For mechanized pipeline girth welding, the CMT process is delivered via a conventional bug and band system. CRC-Evans employs its P450 fully digital welding platform with vertical tracking capability in conjunction with the Fronius TPS 3200 power supply, a push-pull wire feed system.

**P450 CMT Platform**

The process positively detects the short circuit and cuts off the power and thereby reducing the effective heat input.

The main advantages of the CMT process are:

1) No copper backup clamp required – can be used on tie-in applications.

2) Can be used on different materials – carbon or clad steel applications.

3) J Bevel profile - reduces the weld volume required, in comparison to open gap manual TIG welding decreasing the time and cost of a weld.

4) Deposition of a high-quality root - with a profile that has a low re-entrant angle increasing fatigue life (Exceeding C Class) and performance.

**Root inspection:** V Root is an internal inspection system that includes a vision laser sensor in conjunction with a two-dimensional (2D) charge-coupled device (CCD) color camera (Fig 4) to perform a root inspection directly after root and hot pass welding. The internal intelligent root inspection V Root is attached to the rear of the line-up clamp, becoming an in-line analytical tool that minimizes the downtime associated with using a third party tool. This system provides the root profile and the 2D raw color image, clearly showing the discoloration and any geometrical defects of the root pass. The root
inspection system creates a permanent record of the root profile and visual image that can be stored and replayed in the laptop. This can be used as a “go, no-go” as well as a reference for the AUT weld inspection. If a root defect is found, then the joint can be cut and prepped in the same station, far before the defect call-out would happen after all the passes had been deposited, so a significant waste of production time can be avoided.

![Image](image.png)

**Figure 4-** V-Root, performs root inspection after root and hot pass.

**External welding:** The V Weld external fully digital welding machine integrates the laser vision sensor with the CRC-Evans P625V (Fig 5) to become a fully digital dual torch welding system. This system measures the critical dimensions of the narrow gap joint and provides feedback to center the torch and control the vertical position of the welding arc. It also provides the changes in the joint width variations in real time. This information is transmitted digitally to the V Weld lead torch spaced at a known distance from the laser vision sensor. The information is used by the V Weld advanced embedded control system to adapt to the real-time variation in the joint fit-up. The laser vision sensor also measures parent material mismatch (HiLo), and area. Therefore, in addition to the real-time seam tracking and width adaption with the dual torch system, process control can be used to optimize the weld pass depth, ensuring constant joint filling around the pipe. This feature reduces costs with a minimum number of passes to complete each wall thickness, and eliminates the need for partial fill or strip passes.

The Vision Welding System’s first use in the field will be an Incoloy-clad project scheduled for fabrication in late 2011.
Post Weld Inspection: V Cap (Figure 6) Uses a laser sensor mounted on an external welder carriage to measure the Cap HiLo, Cap Height and Cap Width. V Cap can be used for Pre weld inspection to measure Root HiLo, Root Gap, Top Gap, Top HiLo. Scanning is a single button operation. The scan positions are recorded and played back on a computer. This system has found use in strain based design analysis.

Conclusion and Commitment

The V Bevel, V Purge, P450CMT, VRoot, P625 are being used on several projects in the offshore and spool base industry today. The projects have enjoyed a higher quality and productive welding while yielding 0.2% to 2% repair rates. V Cap system was used for the APP project to do strain based design analysis. P625V is slated to be used in 2011.

These developments are just the beginning of laser vision applications, underscoring the CRC-Evans commitment to leading-edge welding technology designed to meet the evolving requirements of the pipeline industry. Increasing productivity and raising the quality bar are constant goals for our company.