PATENTED OILFIELD RFID SOFTWARE AND HARDWARE PACKAGE DELIVERS IMPROVED DOWNWELL PRODUCT ACCOUNTABILITY, QUALITY CONTROL, INVENTORY MANAGEMENT AND ASSET TRACKING

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RFG Petro Systems, a designer and manufacturer of specialty tools and equipment for oil and gas well production, has developed software and custom wireless and digital serial number RFID tags for attachment to rod string components for use within the well-bore. These tags reference manufactured products as to their recorded manufacturing and quality control system data (material specifications, machine pressures, process times, temperatures, manufacturing date/conditions) and logistics of the product from creation to end-of-life.

RFG's custom hardware and software package enables the manufacturer to scan a product at any time and retrieve its manufacturing and logistics history, providing the product user with greater transparency of the product's manufacturing/quality and for better controlling inventory management and asset tracking. By creating new time/date stamps and specific user-controlled instances within the database system during a product's manufacturing, transit and use, data can be linked to it on an individual level to track and trace how the product performs over time. Every instance and data-set taken is provided to the database for the manufacturer to evaluate product life and use and to implement product improvement.

HISTORY

The artificial lift spectrum of products for oil and gas is extremely broad, with countless vendors offering products that are utilized within the wells. When a problem occurs, it can be difficult to trace and track the product, the vendor, the vendor's quality plan and documentation, manufacturing conditions and machine operators – all factors needed to generate a thorough failure analysis report.

The American Petroleum Institute (API) has integrated certain traceability requirements for manufacturers of sucker rods and couplings and product labeling associated with them. Unfortunately, that thin level of traceability often is not enough to meet the end-user's failure analysis needs. Furthermore, the tracing of production information often is dependent on time-investment, cooperation and paperwork of the manufacturer, as well as the paperwork and traceability of the distributors record-keeping.

In addition to traceability difficulties in sucker rods and couplings, no standards or requirements exist in the world of rod guides. The quality plan and traceability of rod-guides – which typically are molded in black and come in various shapes, depending on the manufacturer, produced in facilities all over the country – do not have discernable differences.

Once rod guides are molded, there is virtually no traceability to the exact manufacturing conditions, time and date produced or raw material batch numbers, other than perhaps a quality assurance tag on a bundle of sucker rods with manufacturing and shipping dates, and perhaps the name of the molding operator or inspector. Rod guides are shipped to different end-user yard locations and distributor stocking locations. During transportation over the open road, the quality assurance and production tags fixed to the rods or bundles can become detached and lost.

The above-mentioned limitations between manufacturers, logistics companies and distributors and the well site do not meet the needs of the end-user who wants the answers NOW. Because of this, RFG Petro Systems started working with a creative and innovative software and hardware integration development company, Exares, for our sphere of artificial lift.

SOLUTION

Technology is always advancing, and our industry is heavily dependent on computers, the Internet and the digital world. Resources are readily available to digitize records and data, yet in physical products and goods, especially in the area of oil and gas, it doesn't appear that artificial lift has endeavored to integrate digital serial numbers for tracking the movement and use of forged, machined and molded artificial lift components.

RFG Petro Systems is in the rod guide business, and we have a forging operation to manufacture stabilizer bars and pony rods. We are also in the business of guided sucker rod couplings and standard API –compliant couplings. We pride ourselves on quality, continuous improvement, innovation and integrity. The manufacturing chemistry and process we developed for our rod guides is unique and has never been attempted before. We have focused on refining our manufacturing process, improving our quality control and digitizing all things related to our products. As a relatively young business in this industry, we knew that it was critical to earn the respect of our distributors and end-users, and one way of achieving that was by being 100% transparent in product quality control and assurance of the products produced by RFG Petro Systems.

By integrating RFID tags – incorporating a wireless, scannable, digital serial number into all of our products – we can trace back to the exact minute, even the second, when a product was manufactured, under which conditions, the batch of raw material, the molding or press operator, the environmental conditions – everything. This can all be done instantly by use of a cloud-based web service of Exares, the software company leading the way in seamless tracking and monitoring of artificial lift component manufacturing and logistics. The database and integration of RFID scanning portals and manufacturing monitoring throughout the artificial lift industry will bring a new era of data-collection and product improvement to the market, and RFG is proud to be leading the effort.

Beyond RFG's own use for our internal manufacturing quality control and assurance, this technology can be used in the distributor's yard for inventory management. Inquiries about product type, configuration, and manufacturing date can be easily visualized and referenced, improving oil field first-in-first-out protocol. Product suppliers can alert distributors, notifying them of how many components remain in the distributor's yard, where they are, and provide instructions about what protocol should take place in the handling the product if special circumstances arise.

Moving closer to the well, the database and web-portal are accessible in seconds via handheld RFID scanners linked to smartphones and computers. Whenever there is a question about a product, a few clicks and a trigger pull inform the user that the manufacturer's product quality data information is available. Write in a quick note such as "rod stretch observed," and click again; a request is sent to the manufacturer for this information, perhaps verifying the chemistry and yield strength related to the associated batch of sucker rods. The manufacturer, assumed to have joined this program in an effort to benefit the industry and the end-users, transparently acknowledges that the data is available. There should be no hesitation in releasing the data to the customer.

Furthermore, tagged components can be scanned in order of installation within the well, from the bottom of the rod string to the top. By knowing how many rods are in a well, the exact location of the sucker rod within the well is identified. This is extremely beneficial as now this sucker rod can have an estimated load factor correlated with the sucker rod. Add a stroke counter to the system, and the database now knows the load on the rod and how many cycles the rod has been put in tension. This allows the sucker rod inspection company to then sort rods by cycle-life, assuming they pass inspection, which allows the rod owner and end-user to use rods in healthy environments for extended well life.

AFFIXING THE TRANSMITTER

Embedding RFID tags in rod guides at first conception is a relatively easy task. Affix the tag to the rod, mold over it, and it is protected and permanently attached to the rod and guide. After experimenting with this and testing this during molding, the plastic melt temperatures and the high velocity of the injected material have shown to destroy the tag and dislocate it from the rod body. Further, typical, tags showed a resonance change due to the thick and hard surface of the plastic, as well as its glass and mineral fillers. As a result, specialized tags have been developed to resonate correctly with the radio frequency waves as required by the FCC, through the plastic rod guide and with the tag attached to metal parts.

LINKING THE TAG TO THE DATABASE

The EPC, or digital serial number of the tag, must be scanned and referenced against the database at different checkpoints throughout its travel in order to provide benefit to the manufacturer, distributor, and end-user. Being that the goal is to link manufacturing conditions and transparency to the end-user, it is preferred that tags are integrated at the manufacturing point of the product which is to be tracked and traced.

Coupling Manufacturing

Sucker rod coupling tags can be incorporated throughout the trays for manufacturing, for increased traceability. At the conclusion of manufacturing, the tag can be affixed to the outer body of the sucker rod coupling. This tag can then reference the bin tag, extending the traceability of when a slug of material was cut from bar stock, when the part was turned, thread-rolled, and gauged/inspected.

A multi-instance reader setup would act similar to the sucker rod manufacturing process. Bin tags would represent a lot of parts, for example, 25 pieces. An antenna can be placed before or after each step of the manufacturing process. Material cutting from bar-stock, drilling, machining, thread-rolling, coating. Prior to boxing product, and when tags are applied to the individual part, the individual part will always have ties to the bin, identifying when the part was turned, the material lot, etc., by the manufacturer, as shown in Figure 1.

Rod Guide Manufacturing

Use of RFID tags embedded in rod guides allows a manufacturer to trace the product from manufacturing, collecting all the conditions which the guides were manufactured, to the distributors and beyond. Different scan instances and checkpoints are set throughout the guiding facility. A multi-antenna system is integrated through the facility, whether with fixed, permanent readers, or field/handheld readers. Molding employees scan tags prior to molding, marking the rods as ready to mold, and, after molding, marking the guides as molded. This provides the exact time and date that the guides were manufactured, further referenced to the live data-logging and monitoring system of molding presses, temperatures, and material batches kept on file. Tags are also scanned with the time and date stamp to tell the manufacturer when the product was inspected prior to shipment, also with the time and date of being loaded on the truck. A graphical representation of this is shown in Figure 2.

Distributor

Distribution companies could also utilize and assign tags to products, further providing benefits even if the manufacturer does not utilize this system. Doing so would help track and trace where the product comes from and goes to, allowing for ease of data retrieval upon request of an end-user, but without referencing manufacturing parameters unless a distributor linked a document via image upload, which shows shipment history or material certifications. Tags can be attached to the rod body and the product type and configuration can be assigned to the tag number. The software requests the name of the manufacturer, size, API grade, forging date, heat number, and manufacturer's work order number. These inputs can be assigned in batches, as most often the palletized rods would have this information provided on the bundle (Figure 3).

The software allows for building virtual pallets of individual tags. Doing so allows a user to "move" inventory from one location to another, as a group. For instance, a group of sucker rods are all scanned as they are being palletized. One hundred tags are referenced as a virtual pallet. To reference the pallet, one tag is scanned and the user selects "Pallet" instead of "Rod", as any individual tag would be able to reference the other 99 tags. Scanning one tag would reference and move all tags within the pallet during the next steps. If a rod needs to be extracted from a pallet, a "Remove from Pallet" prompt is selected and the tags scanned while in this feature set would disassociate the sucker rod with the pallet from which it was pulled.

Well Site

Tagged components shall be "Installed" to wells in order to complete the circle of product life database. Scanning tags with readers at the well-site in order of installation provides a location of the rod within the well. The database

calculates the mass of the entire rod string for the well (the weight of the rod string below each rod). Furthermore, anticipated tensile stresses to be exposed on each sucker rod throughout the well can be computed with the weight of the fluid.

At the time of rework and maintenance of the well, the rig crews can scan sucker rods that are laid down. The sucker rods that are brought to the well site to replace the rods which were removed are scanned in the order of installation, along with user input providing where the rod string from the racks of the rig were installed. Moving forward, the database can compute the loading of the rod string.

The sucker rods that were scanned out of the well would be sent to the inspection yard or retired at the option of the operator. The next scan instance would allow for the end-user and owner of the rods to be remotely aware of what happens with the rods.

USE OF THE SOFTWARE DATABASE

User Profiles

A series of user profiles are created for those who are authorized to use the system. This allows specific controls, restrictions, and sharing allowances from each type of user. These include the following:

- Manufacturers
    - Self-inspect and retrieve all data related to the manufacturing of the product observed in a satellite location
    - Inventory control – tracks where product is located, how much has been sold and assigned a well, assuming a distributor authorizes participation in this feedback system
    - Trace product life related to manufacturing parameters and material lots
- Distributors
    - FIFO & Inventory Counts
    - Sales history by customer and well is in a database
    - Rod reclamation and management
    - Sales data for sucker rod average life and cost justification of inspection vs. new rods.
- Inspection Companies
    - Sales benefits, report back to the end customer which rods where kicked out for failed inspection
    - Pass/Reject rates
- End-User
    - Track when products were manufactured, what facility and vendor.
    - Asset management and AFE justification
    - Able to send inquiry requests to manufacturers for specific manufacturing details
    - Tracing of assets from well to well throughout inspection (sucker rods)

Manufacturer

Digitized serial numbers and a web-based database system allow for unparalleled ease-of-use for tracing and tracking products beyond the manufacturing facility. A user of an RFID handheld reader, also known as the RFID gun, can simply walk up to a sucker rod, guide, or coupling, and scan it. The RFID gun communicates with the smart-phone or tablet, which is connected to the internet and the web-database system. The RFID tag serial numbers are referenced in the database, allowing for retrieval of manufacturing time, date, parameters, material batches, etc. Data is returned to the user based on its permissions. Example is shown below:

Rod Guide:

- Manufacturer scans guide
- Retrieves Authorized Information
    - Manufacturer
    - Facility Location
    - Material Batch

    - Size
    - Time/Date bar prepped
    - Time/Date bar molded
    - Machine number
    - Mold temperature
    - Material temperature
    - Cycle data-log plot
    - Coated/palletized
    - Relative quality assurance information
    - Shipped from manufacturer to distributor date
    - Distributor

Distributor

A distributor can monitor incoming inventory from manufacturers implementing the system, and utilize the ease of wireless traceability to optimize logistics and employ a FIFO system. Furthermore, the distributor can track trends of products shipped, search wells through the database to retrieve what product was assigned to it, and do monthly inventory counts for accounting and sales purposes.

Service-based distribution partners can offer unparalleled management of product to the end-users, as data retrieval is stored in a central system which allows for nearly instantaneous retrieval of the data associated with the product. The software system also allows for reports, visualization, and requests to be sent to manufacturers if the data is on-file.

End-User

Field engineers, workover rig teams and consultants can work with the parent end-user to retrieve data for product that is within a well. If a failure of a product occurs at a well site, the RFID tag associated with the product can be scanned and notification can be sent to the manufacturer. In addition to this feature set, the end-user, if authorized, can retrieve material information, manufacturing date, manufacturing parameters, shipment history, usage history – everything that has ever been associated with that tag – all with an RFID gun and smartphone or computer. A few examples are shown below:

Failed Rod:

- End-user retrieves rod part end with tag
- Scan tag
    - Notify manufacturer (email)
    - Notify distributor (email)
- Retrieve Authorized Information
    - Manufacturer
    - Facility Location
    - Date
    - Time
    - Chemistry
    - Size
    - Inspection confirmation
    - Shipped from manufacturer to distributor date
    - Distributor
    - End-user purchase date
    - Shipped from distributor to well location date
    - Well name
    - Install date
    - Cycle count (if integrated)
- If sucker rod has been inspected, in addition to the above:
    - Inspection company
    - Facility Location

    - Time/Date Inspected Threads
    - Time/Date EMI
    - Time/Date Black-light
    - Time/Date Palletized
    - Shipped from inspection company to distributor date
    - Distributor
    - Shipped from distributor to well location date
    - Well name
    - Install Date
    - Cycle count
        - Total cycle count

Failed Rod-Guide:

- End-user retrieves rod part end with tag
- Scan tag
    - Notify manufacturer (email)
    - Notify distributor (email)
- Retrieve Authorized Information
    - Manufacturer
    - Facility Location
    - Date
    - Time
    - Material Batch
    - Size
    - Relative quality assurance confirmation
    - Inspection confirmation
    - Shipped from manufacturer to distributor date
    - Distributor
    - End-user purchase date
    - Shipped from distributor to well location date
    - Install date
    - Cycle count (if integrated)

HARDWARE INTEGRATION

Additional hardware can be integrated into the web-based database system.

Manufacturing Monitoring – Similar to that of RFG Petro Systems, product manufacturing companies can have monitored equipment and data being uploaded to a secure, privatized web-server for easy data retrieval against products which are manufactured, through the traceability of digital serial numbers.

Cycle counter – All rods which are assigned to well after being installed can have cycles counted and uploaded to the web-based system. This along with rod location within the well allows for sucker rod loading and tensile cycles (fatigue) to be shown against each other, telling the end-user the exact grade of rod, rod load, and cycles to failure, no matter what well has the system (Figure 4).

QUALITY ASSURANCE/INTEGRATION

Quality plans can be logged and incorporated into the web portal as they are conducted. The time and date stamps would be representative of the product being manufactured, as the closest before and after inspection time would allow assurances that quality inspections and assurances are made for the product manufactured between those checks. This narrows down the window of variables and possibilities of incorrectly manufactured product, and also publicizes that these checks and data exists for the end user.

The software structure and database system by Exares is specifically built for use in the artificial lift market. This sophisticated database system provides multi-level users, working with manufacturers, distributors and end-users to

cross-share information for the betterment of manufactured oilfield product. In the event of product concern, the distributor or end-user can confirm that the quality checks were conducted at the manufacturer. For detailed information, the data can be requested from the manufacturer, and the information can be released by the manufacturer.

SUMMARY

The goal of this system is to allow the manufacturers, distributors, inspection companies, and end-users to have better access to information from one another in a streamlined program and process at the individual product level. It gets difficult to trace and track the parameters associated with the product – where it came from, where it has been and where it is going. API has done a good job with simple heat codes and manufacturing codes required on wrench squares for sucker rods. Unfortunately, the manufacturer has no accountability to the paperwork that is filed away, and there is no easy retrieval. The system is heavily dependent on multiple human intervention, communication, and time allowances. Furthermore, the end-user has no way to easily monitor the path of the products from the manufacturer to the well site, then to inspection companies, and to the next well site. This system solves all product traceability problems so long as the tags are being scanned at its different locations.

As for rod guides, there are no manufacturing dates molded into them, there is no batch number text molded into them, there is no accountability with the product. Retrieving a product from a well and evaluating when it was made, through what facility, what material batch, molding pressures, temperatures, and time cycles, how long it sat in the distributor's yard, and when it was shipped to the well site, was absolutely impossible, until now.

With ease of use, manufacturing operations and inspection companies can utilize fixed (permanent) readers automating all scan processes in addition to manufacturing parameters being incorporated into the system via data-logging and monitoring; the implementation for this system becomes seamless. The distributors are dependent on handheld readers as they build the customers rod strings and send them to well-site locations, which still require minimal human intervention. Pull a trigger, capture the tags of products on the truck prior to shipment, and assign a customer name, well name, and paperwork reference if needed.

Some of the more sophisticated integration at the well-site may include trained personnel or cellular equipment, such as the cycle counter proposal. As rods are moved from the pipe racks and into the well-bore, the tags can be scanned and the rod loading can be interpolated based on the number of tagged rods already installed in the well. A total depth is calculated, the fluid weight is calculated, and with the cycle counter system, we know how many times the sucker rod saw cyclic loading. Incorporate this with BHT and the degradation of yield and fatigue strength due to down-hole temperatures, and a comprehensive dataset is collected. This data set provides limitless engineering improvements for beam-lift system design. The web-portal of this software allows for impeccable visualization for product and tag tracking, as well as mechanical system engineered analysis for sucker rod fatigue.

This central system is for the end-user, and it is the end-user's responsibility to request, enforce, and ask for this kind of traceability with its products. The manufacturers, at the request of the end-user, will comply with this system. RFG Petro Systems is utilizing it for its own benefit, knowledge, and to enhance the products it manufactures, which happens to also benefit our customers greatly. By expanding the use of this technology across the industry, manufacturers can team up together and make ancient beam lift a 21st century technology.

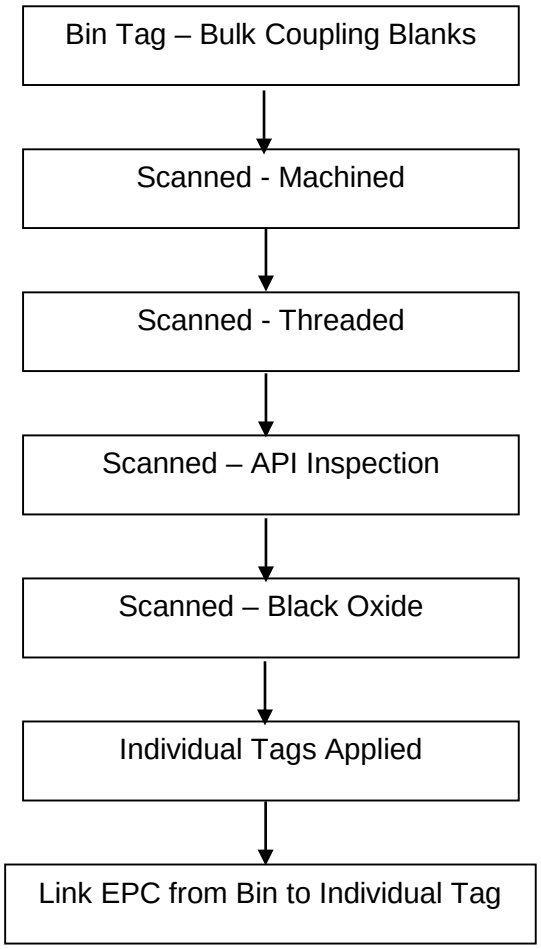
Bin Tag – Bulk Coupling Blanks
Scanned - Machined
Scanned - Threaded
Scanned – API Inspection
Scanned – Black Oxide
Individual Tags Applied
Link EPC from Bin to Individual Tag

Figure 1.

Figure 2.

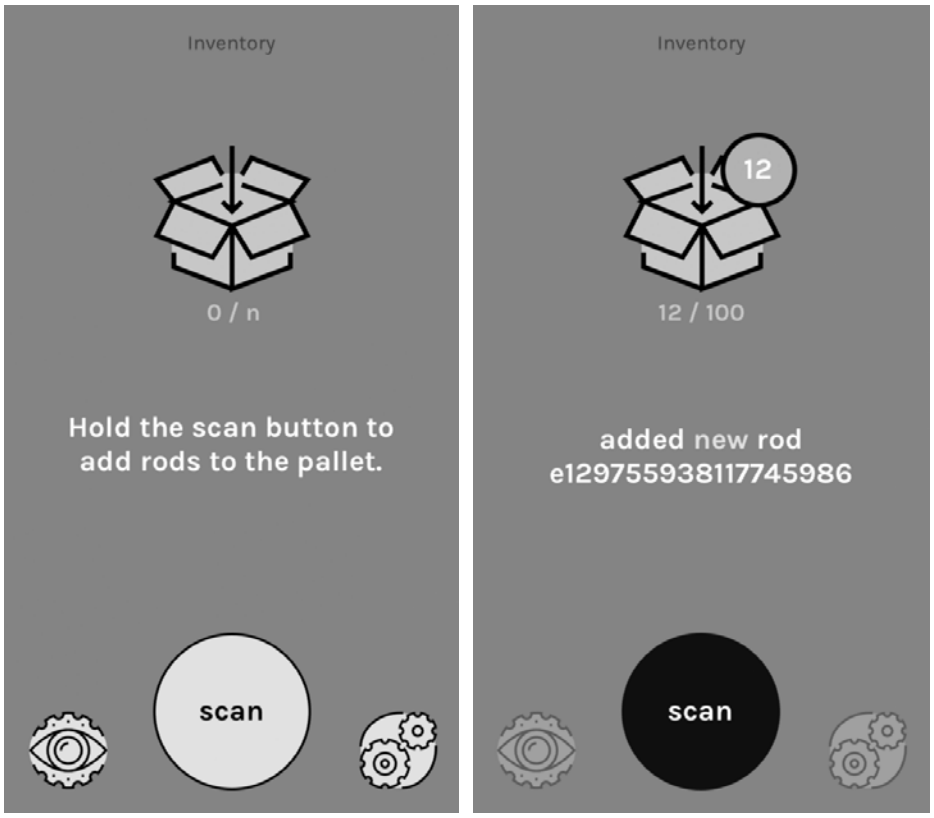
Inventory
0 / n
Hold the scan button to add rods to the pallet.
scan
Inventory
12
12 / 100
added new rod e129755938117745986
scan

Figure 3.

Figure 4.