Norris Sucker Rod Project

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Introduction

Mission Statement
Our mission is to use the knowledge and expertise of our members to provide quality service and innovative solutions to the people and businesses of Oklahoma. We aim to help our clients to achieve their goals and to exceed their expectations. We value work that is done right over work that is done quickly, and seek to add value to our client’s businesses through quality work.

Problem statement
API specification 11B requires that sucker rods are tested for Total Indicator Reading sometimes referred to as "Total Indicator of Run out" or TIR. Norris has designed and installed equipment on several of the CNC rod end threading machines to check TIR. At present they do not perform inspection on all rods. Norris desires to expand this operation to check TIR on all rods or perform 100% inspection.

Statement of Work
Background: API specification 11B requires that sucker rods are tested for Total Indicator Reading (TIR). Norris Sucker Rods has designed and installed equipment on several of the CNC rod end threading machines to check TIR. At present, they do not perform inspection on all rods, but they do desire to expand operations to check TIR on 100% of the rods. After the rods are inspected and TIR measured, random samples are sent to a third party for “verification”. In the past Norris has not had some problems with their readings matching up with the third party’s readings. As of late this has not been as big of an issue, but Norris still wants a complete remake of their current process. We will be designing a new mounting system that will have much less user interference. Doing this will allow for 100% inspection of all rods produced, and will not interfere with the operators.

Scope: The objective of this project is to develop a new process for measuring total indicator reading on sucker rods for Norris Sucker Rods. The new process will be integrated into the
production process and will inspect all rods (15,000 per day maximum) as they are produced. The total cost must be less than $60,000. After the measuring process has been completed, a statistical analysis of rod failures will be done to identify likely causes of TIR failures. As well, attention will be given to the best way to address non-conforming rods.

**Deliverables:**
1) Completed design/prototype
2) Layout/location of inspection equipment
3) Process for reworking non-conforming rods
4) Calibration process to ensure alignment with third party

**Period:** Fall and Spring Semesters (8/2012 – 5/2013)

**Location:** Norris Sucker Rods – Tulsa, OK  
Oklahoma State University – Stillwater, OK

**Applicable Standards:** API Spec 11B

**Acceptance Criteria:** TBD. Further discussion with Norris is needed to determine exact acceptance criteria. However, the design must meet the basic requirements as outlined in the scope of the project of reliability, durability, cost, and accuracy.

**Work Breakdown Structure**

See Appendix A for Work Breakdown Structure.

**Tasks List**

**Oversight**

- Weekly progress reports submitted to Norris, Win Adams, and Dr. Weckler
- Ensure open communication between parties

**Research, Technology, and Information**

- Understand requirements set forth by API Spec 11B
- Research methods/technologies used to measure TIR
- Research technologies that are applicable to our situation
- Visit Norris and determine possible locations to integrate measuring system
- Gather information (measurements, specs, layout) needed for design
Design

- Develop designs based upon location, measuring device, etc.
- Perform engineering analyses on designs (fatigue, yield, cost, etc)
- Produce drawings of design(s) and the parts included
- Put finalized design(s) in a report to be presented to Norris at end of Fall semester

Approval

- Meet with Norris and submit design(s) for approval
- Make any modifications and resubmit for approval

Fabrication

- Submit approved drawings to have parts fabricated
- Produce a calibration rod

Integration

- Assemble measuring devices into mounting system
- Integrate assembled system into Norris’ production process (at specified location)
  - Use existing power
  - Use existing PLCs (if needed)
  - Use existing marking system for failed rods
- Calibrate system

Testing

- Perform functionality tests
- Perform tests for accuracy, repeatability, and durability

Data Collection and Statistical Analysis

- Log data from measuring system
- Perform statistical analysis on collected data as well as on data from Q.C.
- Identify likely areas that cause TIR failures

Customer Satisfaction

- Submit all deliverables to Norris
- Work with Norris to ensure their requirements are met and that they are satisfied
Investigation

Industry Analysis

Our research showed that no sucker rod manufacturer currently inspects 100% of their rods. Norris will be the first to inspect all rods with the implementation of the new measuring system. Not only will this allow them to better market their product, it will also serve as an additional quality check. This would be beneficial since Norris offers their “Zero Defects Guarantee”.

Technical Analysis

Technical specifications for the measurement of end straightness are defined in API Spec 11B.

From API Spec 11B:

**A.6.2 End Straightness**

*A.6.2.1 Sucker Rods and Pony Rods*

End straightness shall be measured by supporting the rod body at a distance of 6.00 in. (152.4 mm) from the rod pin shoulder. The rest of the rod shall be supported at a maximum of 6.00 ft (1.83 m) with centers in the same plane. The amount of TIR bend is measured via a dial indicator, laser or other comparable measuring device. The amount of bend shall be measured at the machined surface of the pin shoulder OD. The maximum allowable TIR values for all rod sizes 5/8 in. to 11/8 in. (15.88 mm to 28.58 mm) is 0.130 in. (3.30 mm).

The method used by Norris, as well any companies that perform inspections on sucker rods, must conform to the guidelines set forth by API. As a result, most methods are similar in that they involve rotating the rod 360° on adequately spaced supports while measuring the total indicator run out using an approved measuring device or system.

While the methods of measuring end straightness may be similar, the measurement devices vary. These devices range from simple dial indicators to sophisticated optical measuring systems. The current device used by Norris is an optical micrometer system from Keyence. This type of device can provide the accuracy and repeatability (0.12mil and 0.008mil, respectively) needed while being integrated into the production process without slowing the rate of production. However, the environment these devices are subjected to at Norris make this type of system less than ideal. Therefore, other technologies were pursued. Linear Variable Differential Transformers (LVDT) operate much like a dial indicator but output a digital signal rather than a dial reading. LVDTs come in many setups and can be used in industrial applications.
Such factors as durability and reliability must also be taken into consideration. The design must be able to withstand a maximum of 15,000 rods per day. The measuring system must be reliable and provide accurate and repeatable results, and a simple calibration procedure should be implemented to ensure that the system is operating correctly. Consideration should be given to these aspects in order to help minimize the maintenance costs and requirements.

**Patent Searches**

To aid in obtaining an idea of what technologies exist that could be used to measure total indicator run out, a patent search was used. From a patent search using Google Patents for “total indicator runout”, the following patents were found that were of some interest:

- **US7197837**
  - Gauge assembly for measuring diameter and total indicated runout
  - Honda Motor Co.
  - Device used to measure diameter and TIR on camshafts.
  - www.google.com/patents/US7197837

- **US 2002/0077770**
  - Method and system for identifying and evaluating runout limits of rotational components
  - Kaminski and Wilson
  - Filed: 12/20/2000
  - Method used to measure runout on rotating components, turbines.
  - www.google.com/patents/US20020077770

- **US6757636**
  - Computerized electronic runout
  - Alstom Technology Ltd.
  - Method/Device to measure runout using magnetic field sensing
  - www.google.com/patents/US6757636

While these patents do not pertain to the measurement of end straightness for sucker rods, the information contained does provide insight on ways to go about measuring runout. No exact matches for the measurement of total indicator on sucker rods were found.

**Design Concepts**

Our first design concept consisted of placing the LVDT’s inside of the CNC machine that is used to cut the threads on the sucker rods. Having the LVDT’s placed here would be ideal because measuring the TIR would be one process. This would cut down on the time, as well as the user interface. The problem we encountered was that there would be no way to conform to API specifications if the LVDT was inside the CNC. API specifications state that the bracings must be at certain points along the rod. The distance from the front of the loading tube to the exit end of the chuck is approximately 40 inches; therefore there would be no way to incorporate a
mounting system inside the CNC that conformed to API specifications. From here we decided the next best option would be to use the current mounting system since it already conforms to API specifications. We plan on building a bracket off of the current mount that holds the LVDT. The current system uses a pneumatic cylinder to push the rod into place to measure the TIR. To make the system less bulky and more user friendly, we have decided to place a roller in the middle of system that will roll the rod into place. An inductive proximity sensor will be used as a limit switch to stop the roller once the rod is in its correct place. This will trigger the actuator to lift the LVDT up until it is touching the shoulder of the rod. The rod will then be rotated 360 degrees and checked for TIR. Once one side of the rod has been measured for TIR, the same process will be done to the other side. From here the rod will either be passed and sent on, or failed and put into the scrap pile. Appendix B shows a CAD drawing of what the set up will look like. Appendix C contains the design layout for the set up.

**Financial Analysis**

**Proposed Budget**

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<tr>
<th>Component Description</th>
<th>Part Number</th>
<th>Unit Price</th>
<th>Quantity</th>
<th>Price</th>
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<tr>
<td>Spring actuated LVDT</td>
<td>GP11-5-S</td>
<td>$525</td>
<td>2</td>
<td>$1050</td>
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<td>AC powered signal conditioning</td>
<td>LDX-3A</td>
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<td>Inductive proximity sensor</td>
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<tr>
<td>Pneumatic actuator</td>
<td>0.75DSRx1.000</td>
<td>$250</td>
<td>2</td>
<td>$500</td>
</tr>
</tbody>
</table>

| sub total                                         |             | $2913      |
| miscellaneous                                     | x 1.10      |            |
| total cost                                        |             | $3204      |

**Cost Comparison**

The estimated cost of the full Keyence system per station is $10,000. Our budget estimates the cost of our system to be $3,204. This represents a savings of $6,796 per station. Norris sucker rods currently run 9 stations at their Tulsa plant. Utilizing our system represents a total savings of $61,164.
Project Schedule

During the 2013 spring semester, we will design and build a set up like the one shown in appendix B. From here we will be able to run tests and work out the kinks in the system. Norris will fund the project and will be sending us the needed materials; LVDTs, actuators, PLC’s, etc. The setup will be in the Bio-system’s laboratory on campus and will conform to API specification 11b. Once the setup is working properly, we will then present Norris with the system. From here they can decide on whether to implement the system into their manufacturing facility.

Conclusion

Our main focus is to implement a system that will be able to check TIR for 100% of the rods leaving Norris. The system must be more users friendly for the operators, as well as more efficient. The current shadow system is unreliable and is causing discrepancies between Norris and the third party inspectors. The system we are designing will be much smaller, and will therefore be much easier to maneuver around, making the system more user friendly for the operators. As well, our design will provide a significant cost benefit.
References

Sucker Rod Image on title page: http://www.norrisrods.com/images/body_pic_suckerrods1.jpg

Norris Logo on title page: http://www.ipaa.org/meetings/images/NorrisSuckerRods.JPG

Appendix A

WBS 1.0 Current System Remake

Redesign of current system used for checking TIR.

  WBS 1.1 – Project Oversight

  Work with Norris to ensure successful completion of the project on time and on budget. Submit progress reports to the customer when a step has been completed. Get required information from Norris, such as the CNC specs, which will be crucial to complete the project. Task is complete when information is received and progress report defining the schedule is sent out.

  WBS 1.2 – Requirements

  New design will have to conform to API specifications. 100% of rods being sent out must be checked. Third party readings must match the readings coming out of Norris. Task is complete when all requirements are approved.

  WBS 1.3 – System Redesign

  Redesign current system used to check TIR at Norris based on the requirements outlined in WBS 1.2. Task is complete once the new system is in place and has been approved by the appropriate authority.

WBS 2.0 Documentation and Technology

Research available technology’s and patents that could be used in the design process. Produce drawings for mounting system.

  WBS 2.1 Research

  Research patents and other technologies that could be used to determine TIR. Task is complete when an acceptable technology is found that does not conflict with patents.

  WBS 2.2 Technology

  Once technology has been selected, decide on how to integrate the technology into the current system. Task is complete when all specifications have been gathered and technology is integrated into the design.

  WBS 2.3 Drawings

  Produce drawings for mounting system. Task is complete once drawings have been approved and sent out for fabrication.
WBS 3.0 Approval

Review design with customer to ensure standards are met.

WBS 3.1 Review design

Work will be complete when the engineering has been approved and drawings have been released.

WBS 4.0 Fabricate Mounting System

Fabricate and install mounting system into CNC. Task will be complete once mounting system has been integrated into the CNC.

WBS 4.1 Materials

Gather materials needed to fabricate system. Task is complete once all materials have been received and verified.

WBS 4.2 Fabricate System

Work with shop to get part machined for mounting system. Task is complete once all parts have been fabricated and inspected.

WBS 4.3 Install System

Work with Norris to install mounting system into CNC machine. Task is completed once system is installed and ready for system integration.

WBS 5.0 Integration of Sensor System

Integrate sensors into mounting system. Work is complete once system is fully functional.

WBS 5.1 Install Sensors

Install new sensors into current system. Task is complete once all sensors have been installed.

WBS 5.2 Support System

Integrate sensors into existing PLC. Task in complete once sensors have been integrated.

WBS 5.3 Functional Check

Conduct checks on all systems to ensure they are working properly. Task is complete once all systems have been checked and are working correctly.
Appendix B

Design
Appendix C

Design layout