WET PLASTIC WEAR TESTER FOR ESTIMATING ROD GUIDE LIFE

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ABSTRACT
The use of rod guides in artificial lift applications has evolved to a level where accurate simulation of downhole conditions is necessary to evaluate various materials. R&M Energy Systems has designed and built a second generation plastic wear test machine that conducts tests in a heated fluid environment. A state-of-the-art data acquisition system collects all pertinent information. A standard procedure for establishing wear rates is proposed to enable end-users to compare wear characteristics of rod guide plastics in simulated downhole conditions.

INTRODUCTION

For 30 years, the oil indushy has been using thennoplastics to manufacture a wear resistant centralizer/rod guide. Kod guides are used as sacrificial parts to keep sucker rods and couplings from wearing production tubing and help stabilize rod strings in deviated wells. In the past, a reliable, repeatable method of measuring wear and cstiinating the life of these thermoplastics in downhole conditions did not exist. Over the years, plastics have been formulated with increased temperatnrc and strength limits. Although these are important attributes, the end-user is more interested in wear rates of thermoplastics in their applications. Currently there are no standards for measuring or predicting the wear rate of plastics in a wet environment. ASTM D 3702-94 is an industry standard that is used for determining wear rates ofplastics in a dry environment. Unfortunately, dry wear rates do not correspond to a e t wear rates. R&M Energy Systems determined that a method and apparatus for testing plastics in a wet environment was needed.

DESCRIPTION

The NGWTM (next generation wear test machine) is manufactured using 304 stainless steel to eliminate corrosion associated with running in a wet environment. A 16.5" x 8.5" chamber contains the fluid that the plastic samples arc immersed. The NGWTM is direct driven by a one horsepower DC motor. A regenerative DC motor controller is used to maintain the speed within +/- 1% of the set point. A replaceable drum is used as the abrasion surface. This drum is manufactured from AISI 1026 carbon steel with the surface finish specified for consistent test results. The design of the abrasion drum adds a great deal of flexibility to this machine. The drum can bc coated with any product used for coated production tubing, such as epoxy or poly. This provides the ability to determine which thermoplastic is less abrasive to these coatings. The fluid used in the NGWTM is circulated at 10 gpm and heated using a standard inline heater. If clean water is the test fluid, it is tiltcrcd using a sand and particle filter. The NGWTM can test up to six themioplastic specimens per test. This allows side-by-side comparisons of different plastic polymers and shortens the test period considerably. A data acquisition system is utilized to record drum speed (rpm), number of revolutions, displacement of each sample and temperatures (ambient and fluid). Torque is not currently recorded, but may he in the future. Test specimen diameter was chosen for ease ofmanufacture as well as proper PV (Pressure x Velocity). The specimens are machined from molded rod guides using a hollow end mill tool. Each specimen is inserted into a weighted specimen retainer prior to installation in the NGWTM. The individual specimens are guided by a linear bearing.

CALCULATION/THEORY

The NGWTM uses the PV (pressure x velocity) associated with ASTM standard D3702-94. This standard indicates that a PV should be chosen to correlate with normal operating conditions. **A** PV of 18,200 was chosen, where P = 116.1 psi and V = 157.1 ft/min. V of 157.1 ft/min is the approximate velocity of a pumping unit running at 6.5 spm with 144" stroke length. The pressure of 116.1 psi is equivalent to approximately 400 lbs of side-load force per rod guide. **Al**though this number is greater than what most deviated wells will see, it is still quite common. Pressure and velocity is calculated as follows:

PRESSURE

$F = Force\ (lbs)$
$A = Area\ (in^2)$
$r_1 = Radius\ of\ specimen\ (in)$
$P = Pressure\ (lbs/in^2)$

$P = F / A$
$F = 3.588$
$A = \pi r_1^2$
$r_1 = .09925$
$A = \pi \times 0.09925^2$
$A = 0.0309\, in^2$
$P = 3.588\, lbs / 0.0309\, in^2$
$\underline{\underline{P = 116.1\, psi}}$

VELOCITY

$C = circumference = 2\pi r_2\ (in)$
$r_2 = Radius\ of\ Abrasion\ Drum\ (in)$
$RPM = Abrasion\ Drum\ (rev/min)$

$r_2 = 2in$
$C = 12.566\, in$
$V = C \times RPM$
$V = 12.566\, in(1\, ft / 12\, in) \times 150\, RPM$
$\underline{\underline{V = 157.1\, ft / \min}}$

A force of 3.588 lbs for each specimen is achieved through copper weights and the displacement sensor spring force. This weight is mounted directly above each test specimen. Each test specimen has its own displacement sensor. Figure 1 shows an exploded view of the NGWTM. The machine sits horizontally with all six samples mounted vertical against the abrasion drum. The test duration is 12 hours. The fluid is circulated at 130°F. The pump is able to circulate various fluids such as water, oil, water-oil mix, with or without sand. When pumping a fluid other than clean water, a by-pass is built into the piping system to circumvent the water filter. The data acquisition system collects data from all six displacement sensors, an optical encoder and two thermocouples. The optical encoder measures RPM. The thermocouples measure ambient and fluid temperatures. Displacement measurements are recorded once every second, then averaged to give one value every ten minutes. This same technique is used to record drum speed and temperature measurements. This lends stability to the information recorded by the data acquisition system.

OPERATING PROCEDURES

To setup the machine, an abrasion drum is slipped onto to the drum side drive shaft. The motor side drive shaft is then screwed into the tube side drive shaft. These parts are then tightened together, holding the abrasion tube in place. The abrasion drum and each of the six specimens are cleaned with alcohol. Once the drum and test specimens are clean, they must be handled with rubber gloves. The test specimens are then inserted into the specimen retainer and the set screw is tightened. The specimen retainer is then placed into the holding bar containing the linear bearings. The pump and heater are started and the water and test specimens are allowed to reach operating temperature. The motor and data acquisition system are activated. The NGWTM is then run for period of 12 hrs. The abrasion drum is replaced after each test.

DATA

Chart 1 shows a sample of data collected from the NGWTM. This chart contains wear rates of four common rod guide plastics. Samples 1 and 2 were tested side-by-side. Since these plastics are common, life expectancy is well documented. These tests correspond to known life expectancy. The data acquisition system records the data into an ASCII file. This allows the user to import the data into a spreadsheet program such as Excel.

CONCLUSION

The NGWTM gives accurate comparative life expectancy of thermoplastics utilized for rod guides. With the accuracy and flexibility of this machine, all plastics and tubing coatings can be tested. Due to the infinite variables found in productions wells, standardization of wet plastics testing will provide a definitive run life of a plastic rod guide. However, the NGWTM will give the end-user an accurate comparative test. This comparative test is vital to substantiating various rod guide manufacturers' claims and will allow end-users to make a more informed choice when selecting plastics.

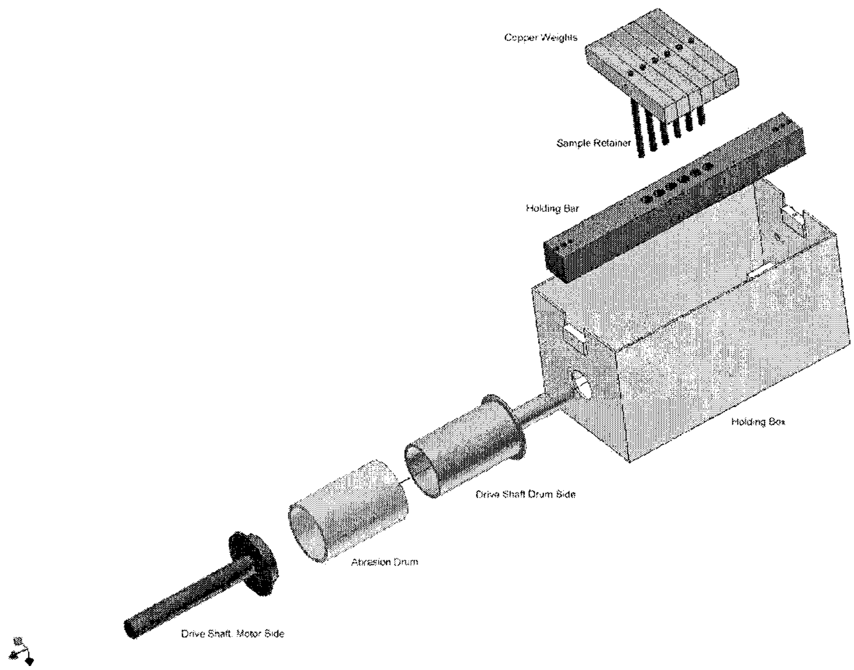

Figure 1 - Picture Showing NGWTM Parts

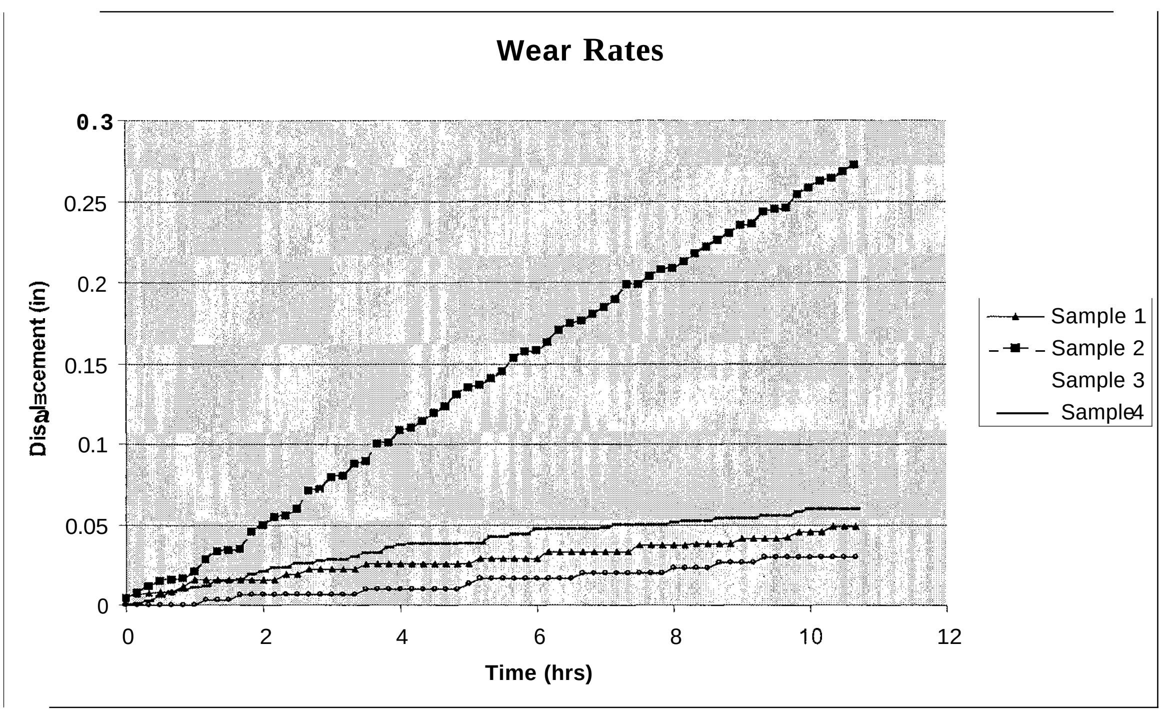

Figure 2 - Chart Showing Wear Rates of Plastic Speciments