LEVERAGING BIG DATA TO IDENTIFY UNDERUTILIZED PUMPING UNITS

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Abstract

Re-utilization of artificial lift equipment and parts is a common practice among operators and service providers across the industry. It is common practice for operators to resize artificial lift equipment at failure or proactively as economics allow. As an operating company, we have found it valuable to build processes to track both inactive inventory and underutilized active assets, which can generate cash savings and value in artificial lift projects.

In this paper, we share how we leveraged our internal data to classify and rank our pumping unit population of over 7,000 wells in the Permian Basin. We developed an application using an industry standard relational database system and visualization software. As a result, the company has deferred purchasing new pumping units for the last three years.

Introduction

Occidental's Permian EOR business unit operates 7,481 beam-pump units across 86,000 square miles of the Permian Basin. This is a large population of assets that we track using well information and asset management software.

In 2016, a cross-functional team undertook a project to utilize our big data set and identify the population of beam pumping units that were underutilized in their current situations. Screening beam pumps for better utilization was not new to the organization, but an evergreen and widely accessible inventory visualization tool was.

A Method to Screen Underutilized Beam Pumping Units

At our company, active beam pumping unit inventory is tracked with an industry-standard well management system, which holds well-specific information such as gearbox size, unit type, rod material type, depth of the pump, daily production volumes, and other details.

The API RP 11L3 standard (see Table 1) was used as a model to develop fit-for-purpose estimates of the minimum size equipment to move a known volume from a given depth. Scenarios characteristic of our beam-pumped well population were ran in rod design software to generate unit sizes for the range of conditions in our fields. We used polished rod velocity as a primary reference variable to evaluate if the design inputs were generating reasonable unit size outputs. We also leveraged the operational experience of the group and used a certain amount of "reasonable judgment" to analyze the results.

The outputs, called Fit-for-Purpose (FFP) Tables (see Table 2), were categorized by depth and total fluid produced, similar to the API RP 11L3 tables. The results were optimized according to the following criteria: a correctly sized pumping unit would operate at maximum stroke length, would run 19 hours a day, and would be at least 80% efficient. We felt that with these specifications, the resulting FFP tables would provide reasonable reference points to compare with our current installations.

First, we needed to evaluate our dataset to determine what percentage of the well population had sufficient data for the analysis. We determined that we would need at least the following data in the system to make the comparison:

Pump depth

Total daily production volume

Rod string material (steel, fiberglass, etc.)

Unit type (conventional, special geometry, etc.)

Unit gearbox torque rating (912, 640, etc.)

After a data review, we confirmed that this information was being populated into the database tables, and that the tables were connected to our relational database system. However, not all of the 7,481 beam pump units had data for all five columns; only 4,024 wells, or 60%, did. This highlighted an opportunity to improve the data integrity of our system, which is an ongoing process. In the interim, we agreed that a 4,000+ well dataset was large enough to proceed with the evaluation.

The FFP tables were used as a standard for which gear box size could be used. Because most of the wells were less than 7,000 ft long and did not produce large volumes, structure rating was not a significant factor in our final outputs. Once a unit has been identified for a specific application, a detailed analysis should be conducted to confirm the design is within the appropriate parameters.

The FFP tables were then uploaded to our relational database system, which allows us to match our well information software (populated with active well data) to the unit size listed in the FFP table in Figure 1.

It also allowed us to script supplementary logic to screen data and evaluate other components of the system, such as the prime movers that power the pumping units. This required us to pull in some additional data specific to sizing the motors. The additional data included:

Polished rod horsepower (PRHP)

Motor horsepower (HP)

Motor Type – (NEMA D, NEMA B, etc.)

Our motor population consists primarily of NEMA D (96%) and NEMA B motors. To script the logic, we referenced three methods for sizing NEMA D motors (see Figure 2). The logic of implementing the three methods followed the flowchart shown in Figure 3.

The first method is the “two times polished rod horse power (PRHP)” method, shown in Equation 1.

$$\text{Motor Size (HP)} = 2\ x\ PRHP \qquad (1)$$

The limitation of this method was that the last value for PRHP in the data table was collected from the most recent card. Due to the pump-off frequency, this method could have data points that were not reflective of the current value for this variable, thereby introducing error into the evaluation. To reduce that error, the flow chart was later modified to consider only the remaining two methods.

Those methods were: the Lufkin Motor Sizing Method (Chilingarian, 1987), which used the formulation for NEMA D motors shown in Equation 2. This formulation is an evaluation of the hydraulic requirements of the system.

$$\text{Motor Size (HP)} = \frac{Total\ Fluid\ x\ Depth}{56000} \qquad (2)$$

The minimum motor size method (Gault) uses Equation 3 to determine the minimum motor horsepower required to start a pumping unit in motion from idle.

$$\text{Motor Size (HP)} = \frac{Gearbox\ Torque\ Rating}{20} \qquad (3)$$

This calculation implies that a smaller motor may not generate enough startup torque to start a pumping unit from a standstill, so all motors should be at least this powerful. The horsepower results of these two methods may not match a standard motor size, so the results are rounded up to the next standard size.

Of the motors screened, 94% defaulted to the minimum recommendation based on the gearbox limitations of the minimum motor size method. This sizing logic allows us to set a reference point for horsepower requirements for each beam pump unit in our active population and compare them with the motor horsepower of what is currently installed.

We found there were 1,471 units and 2,979 motors out of our 7,481 Permian EOR active beam pumps that were at least two sizes larger than required at the current production levels. This allowed us to take the next step, which was to compile a list of underutilized assets.

Tools to Visualize Utilization

To optimize utilization of these assets, our team developed tools to visualize the utilization of this inventory in a Data Visualization Web Player (see Figure 3). For each asset, we determined the utilization ratio for the pumping unit (Equation 4) and motor (Equation 5). The larger the number, the more underutilized the asset is under current conditions.

$$\text{Pumping Unit Utilization Ratio} = \frac{\textit{Installed Unit Size}}{\textit{Fit For Purpose Unit Size}} \tag{4}$$

$$\text{Motor Utilization Ratio} = \frac{\textit{Installed Motor HP}}{\textit{Minimum Required Motor HP}} \tag{5}$$

Within this visualization tool, our entire active and inactive beam and motor inventory can be filtered by field, size, utilization ratio, etc.

These tools are evergreen and can be referenced by each asset team or staff member in the organization when considering equipment requirements for future business activities.

Organizational Results

Since 2015, the active underutilized inventory has dropped to 1,078 units from 1,471 units. Over that period, our Permian EOR business unit has utilized approximately 300 pumping units for new drills, lift revisions, and other activities. This initiative has allowed us to defer purchasing new pumping units for two years (see Figure 4), thereby reducing operating expenses. It is our recommendation to utilize software applications and methods like these to manage and evaluate your large artificial lift datasets to optimize inventory.

	ROD NO. 76			PUMP DEPTH 5000.			PRODUCTION 500.			
PUMP DIA.	STROKE	SPM	PPRL	MPRL	STRESS	PT	PRHP	CBE	PROD UNANCH.	WRF
1.25	192.	13.7	19556.	387.	32539.	918.	47.1	9717.	490.0	7839.
1.25	216.	12.2	19452.	991.	32367.	993.	47.6	9717.	491.0	7839.
1.25	240.	11.2	19264.	1177.	32053.	1093.	47.8	9717.	491.8	7839.
1.25	300.	9.1	18517.	2019.	30810.	1302.	46.3	9717.	493.2	7839.
1.50	64.	25.1	19893.	1969.	33101.	268.	32.7	10420.	461.4	7918.
1.50	74.	23.3	19581.	1736.	32581.	326.	34.0	10420.	464.8	7918.
1.50	86.	21.1	19323.	1709.	32151.	394.	34.2	10420.	467.7	7918.
1.50	100.	19.1	19201.	1477.	31949.	469.	34.0	10420.	470.4	7918.
1.50	120.	15.9	18671.	1832.	31067.	540.	32.1	10420.	475.6	7918.
1.50	144.	13.1	18265.	2667.	30391.	595.	30.8	10420.	480.0	7918.
1.50	168.	11.3	18020.	3144.	29984.	660.	30.7	10420.	482.3	7918.
1.50	192.	10.1	17685.	3448.	29425.	729.	30.1	10420.	484.3	7918.
1.50	216.	9.0	17416.	3842.	28979.	790.	30.3	10420.	486.0	7918.
1.50	240.	8.1	17198.	4238.	28616.	850.	30.8	10420.	487.3	7918.
1.50	300.	6.5	16854.	4618.	28044.	1019.	30.5	10420.	489.9	7918.
1.75	48.	26.6	19532.	3458.	32499.	186.	27.5	11245.	445.9	8005.
1.75	54.	24.5	19115.	3403.	31805.	209.	28.0	11245.	450.0	8005.
1.75	64.	21.9	19069.	3108.	31729.	252.	27.5	11245.	454.8	8005.
1.75	74.	19.9	19096.	2931.	31774.	303.	27.3	11245.	458.8	8005.
1.75	86.	16.0	19098.	1523.	31778.	372.	27.6	11245.	462.7	8005.
1.75	100.	15.6	18888.	2705.	31428.	446.	27.2	11245.	467.5	8005.
1.75	120.	12.3	18330.	3851.	30499.	499.	24.1	11245.	474.4	8005.
1.75	144.	10.4	18063.	4029.	30054.	564.	24.1	11245.	478.3	8005.
1.75	168.	8.9	17716.	4589.	29477.	611.	24.1	11245.	481.4	8005.
1.75	192.	7.8	17400.	5201.	28952.	646.	24.7	11245.	483.8	8005.
1.75	216.	6.9	17192.	5426.	28606.	687.	24.9	11245.	485.7	8005.
1.75	240.	6.1	17109.	5349.	28468.	750.	24.5	11245.	487.2	8005.
2.00	48.	24.4	19556.	4020.	32539.	175.	24.5	12205.	414.9	8114.
2.00	54.	22.2	19486.	3860.	32422.	200.	24.7	12205.	422.3	8114.
2.00	64.	19.8	19781.	3707.	32913.	252.	25.1	12205.	430.6	8114.
2.00	74.	17.8	19685.	785.	32753.	295.	24.7	12205.	437.0	8114.
2.00	86.	15.8	19715.	1348.	32803.	359.	24.8	12205.	443.4	8114.
2.00	100.	12.6	19176.	4369.	31907.	412.	21.7	12205.	455.0	8114.
2.00	120.	10.3	19086.	4356.	31757.	501.	21.5	12205.	463.4	8114.
2.00	144.	8.5	18809.	4845.	31297.	579.	21.4	12205.	469.9	8114.
2.00	168.	7.2	18471.	5549.	30733.	624.	21.4	12205.	474.5	8114.
2.25	64.	18.4	20824.	2457.	34649.	250.	23.2	13287.	397.8	8232.
2.25	74.	16.4	20705.	1347.	34452.	288.	23.3	13287.	407.9	8232.
2.25	86.	13.9	20763.	4242.	34548.	340.	23.1	13287.	420.7	8232.
2.25	100.	10.9	20423.	4927.	33982.	412.	19.8	13287.	437.4	8232.

Table 1: API RP 11L3 – Beam Pumping Unit Sizing Table

Depth	100% Pump Capacity	80% Pump Cap.	Gear Box	Structure	Stroke Length (inches)
4000	25	20	57	89	48
	50	40	80	90	48
	75	60	114	95	54
	100	80	114	95	64
	200	160	228	109	86
	300	240	320	133	100
	400	320	456	143	120
	500	400	640	173	100
	600	480	640	200	120
5000	25	20	57	109	48
	50	40	80	109	48
	75	60	80	119	54
	100	80	114	119	64
	200	160	228	143	86
	300	240	320	173	100
	400	320	456	173	120
	500	400	640	256	120
	600	480	912	256	144
6000	25	20	57	133	48
	50	40	80	133	48
	75	60	80	133	54
	100	80	114	143	64
	200	160	160	173	86
	300	240	320	200	100

Table 2: Example of Fit-for-Purpose Output Table

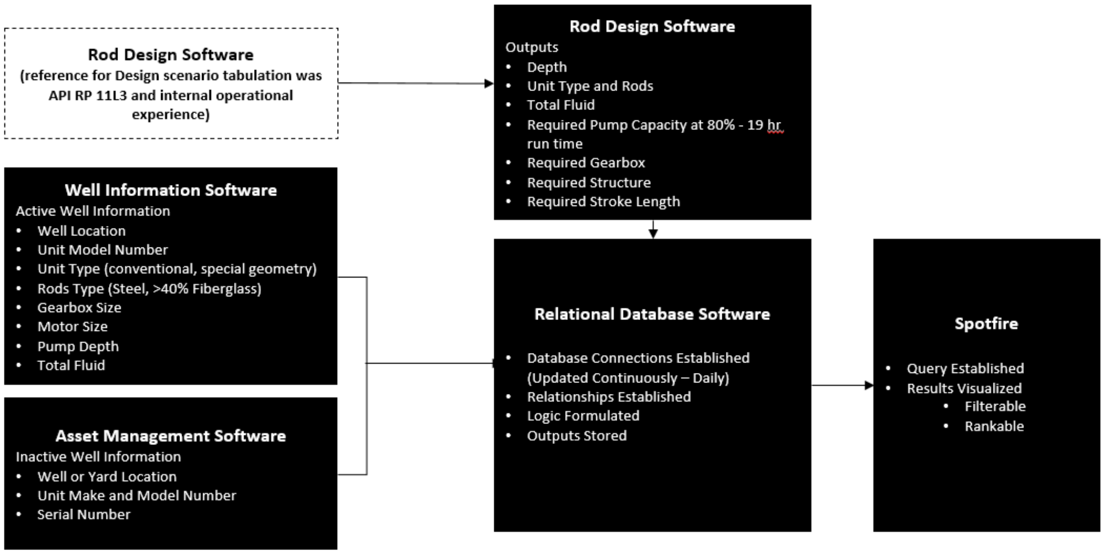

Figure 1: Process Flow Diagram

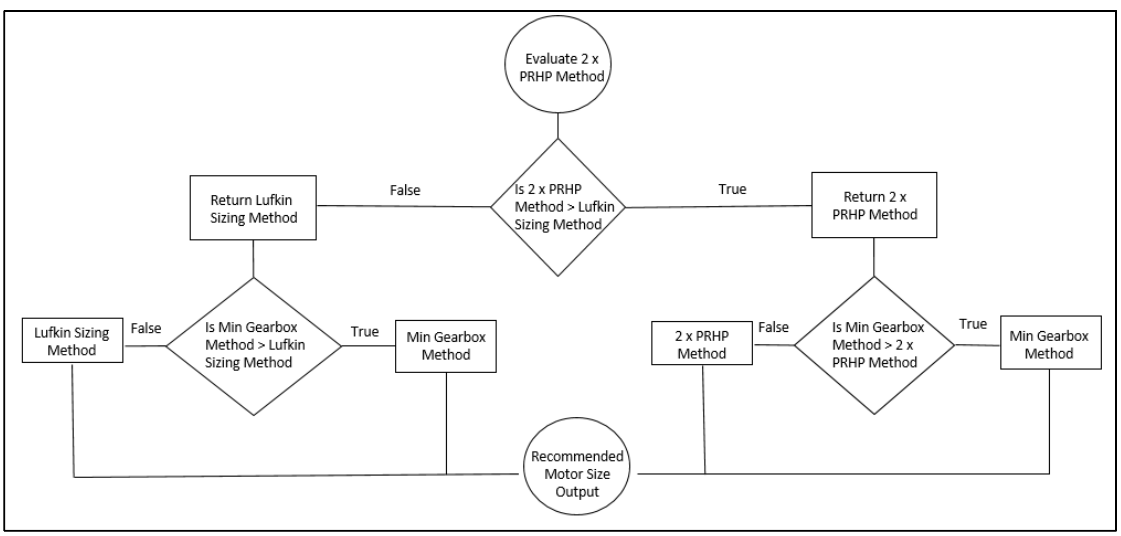

Figure 2: Flowchart for Calculating Pumping Unit Motor Sizes

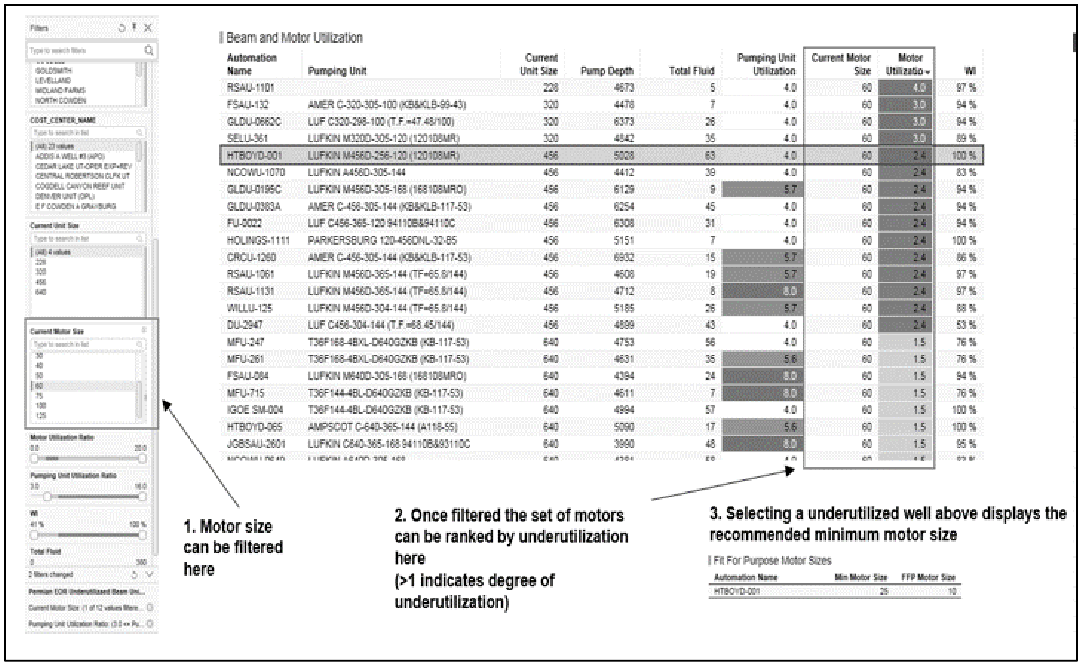

Figure 3: Beam Pumping Unit and Motor Inventory Utilization Screen Captures

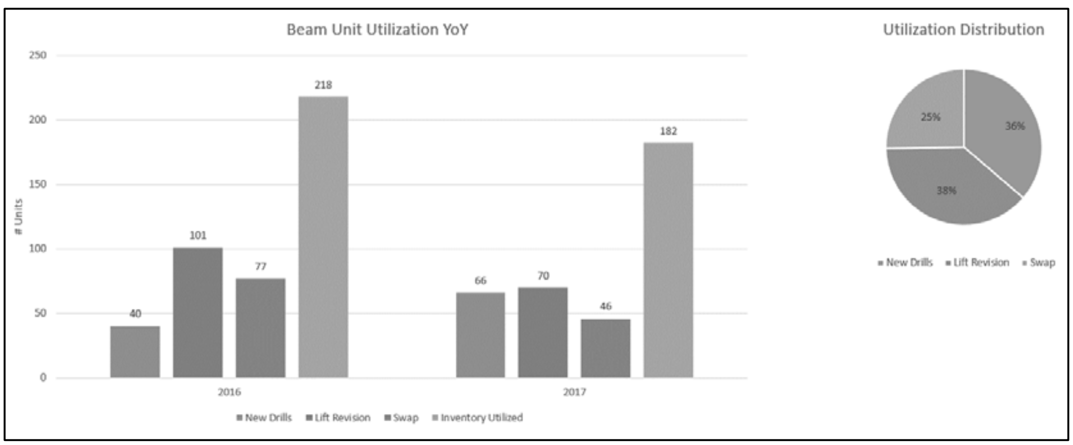

Figure 4: Beam Unit Utilization Categories 2016-2017

References:

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