

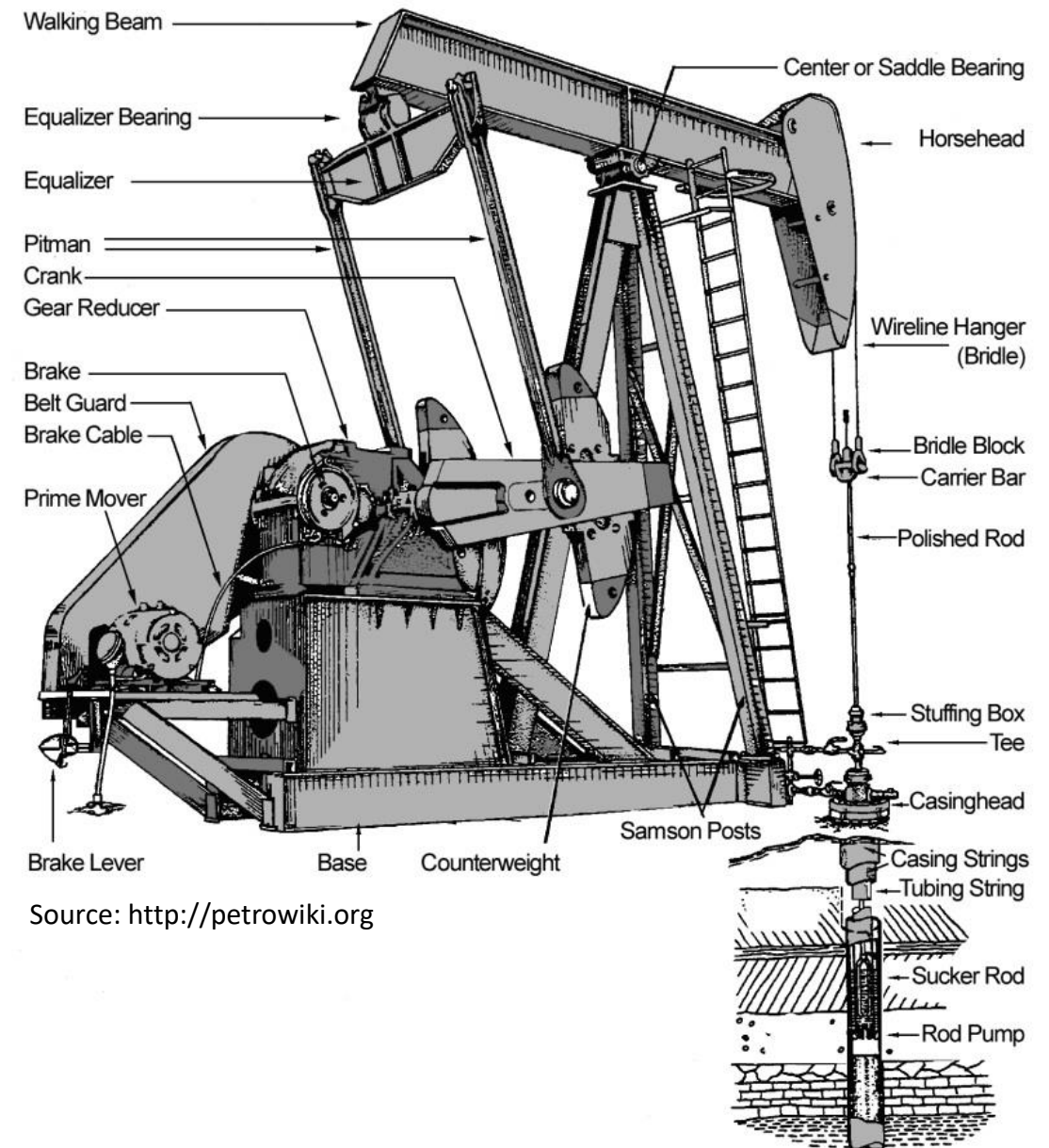


Optimization, Predictive Analytics, & Real-Time Process Models

Rod Pump Analytics

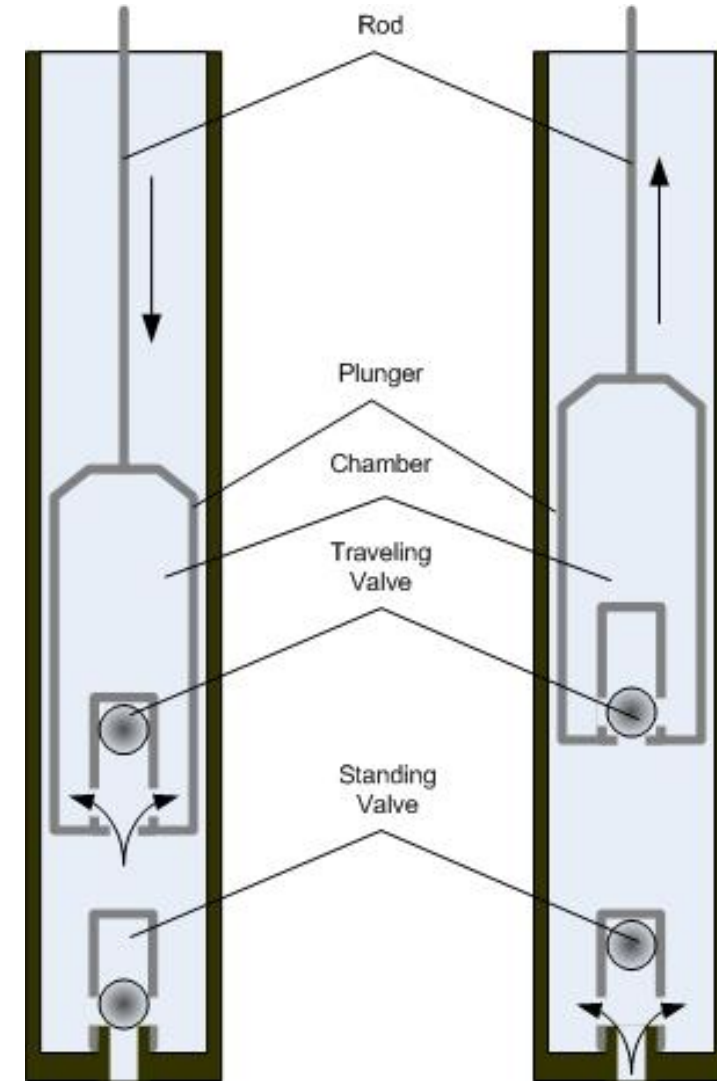
Rod Pump System

- Simple mechanism to extract subsoil fluids
- Major components
 - Prime mover
 - Gear reducer or gearbox
 - Pumping unit
 - Sucker rod string
 - Subsurface pump



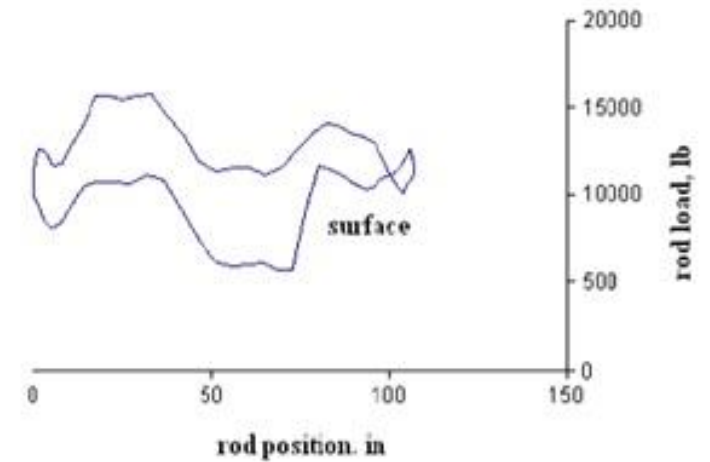
Challenges

- Many rod pumps difficult to monitor and maintain
- Most wells under or over deliver
 - Difficult to match well inflow with fixed productivity pumping system
 - Downstroke: Plunger volume flooded = small production at surface
 - Upstroke: Fluid arrives at surface, barrel refilled
- Subsurface behavior inferred using dynamometer card

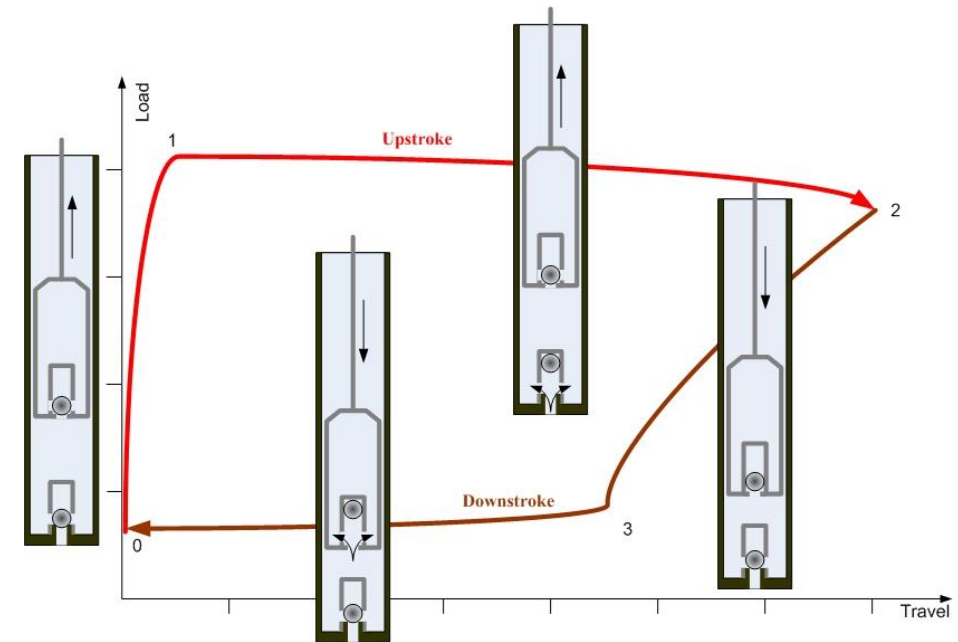


Dynamometer Card

- Dynamometer card: graphical representation of relationship between rod load and stroke position
- Two types:
 - Surface
 - Pump (downhole)
 - Plot of calculated loads at various positions of pump stroke

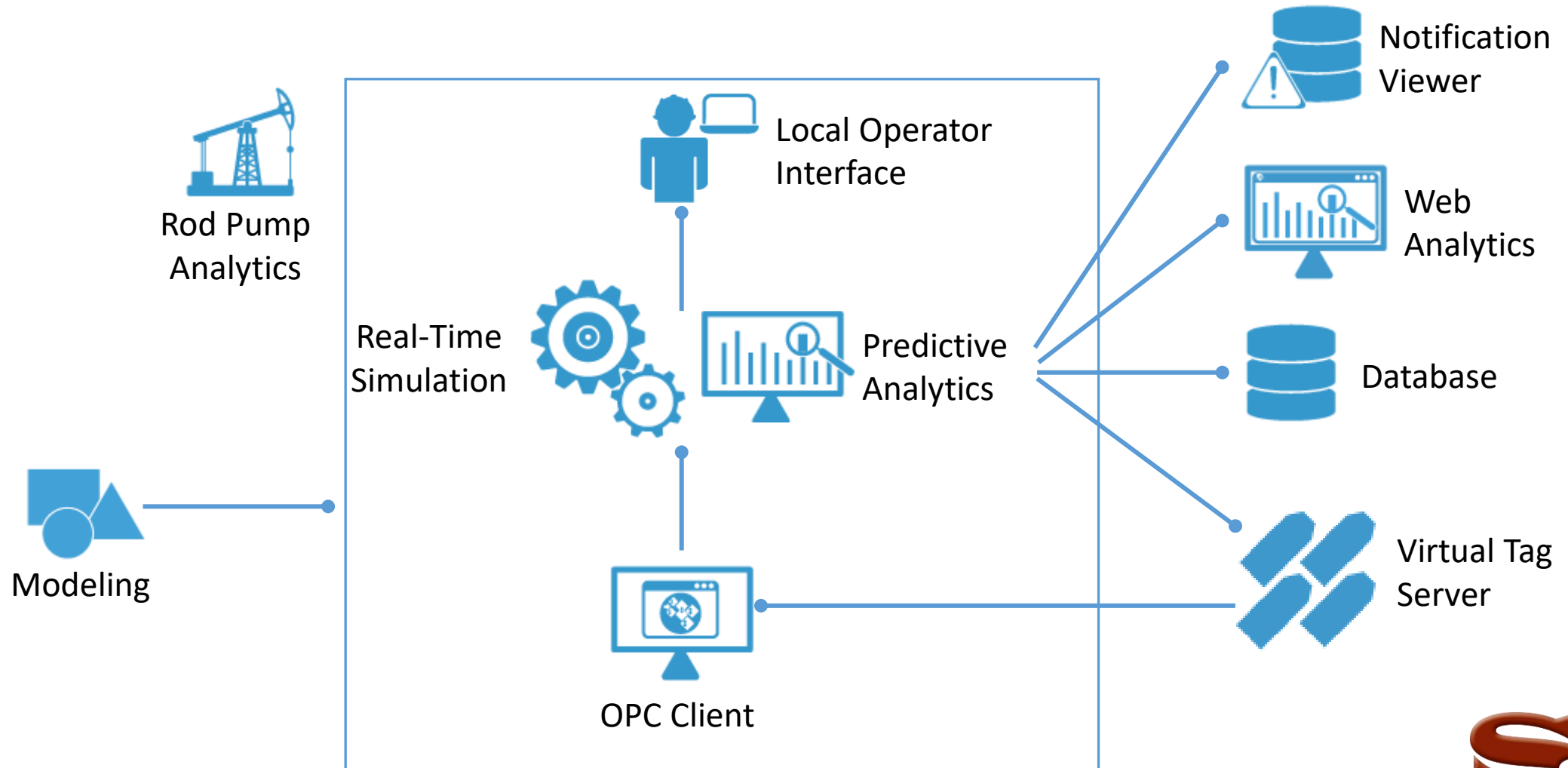


Surface dynamometer card example (source: S. G. Gibbs)



Downhole dynamometer card example

Solution Overview



Benefits

- Determine actual operating conditions
- Anticipate rod pump problems and provide maintenance scheduling decisions
- Provide smart alerts
- Match capacities using regulatory control and pump-off control

Real-Time Simulation

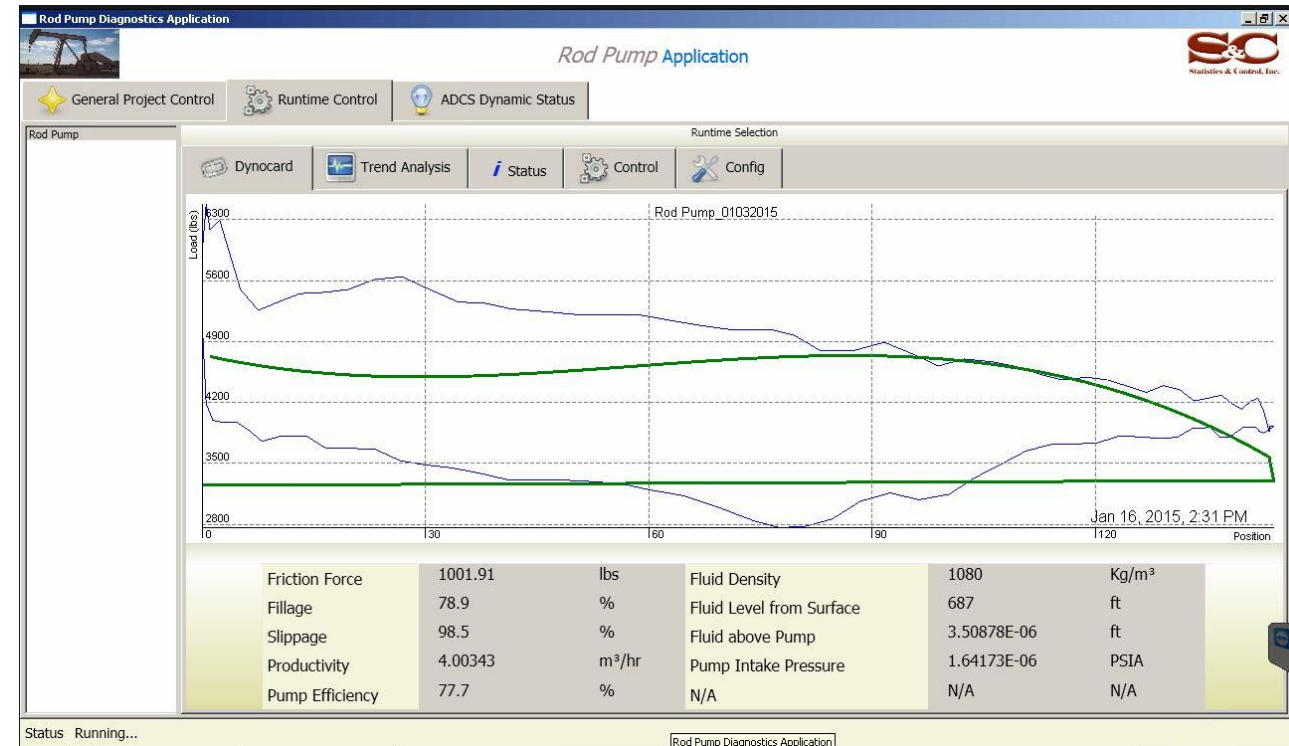
- Implements pump-off control, Rod Pump Analytics Module
- Features
 - Accurately estimate total fluid production from wells (shallow or deep) without complex well site configuration
 - Analyze system load by detecting load cell drift from changing downhole conditions
 - Access dynamometer cards for events (e.g., Full, Current, Shutdown, etc.) and cards leading up to event
 - Provide alarms for torque, stress, pump efficiency, prime mover size, unbalance, etc.

Pump-Off Control

- Goal: Optimal speed allows rod pump to have sufficient time to free fall through fluid on downstroke
- Functions
 - Controls running times of pumping units
 - Optimizes pumping unit run time, reducing damage to pumping system
 - Match capacities
 - Automatically detect when pumping system beginning to run out of available fluid to pump and shuts
 - Shuts well down for adjustable “idle time” so well can replenish fluid in wellbore

Dynocard Visualization

- Displays graph based on rod load and stroke position
- Represents downhole dynamometer card
- Data sources
 - Field Rod Pump: OPC
 - Enterprise Rod Pump: OPC (rare) or ODBC (most common)
- Lines
 - Green: **Optimized**
 - Blue: Real-time data



Control Visualization

- Shows set points for pump operation and rules for pump-off control

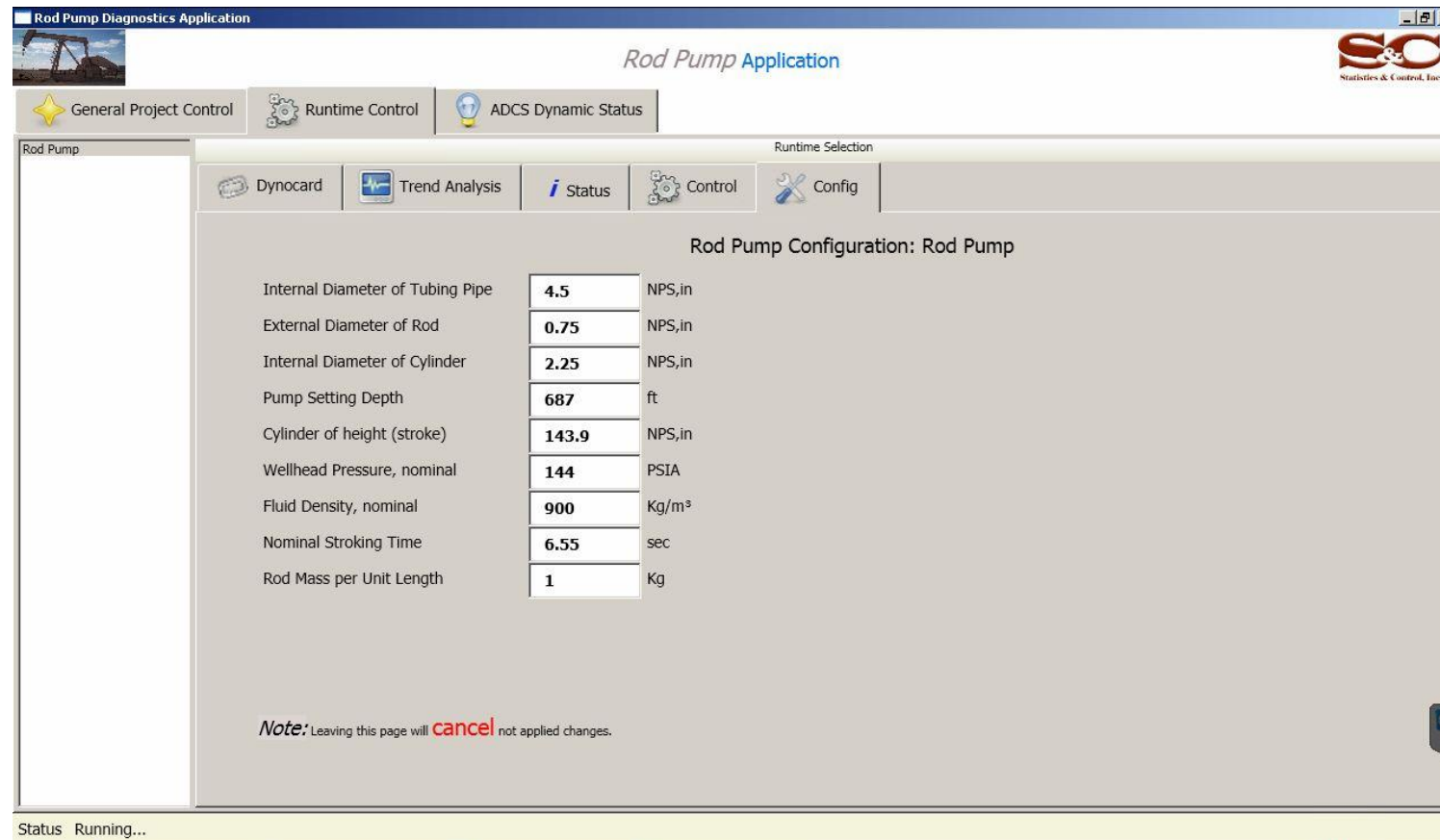
The screenshot displays the 'Rod Pump Diagnostics Application' interface. At the top, there are navigation tabs for 'General Project Control', 'Runtime Control', and 'ADCS Dynamic Status'. Below these, the 'Rod_Pump' section is active, showing 'Runtime Selection' options: 'Dynocard', 'Trend Analysis', 'Control', and 'Config'. The 'Control' tab is selected, displaying a control panel with 'Run' (pink), 'Stop' (red), 'Auto' (green), and 'Manual' (yellow) buttons. A note states: 'Run/Stop control available in Manual mode'. Below this, a light blue banner indicates 'Pump Off Control Status: Downtime remaining: 01 min 52 sec'. The main area shows 'Rod Pump: RodPump' with a table of parameters:

Fillage Low SP	100	%	Wellhead Pressure, RP	0	PSIA
Number of Travels Before Stop	3		Rod Position, RP	81.57	NPS,in
Pump Off Position	20	%	Torque, RP	4738	N*m
Down Time SP	3	min			

A note at the bottom reads: 'Note: Leaving this page will cancel not applied changes.' The status bar at the bottom left shows 'Status: Running...' and the bottom right has an 'Open Log File' button.

Configuration Visualization

- Configure and modify well and pump parameters



The screenshot displays the 'Rod Pump Configuration: Rod Pump' window within the 'Rod Pump Diagnostics Application'. The application has a top navigation bar with 'General Project Control', 'Runtime Control', and 'ADCS Dynamic Status'. Below this is a 'Runtime Selection' bar with 'Dynocard', 'Trend Analysis', 'Status', 'Control', and 'Config' tabs. The 'Config' tab is active, showing a table of configuration parameters.

Parameter	Value	Unit
Internal Diameter of Tubing Pipe	4.5	NPS,in
External Diameter of Rod	0.75	NPS,in
Internal Diameter of Cylinder	2.25	NPS,in
Pump Setting Depth	687	ft
Cylinder of height (stroke)	143.9	NPS,in
Wellhead Pressure, nominal	144	PSIA
Fluid Density, nominal	900	Kg/m ³
Nominal Stroking Time	6.55	sec
Rod Mass per Unit Length	1	Kg

Note: Leaving this page will **cancel** not applied changes.

Status Running...

Conclusion

- Determine actual operating conditions
- Anticipate rod pump problems and provide maintenance scheduling decisions
- Provide smart alerts
- Match capacities using regulatory control and pump-off control
- Monitor from anywhere using HTML 5 technologies