

Definition of Electrosubmersible pump (ESP) design and selection workflow

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Contents:

1. Introduction- work scope

2. Background

3. Survey of ESPs in Europe

4. Survey of ESPs in the Netherlands

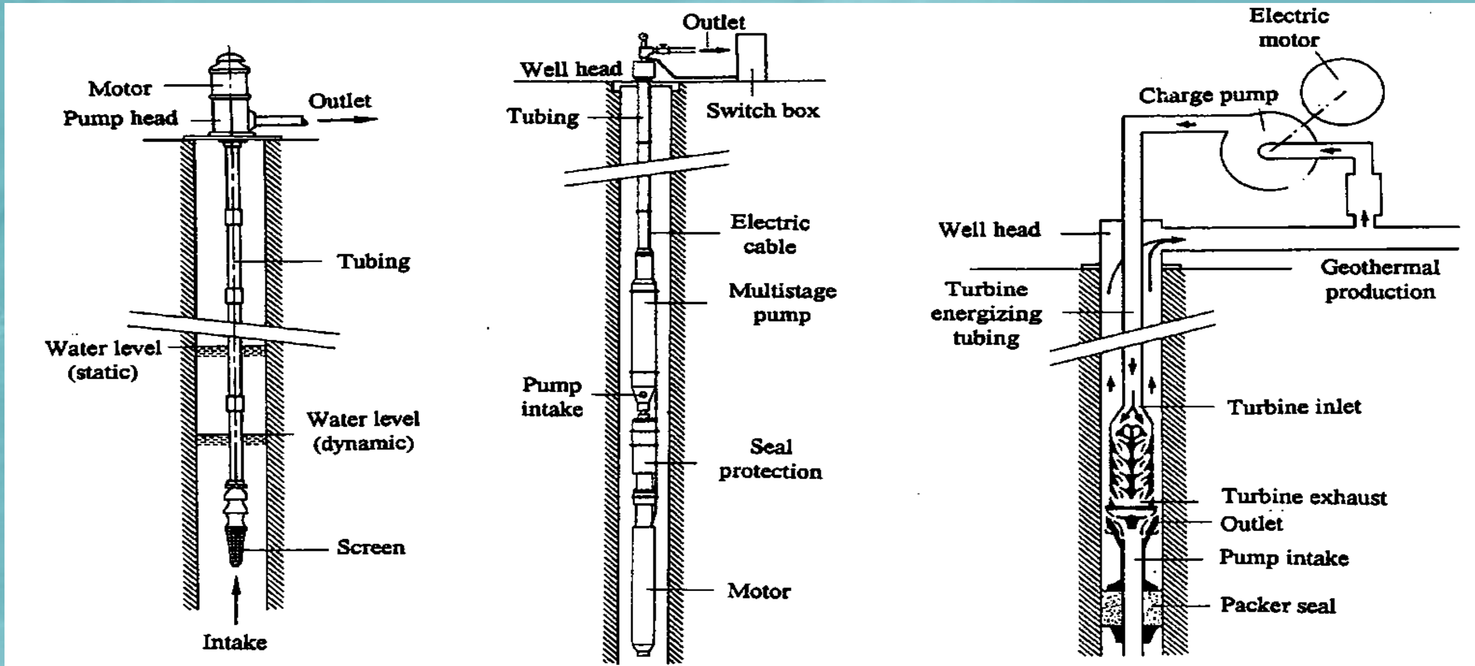
5. Recommendations

1. Introduction

Work scope

1. Review of ESP performance in Europe
2. Optimizing pump (life, COP) performance
3. Securing ESP reliability

2. Background: pump types

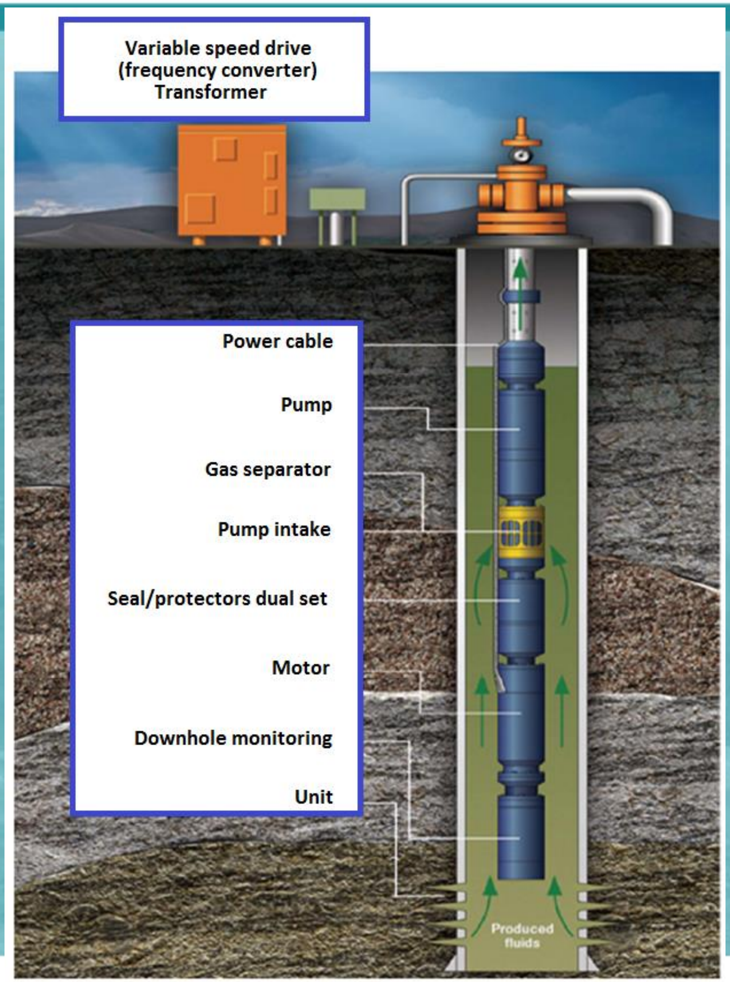


a) Line shaft pump (LSP) b) Electrosubmersible pump (ESP) c) Hydraulic turbine pump (HTP)

2. Background: comparison

PUMP TYPE	Efficiency	Depth	Temperature	Suppliers	Pros	Cons
Lineshaft pumps	~ 50 %	limited to 500-600 mbgl	150-200 °C	Limied availability	Motor, seals, bearings are at surface	Lomg installation time. Requires perfect alignment
Electro submersible pumps	55-60%	~ 300 to ~ 1700 m	Mostly < 120 °C	Highly competitive market	Short installation time, easy handling	Less accesible motor, seals and bearings
Hydraulic turbine pumps	40%	~ 500 m		Limited availability	No electrical parts in well	Limited experience Anchoring damages well casing

2. Background: ESP construction



2. Background: ESP design

Derive Well inflow curve

↓

Calculate required power rating

↓

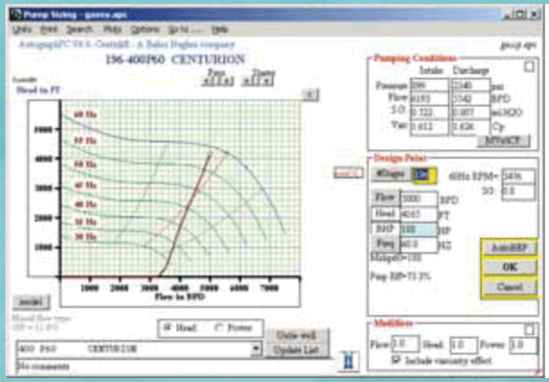
Select pump and pump set depth

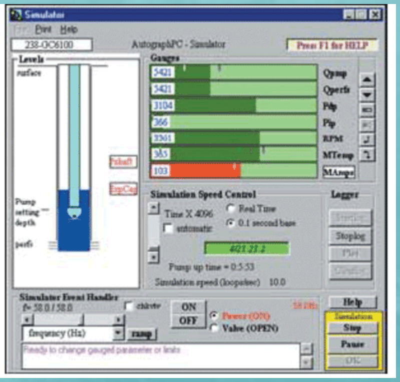
↓

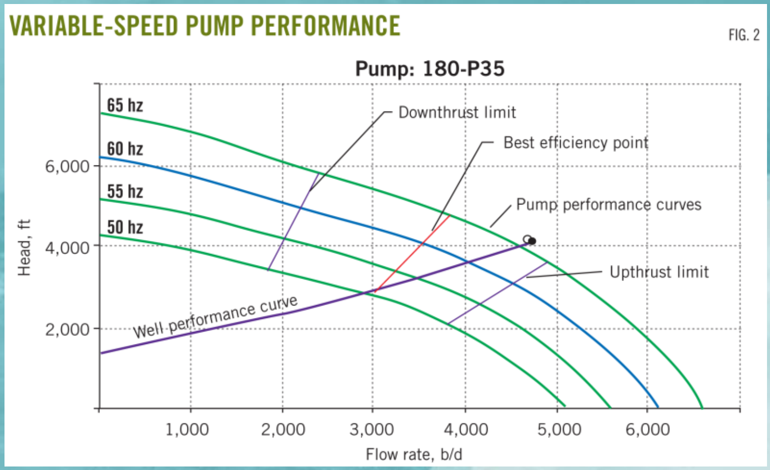
Select motor,seals and power cable

↓

Select transformer and variable speed driver







2. Background: efficiencies

$$\eta_{total} = \eta_{pump}\, \eta_{motor}\, \eta_{eleccable}\, \eta_{transformer}\, \eta_{freq}$$

η_{pump}	pump efficiency	~ 70%
η_{motorl}	motor efficiency,	~ 90 %
η_{cable}	electrical cable efficiency	~ 97%
$\eta_{transformer}$	efficiency of transformer	~ 99%
$\eta_{frequency}$	efficiency of frequency converter	~ 94%
η_{total}	overall efficiency	**~ 55%**

3. Survey in Europe: Overview

Country	Area	Description
France	Paris Basin	• LSP, ESP, HTP s have been operated → Currently only ESPs are operational • Highly corrosive water → control with inhibitors improves ESP life to 5 years
Germany	Molasse Basin (Munich)	• High temperature wells, forbidden to inject inhibitors •Results in short lifetimes of ESP (< 1 year)
	Upper Rhine Graben	• High temperature wells, forbidden to inject inhibitors •LSP lifetime ~ 3 years
Iceland		•Lifetime of 4 years for ESPs

3. Survey in Europe: Trends

Summary and outlook:

• The use of in hole corrosion and scaling inhibition increases the pump life.

•The performance of lineshaft pumps is strongly site specific, and in most instances limited to medium enthalpy producer wells, within the 150°C to 200°C range,

•ESPs are leading the low enthalpy geothermal sector (70- 120°C) range with 4 to 5 year pump life objective.

•ESPs could step into the medium enthalpy slot manufacturing majors.

4. Survey in the Netherlands

- Questionaire sent to operators, 8 out of 13 responded

- Overall, ESPs operate at
    - Flow rates between 100-300 m^3/h,
    - At temperatures between 80 and 100 ºC.

- Baker Hughes ESPs have been installed in almost all wells, predicts a lifetime of ~ 5 years.

- Some ESPs operate at edge of specified range of manufacturer
    - → may lower lifetime
    - → results in lower efficiency

- With available data not possible to asses ESP efficiency

4. Survey in the Netherlands: Impact of lower efficiency

Example:

Power of ESP pump is 400 kW
8500 operating hours

Assume efficiency of 35% instead of 55%.
Assume electricity price of € 0,06/kWh

Avoidable electricity costs of

= (55-35)%*400 * 0,06= € 40.800,- on a yearly basis.

Table 6: ESP OPEX
(*) yearly provision assuming a four year life

4. Suvey in the Netherlands: OPEX and CAPEX costs

ITEM	DESCRIPTION	CAPEX COST (k€)	
		Min	Max
1	Pump		
2	Upper Seal		
3	Lower Seal		
4	Motor		
5	Cable		
6	Monitoring/Control Unit		
7	Shipment		
8	Field service (ESP operator)		
9	ESP RIH crew		
	TOTAL	**180**	**300**

ITEM	DESCRIPTION	OPEX COST (k€/yr)	
		Min	Max
1	Monitoring/Light maintenance	10	10
2	ESP replacement (*)	35	60
3	POOH damaged ESP (*)	5	7
4	RIH new ESP (*)	7.5	9
5	Contingencies	6	9
	TOTAL	**63.5**	**95**

5. Recommendations

<u>ESP design:</u>

•Utilize design guidelines on expected reservoir performance. Record well deliverability and fine tune the design

•Account for potential degradation of well and reservoir performance

•Utilize tandem (two seal) protect in ESP

5. Recommendations

ESP maintenance:

•Record periodically performance of ESP (working point, efficiencies, reactive current, harmonic distortion,....)

• Uitilize sound O&M protocols

• ESPs are designed for continuous operation → Limit number of starts/stops

•Utilize chemical inhibition to protect ESP

• Spare parts on stock for fast duty cycles


Questions?