

## DAFTAR ISI

HALAMAN JUDUL .....	1
LEMBAR PENGESAHAN.....	2
HALAMAN PERNYATAAN KEASLIAN KARYA ILMIAH.....	3
HALAMAN PERSEMBAHAN.....	4
RINGKASAN.....	5
ABSTRACT .....	6
KATA PENGANTAR .....	7
DAFTAR ISI .....	9
DAFTAR GAMBAR.....	13
DAFTAR TABEL .....	15
DAFTAR LAMPIRAN.....	xvi
DAFTAR SIMBOL .....	xvii
BAB I PENDAHULUAN .....	16
1.1. RUMUSAN MASALAH.....	16
1.2. BATASAN MASALAH.....	17
1.3. MAKSUD DAN TUJUAN.....	17
1.4. METODOLOGI .....	17
1.5. HASIL YANG DIPEROLEH.....	18
1.6. SISTEMATIKA PENULISAN .....	19
BAB II TINJAUAN UMUM LAPANGAN “HAS” .....	20
2.1 LETAK GEOGRAFIS LAPANGAN HAS .....	20
2.2 STRUKTUR GEOLOGI LAPANGAN HAS.....	21
2.3 STRATIGRAFI REGIONAL.....	22
2.4 STRATIGRAFI LAPANGAN HAS .....	23
2.4.1. <i>Formasi Lidah</i> .....	24
2.4.2. <i>Formasi Mundu</i> .....	25
2.4.3. <i>Formasi Kawengan</i> .....	25
2.4.4. <i>Formasi Ledok</i> .....	25
2.4.5. <i>Formasi Wonocolo</i> .....	26
2.4.6. <i>Formasi Ngrayong</i> .....	26
2.4.7. <i>Formasi Tuban</i> .....	27

2.5 PETROLEUM SYSTEM.....	28
2.5.1. <i>Batuan Reservoir</i> .....	29
2.5.2. <i>Mekanisme Jebakan</i> .....	29
2.6 SEJARAH PENGEMBANGAN LAPANGAN HAS.....	30
2.6.1. <i>Reservoir</i> .....	30
2.6.2. <i>Produksi</i> .....	31
BAB III TINJAUAN PUSTAKA (LITERATURE REVIEW).....	32
3.1 ARTIFICIAL LIFT .....	32
3.1.1. <i>Artificial Lift Method Selection for Mature Oil Fields: A Case Study (Darvish &amp; Hadipour, 2019)</i> .....	32
3.1.2. <i>Selection of Artificial Lift (James F. Lea and Henry V. Nickens, 1999)</i> .....	32
3.1.3. <i>Defining the Artificial Lift System Selection Guidelines for Horizontal Wells University of Tulsa (J. Valbuena, E. Pereyra, et al., 2016)</i> .....	32
3.1.4. <i>Guideline of Artificial Lift Selection for Mature Field (Naguib, M. A., et al., 2000)</i> .....	33
3.2 METODE PEMILIHAN ARTIFICIAL LIFT .....	33
1.1.1. <i>Novel EOR Strategy-Decision System Based on Delphi-AHP-TOPSIS Methodology (Bin Liang et al., 2015)</i> .....	33
1.1.2. <i>Selection of the Best Artificial Lift Method for One of the Iranian Oil Field Using Multiple Attribute Decision Making Methods (Ehsan Fatahi, et al., 2012)</i> .....	33
1.1.3. <i>Modelling Approach For Multi-criteria Decisionmaking Selection Process For Artificial Lift Systems In Crude Oil Production (Rodriguez, et al., 2018)</i> .....	33
3.3 Keekonomian .....	18
3.3.1. <i>Design and Economic Evaluation of the ESP and Gas Lift on the Dead Oil Well (Imran A. Hullio. et al., 2018)</i> .....	34
BAB IV METODOLOGI DAN TEORI DASAR.....	35
4.1 METODOLOGI.....	35
4.1.1. <i>Pengumpulan dan Persiapan Data</i> .....	35

4.1.2. <i>Pemilihan Metode Artificial Lift</i> .....	36
4.1.3. <i>Desain/Perencanaan Metode Artificial Lift</i> .....	36
4.1.4. <i>Analisa Keekonomian</i> .....	36
4.2 TEORI DASAR.....	37
4.2.1. <i>Kebutuhan Artificial Lift</i> .....	37
4.2.2. <i>Metodologi Screening Artificial Lift</i> .....	40
4.2.3. <i>Metode Simple Additive Weigting (SAW)</i> .....	41
4.2.4. <i>Jenis-Jenis Artificial Lift</i> .....	41
4.2.5. <i>Sucker Rod Pump (SRP)</i> .....	41
4.2.6. <i>Progressive Cavity Pump (PCP)</i> .....	49
4.2.7. <i>Electrical Submersible Pump (ESP)</i> .....	55
4.2.8. <i>Gas Lift</i> .....	69
4.2.9. <i>Gas Beracun H<sub>2</sub>S</i> .....	80
4.3 ANALISA KEEKONOMIAN.....	83
4.3.1. <i>Net Present Value (NPV)</i> .....	83
4.3.2. <i>Rate of Return (ROR)</i> .....	83
4.3.3. <i>Profit to Investment Ratio (PIR)</i> .....	84
4.3.4. <i>Discounted Profit to Investment Ratio</i> .....	84
4.3.5. <i>Pay Out Time (POT)</i> .....	85
4.3.6. <i>Analisa Sensitivitas</i> .....	85
BAB V PERENCANAAN DAN PEMILIHAN ARTIFICIAL LIFT .....	87
5.1 PERSIAPAN DATA .....	87
5.2 PEMILIHAN METODE ARTIFICIAL LIFT.....	88
1.1.1. <i>Metode Delphi</i> .....	88
1.1.2. <i>Metode TOPSIS</i> .....	91
1.1.3. <i>Metode SAW</i> .....	93
5.1 OPTIMASI ARTIFICIAL LIFT .....	96
1.1.1. <i>Optimasi menggunakan Electric Submersible Pump (ESP)</i> .....	97
1.1.2. <i>Optimasi menggunakan Gas Lift</i> .....	101
5.2 SKENARIO ANALISA KEEKONOMIAN .....	106
5.3 ANALISA KEEKONOMIAN.....	95
BAB VI PEMBAHASAN.....	111

BAB VII KESIMPULAN DAN SARAN.....	114
DAFTAR PUSTAKA .....	98
LAMPIRAN .....	100

## DAFTAR GAMBAR

Gambar 2. 1. Peta Lokasi Lapangan HAS.....	20
Gambar 2. 2 Play Types Jawa Timur Basin .....	24
Gambar 2. 3 Stratigrafi Lapangan HAS .....	28
Gambar 2. 4 Elemen dari Petroleum System.....	30
Gambar 2. 5 Lokasi Sumur dan Ketersediaan Data PVT di Lapangan ‘HAS’	30
Gambar 2. 6 Sejarah Produksi Lapangan HAS.....	31
Gambar 4. 1 Flowchart Metodologi Penelitian.....	37
Gambar 4. 2 Skema Profil Tekanan dan Sistem Produksi.....	38
Gambar 4. 3 IPR dan Outflow pada Sumur Sembur Alam yang Masih Produksi .....	39
Gambar 4. 4 Skema Profil Tekanan saat Sumur Menggunakan Artificial Lift (Aliyev, 2013).....	40
Gambar 4. 5 Komponen Sucker Rod Pump (SRP).....	42
Gambar 4. 6 Subsurface Equipment.....	45
Gambar 4. 7 Peralatan di Bawah Permukaan (Brown, K. E., 1980).....	47
Gambar 4. 8 Skema Sistem PCP (Aliyev, 2013).....	51
Gambar 4. 9 Skema PCP dan Komponennya (Aliyev, 2013).....	51
Gambar 4. 10 Gerakan Rotor dan Stator(Wittrisch, Cholet, C. 2013).....	53
Gambar 4. 11 Penampang Pompa PCP (Wittrisch, C, Cholet, H. 2013) .....	53
Gambar 4. 12 Spesifikasi Setiap Elastomer (NOVOMET, 2020) .....	55
Gambar 4. 13 Instalasi Electric Submersible Pump (Brown, Kermit E., 1980)	56
Gambar 4. 14 Pressure Sensing Instrument (Pertamina, 2004) .....	56
Gambar 4. 15 Bagian Utama dari Motor (Takacs, Gabor., 2009) .....	57
Gambar 4. 16 Protector (Takacs, Gabor., 2009).....	58
Gambar 4. 17 Gas Separator (Takacs, Gabor 2009) .....	60
Gambar 4. 18 Skema Impeller dan Diffuser (Brown, Kermit E., 1980).....	60
Gambar 4. 19 Unit Pompa (Takacs, Gabor., 2009).....	61
Gambar 4. 20 Kabel Listrik (Takacs, Gabor., 2009).....	62
Gambar 4. 21 Junction Box (Brown, Kermit E., 1980).....	63
Gambar 4. 22 Switchboard (Takacs, Gabor., 2009).....	64
Gambar 4. 23 Pump Performance Curve IND1300/60 Hz (EJP Catalogue, 2004).....	65
Gambar 4. 24 Upthrust & Downthrust (Brown, Kermit, E, 1980) .....	67
Gambar 4. 25 Impeller Thrust Area (Coltharp, 1984).....	67
Gambar 4. 26 Mekanisme Operasi Continous Gas Lift (Brown, K.E., “The Technology of Artificial Lift Methods”).....	71
Gambar 4. 27 Diagram Kedalaman Tekanan untuk Perencanaan Sembur Buatan.....	<b>Error! Bookmark not defined.</b>
Gambar 4. 28 Siklus Operasi Intermittent Gas Lift (Brown, K.E., “The Technology of Artificial Lift Methods”).....	72

Gambar 4. 29 Grafik Tekanan Dasar Sumur Pada Proses Intermittent Gas Lift .....	74
Gambar 4. 30 Fluid Operating Valve (Brown, K.E., “The Technology of Artificial Lift Methods”) .....	76
Gambar 4. 31 Skema Thortling Pressure Valve (Brown, K.E., “The Technology of Artificial Lift Methods”).....	77
Gambar 4. 32 Tipe Instalasi Gas Lift (Brown, K.E., “The Technology of Artificial Lift Methods”) .....	79
Gambar 4. 33 Diagram Laba-laba (Allison, Guy. 1992).....	86
Gambar 5. 1 Faktor-faktor yang perlu dipertimbangkan untuk memilih Artificial Lift (Artificial Lift Workshop,Pertamina EP) .....	88
Gambar 5. 2 Inflow vs Outflow Setelah Optimasi ESP HAS-12 .....	98
Gambar 5. 3 Prediksi Basecase Sumur HAS-12 .....	98
Gambar 5. 4 Basecase vs Optimasi Sumur HAS-12 .....	99
Gambar 5. 5 Inflow vs Outflow Setelah Optimasi ESP di HAS-18 .....	100
Gambar 5. 6 Prediksi Sumue HAS-18.....	101
Gambar 5. 7 Basecase vs Optimasi Sumur HAS-18 .....	101
Gambar 5. 8 Gas lift Performance Curve Sumur HAS-12 .....	103
Gambar 5. 9 Inflow vs Outflow Optimasi Gas Lift Sumur HAS-12 .....	104
Gambar 5. 10 Prediksi Gas Lift vs Basecase Sumur HAS-12 (Clean Gas)...	105
Gambar 5. 11 Sensitivitas NPV Skenario I .....	109
Gambar 5. 12 Sensitivitas NPV Skenario II .....	110
Gambar 5. 13 Sensitivitas NPV Skenario III.....	110

## DAFTAR TABEL

Tabel 4 1 Data Sucker Rod (Brown, K. E., 1980) .....	49
Tabel 4 2 Kriteria Penentuan Sistem Injeksi .....	69
Tabel 5. 1 Ketersediaan Data Lapangan “HAS” .....	87
Tabel 5. 2 Parameter Screening Artificial Lift .....	89
Tabel 5. 3 Scoring untuk setiap parameter .....	90
Tabel 5. 4 Scoring untuk parameter sumur HAS-12.....	90
Tabel 5. 5 Tabel Hasil Perhitungan Nilai Di+ dan Di- HAS-12.....	92
Tabel 5. 6 Hasil Perhitungan Nilai Di dan Ci Sumur HAS-12.....	92
Tabel 5. 7 Hasil Perhitungan metode SAW HAS-12.....	94
Tabel 5. 8 Total Nilai Perhitungan Nilai Metode SAW Sumur HAS-12.....	95
Tabel 5. 9 Hasil Screening Artificial Lift Lapangan HAS .....	95
Tabel 5. 10 Hasil Optimasi Sumur HAS-12 .....	99
Tabel 5. 11 Hasil Optimasi Sumur HAS-18 .....	100
Tabel 5. 12 Optimasi Gas Lift Sumur HAS-12 .....	103
Tabel 5. 13 Sensitivitas Laju Gas Injeksi dan Tekanan Injeksi Sumur HAS-12 .....	103
Tabel 5. 14 Kumulatif Gain Oil Setiap Scenario Optimasi .....	106
Tabel 5. 15 Time Schedule Skenario Keekonomian.....	107
Tabel 5. 16 Hasil Perhitungan Keekonomian Lapangan.....	108