Gerotor Pump Performance Correlation Study – Version 2.0.30

17/03/2016

Gerotor Design Studio Ltd
Unit 8 Sumner Point, Lancashire Business Park, Enterprise Drive, Leyland PR26 6TZ
Company Number: 10609806

Correlated Pumps:

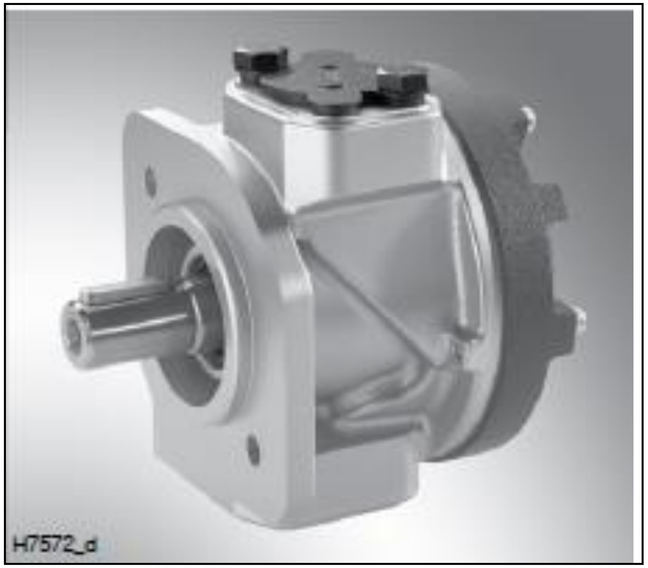
- **Bosch Rexroth PGZ4**
  - **Size ’80’ – Model PGZ4-1X/080RA07VE4**

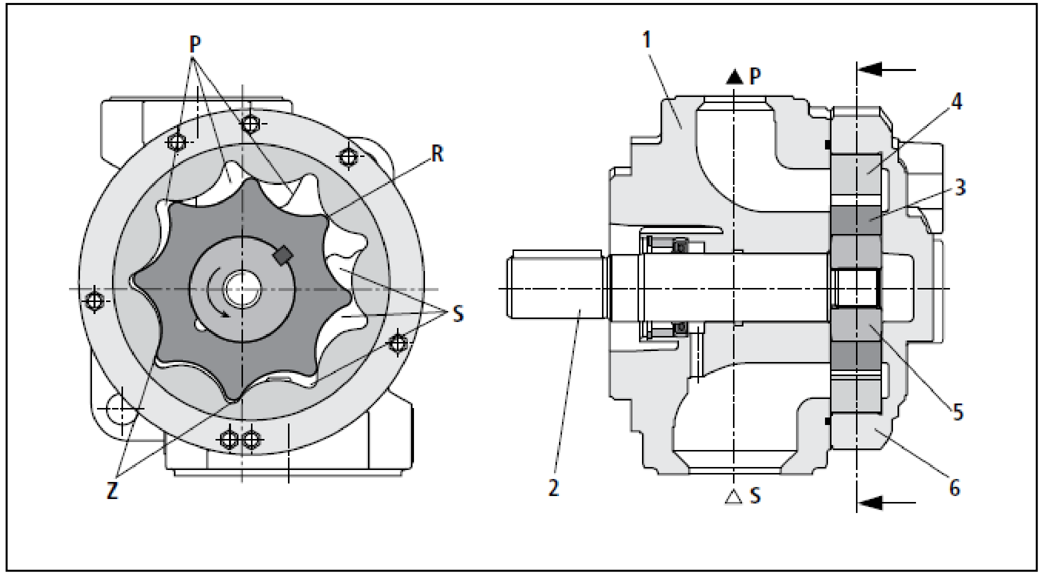
- **Parker Hannifin PGG20010**

- **Miniature Gerotor – Fluid Power Research Laboratory, University of Turin, Italy**

Bosch Rexroth PGZ4
Model PGZ4-1X/080RA07VE4

Bosch Rexroth PGZ4 Series:





- Fixed Displacement (no pressure relief valve)
- Single sided porting, but with Shadow Porting feature
- 8 lobes Inner / 9 lobes Outer
- Information from www.boschrexroth.com

Bosch Rexroth PGZ4 Series:

www.gerotordesignstudio.com

Technical data (For applications outside these parameters, please consult us!)

general

Type	Gerotor pump
Type of connection	ISO 4-hole mounting flange according to ISO 3019-2 and VDMA 24560 SAE 2-hole mounting flange ISO 2-hole mounting flange according to ISO 3019-2, matching through-drive KB2 ISO 2-hole mounting flange according to ISO 3019-2, matching through-drive KB3
Line connection	Flange connection
Shaft load	Radial and axial forces cannot be transmitted
Direction of rotation (viewed on shaft end)	Clockwise

hydraulic

Hydraulic fluid	HLP - mineral oil according to DIN 51524 part 2 **Please observe our specification according to data sheet RE 90220** **Other fluids upon request!**
Hydraulic fluid temperature range °C	–20 to +80, observe the admissible viscosity range!
Ambient temperature range °C	–20 to +80
Viscosity range mm^2/s	10 to 2000
Max admissible degree of contamination of the hydraulic fluid - cleanliness class according to ISO 4406 (c)	Class 21/18/15 [1]

Frame size 4	Frame size		PGZ4					
Size	Size		20	32	40	50	63	80
Displacement	V	cm^3	21.0	33.4	42.1	52.0	64.4	84.2
Weight	m	kg	4.7	5.3	5.6	6.0	6.7	7.8
Flow [2]	q_V	l/min	28	46	58	71	88	116
Mass moment of inertia (around drive axis)	J	kgm^2	0.00086	0.00134	0.00167	0.00205	0.00253	0.00329
Speed range	n_{min}	rpm	200	200	200	200	200	200
	n_{max}	rpm	3000	3000	3000	3000	2300	1800
Operating pressure, absolute – Inlet	p	bar	0.7 to 2 (short-time during start 0.5 bar)					
Nominal pressure – Outlet, continuous	p_N	bar	15					
Min required driving power		kW						
– at $\Delta p \approx 1$ bar, $n = 1{,}450$ min^{-1}			0.75	1.1	1.1	1.1	1.1	1.1
– at $\Delta p \approx 10$ bar, $n = 1{,}450$ min^{-1}			1.5	2.2	2.2	2.2	3.0	3.0
Sound pressure level at 0 – 15 bar [3]		dB(A)	55	56	57	59	60	62

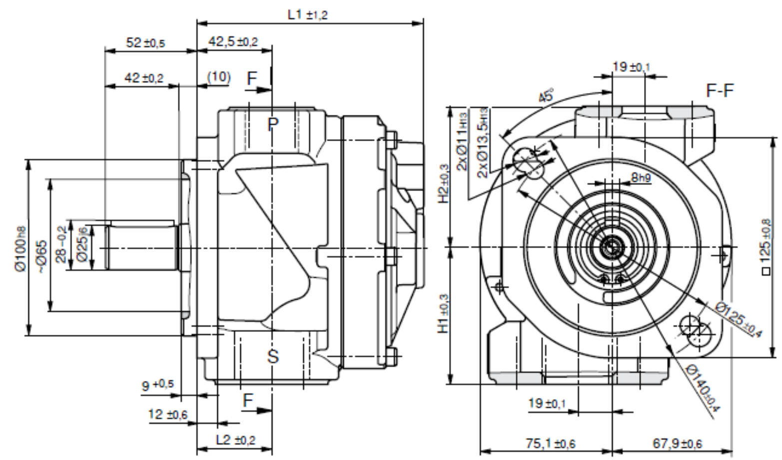
[1] The cleanliness classes specified for the components must be adhered to in hydraulic systems.
An efficient filtration prevents failures and simultaneously increases the lifetime of the components.
For the selection of filters, see data sheets RE 50070, RE 50076, RE 50081, RE 50086 and RE 50088.

[2] Measured at $n = 1.450$ rpm, $p = 10$ bar, and $\nu = 30$ mm^2/s

[3] Measured in sound-absorbent acoustic room at $n = 1450$ rpm and $\nu = 30$ mm^2/s

PGZ $\frac{4}{5}$ -1X/ … RA07VE4

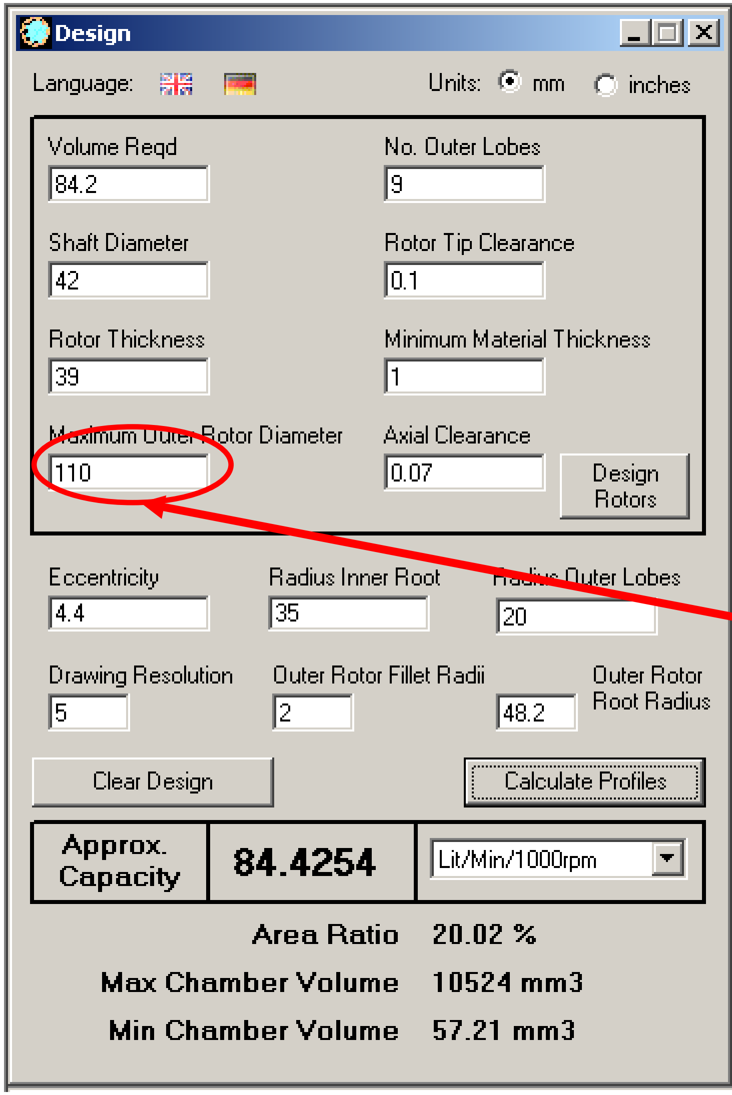
Drive shaft cylindrical,
4-hole mounting flange according to ISO 3019-2 and VDMA 24560



Type Size	Material No.	L1	L2	H1	H2	S [1]	P [1]
PGZ4-1X/020RA07VE4	R901230020	116,5	42,5	77,4	79,6	1 1/2"	1"
PGZ4-1X/032RA07VE4	R901230024	121,5	42,5	77,4	79,6	1 1/2"	1"
PGZ4-1X/040RA07VE4	R901230028	125	42,5	77,4	79,6	1 1/2"	1"
PGZ4-1X/050RA07VE4	R901230032	129	42,5	77,4	79,6	1 1/2"	1"
PGZ4-1X/063RA07VE4	R901230036	134	42,5	77,4	79,6	1 1/2"	1"
PGZ4-1X/080RA07VE4	R901230040	142	42,5	77,4	79,6	1 1/2"	1"
PGZ5-1X/063RA07VE4	R901230044	134	48,5	72,9	76,1	2"	1 1/4"
PGZ5-1X/080RA07VE4	R901230048	142	48,5	72,9	76,1	2"	1 1/4"
PGZ5-1X/100RA07VE4	R901230052	150,5	48,5	72,9	76,1	2"	1 1/4"
PGZ5-1X/140RA07VE4	R901230056	163	48,5	72,9	76,1	2"	1 1/4"

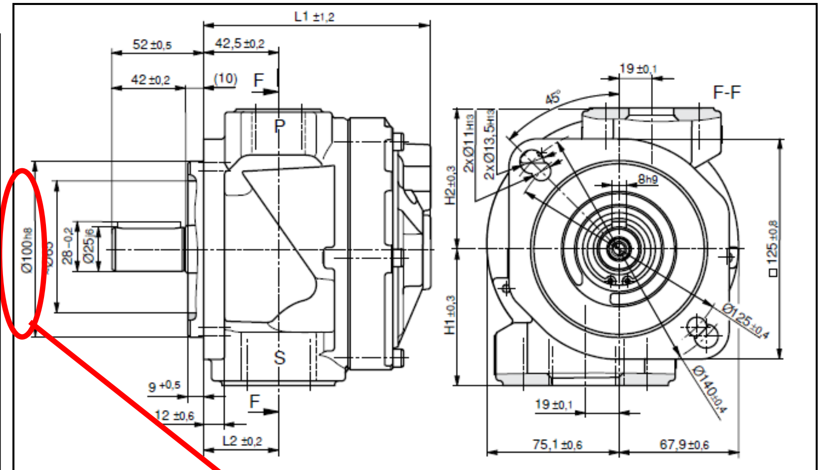
Bosch Rexroth PGZ4-1X/080RA07VE4:

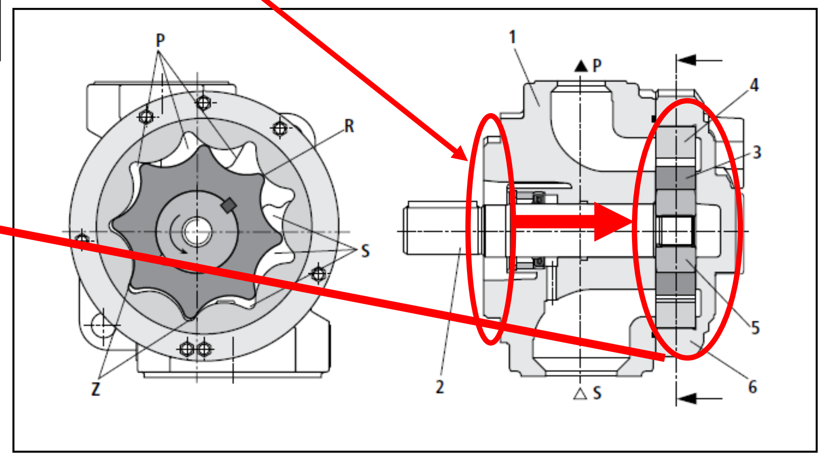
Build of GDS model – Gerotor Design



To acquire unknown dimensions, scaling of the provided drawings had to be used.
For example, the rotor OD was derived from the given dimension of the pump external mounting nose.

Dimensions acquired by this method:
- **Outer Rotor Diameter**
- **Eccentricity**
- **Rotor Thickness (using L1 and L2 dimensions on drawings)**
- **Shaft Diameter ('driving disk')**





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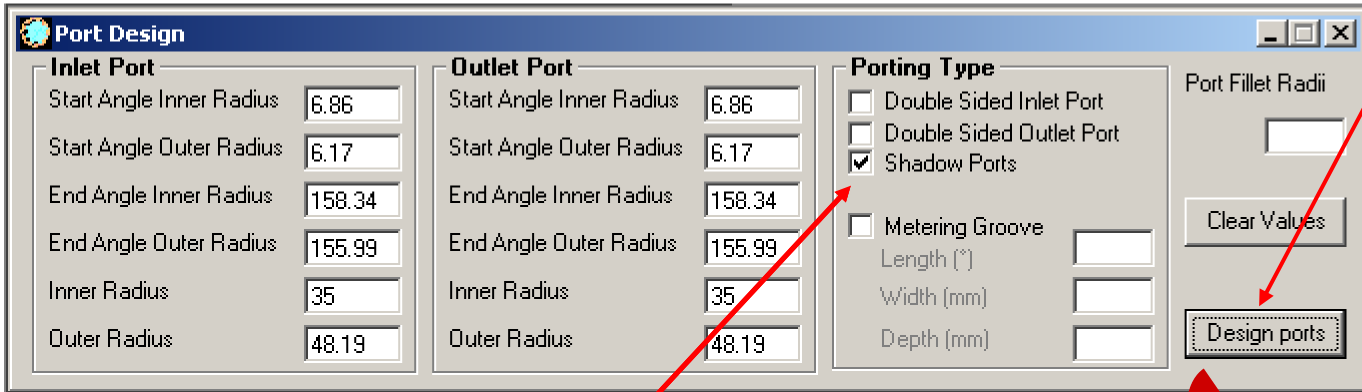
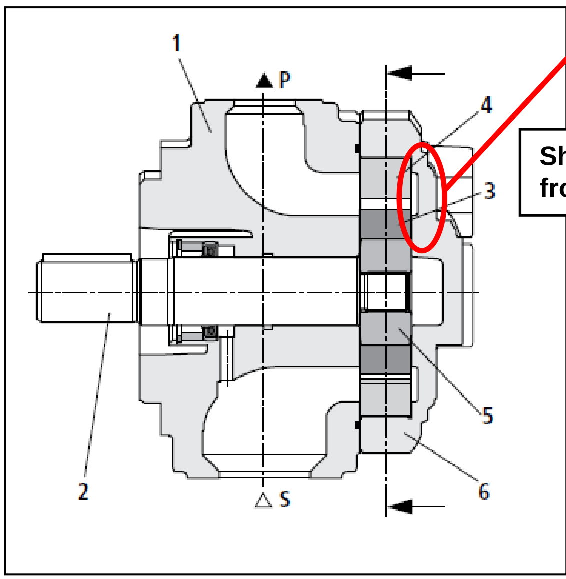
Bosch Rexroth PGZ4-1X/080RA07VE4:

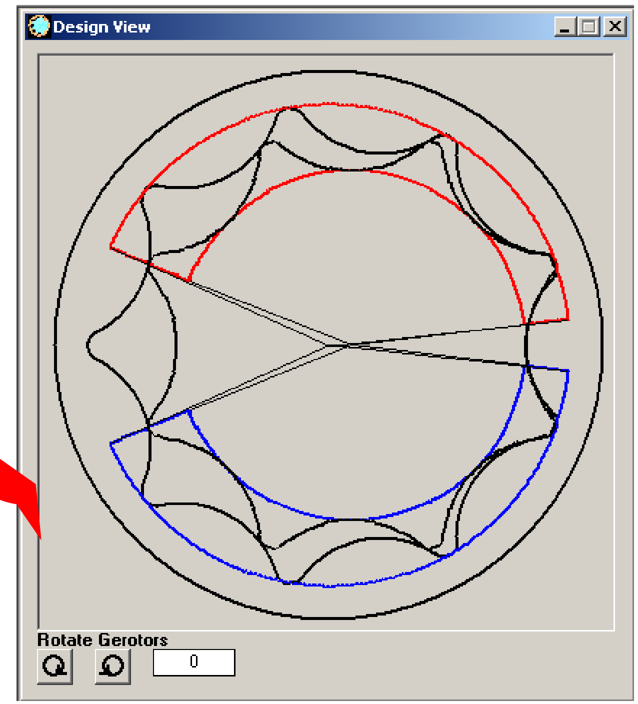
Build of GDS model – Porting Design

Actual Port Design was not known, therefore the GDS 'Design Ports' feature was used to generate porting based on the gerotor dimensions.





Shadow porting is evident from the sectional drawings



Bosch Rexroth PGZ4-1X/080RA07VE4:

Build of GDS model – Fluid / Material / Pump Properties

hydraulic

Hydraulic fluid		HLP - mineral oil according to DIN 51524 part 2 **Please observe our specification according to data sheet RE 90220** **Other fluids upon request!**
Hydraulic fluid temperature range	°C	–20 to +80, observe the admissible viscosity range!
Ambient temperature range	°C	–20 to +80
Viscosity range	mm²/s	10 to 2000

Frame size 4	Frame size		PGZ4					
Size	Size		20	32	40	50	63	80
Displacement	V	cm³	21.0	33.4	42.1	52.0	64.4	84.2
Weight	m	kg	4.7	5.3	5.6	6.0	6.7	7.8
Flow [2]	q_V	l/min	28	46	58	71	88	116
Mass moment of inertia (around drive axis)	J	kgm²	0.00086	0.00134	0.00167	0.00205	0.00253	0.00329
Speed range	n_{min}	rpm	200	200	200	200	200	200
	n_{max}	rpm	3000	3000	3000	3000	2300	1800
Operating pressure, absolute – Inlet	p	bar	0.7 to 2 (short-time during start 0.5 bar)					
Nominal pressure – Outlet, continuous	p_N	bar	15					
Min required driving power		kW						
– at $\Delta p \approx 1$ bar, $n = 1{,}450$ min⁻¹			0.75	1.1	1.1	1.1	1.1	1.1
– at $\Delta p \approx 10$ bar, $n = 1{,}450$ min⁻¹			1.5	2.2	2.2	2.2	3.0	3.0
Sound pressure level at 0 – 15 bar [3]		dB(A)	55	56	57	59	60	62

[1] The cleanliness classes specified for the components must be adhered to in hydraulic systems. An efficient filtration prevents failures and simultaneously increases the lifetime of the components. For the selection of filters, see data sheets RE 50070, RE 50076, RE 50081, RE 50086 and RE 50088.

[2] Measured at $n = 1.450$ rpm, $p = 10$ bar, and $v = 30$ mm²/s

[3] Measured in sound-absorbent acoustic room at $n = 1450$ rpm and $v = 30$ mm²/s

Specifications and Approvals

Mobil DTE 10 Excel Series meets or exceeds the requirements of:	15	22	32
DIN 51524-2: 2006-09	X	X	X
DIN 51524-3: 2006-09	X	X	X
ISO 11158 L-HV	X	X	X
JCMAS HK VG32W (JCMAS P 041:2004)			X
JCMAS HK VG46W (JCMAS P 041:2004)			
Bosch-Rexroth RE 90220-01			X

Typical Properties

Mobil DTE10 Excel	15	22	32
ISO Viscosity Grade	15	22	32
Viscosity, ASTM D 445			
cSt @ 40° C	15.8	22.4	32.7
cSt @ 100° C	4.07	5.07	6.63
Viscosity Index, ASTM D 2270	168	164	164
Brookfield Viscosity ASTM D 2983, cP @ -20 °C			1090
Brookfield Viscosity ASTM D 2983, cP @ -30 °C			3360
Brookfield Viscosity ASTM D 2983, cP @ -40 °C	2020	6390	14240
Tapered Roller Bearing (CEC L-45-A-99), % Viscosity Loss	5	5	5
Density 15° C, ASTM D 4052, kg/L	0.8375	0.8418	0.8468

Performance

Fluid Properties

Fluid Density (Kg/m^3)	847
Kinematic Viscosity (cSt)	30
Vapour Pressure (mmHg)	0.1
Bulk Modulus (GPa)	1.85

Gerotor Material Properties

	Inner	Outer
Youngs Mod (GPa)	210	210
Poissons Ratio	0.29	0.29
Coefficient of Friction	0.1	

Pump Performance Range

Speed Range (RPM)	200	to	1450
Pressure Range (bar)	1	to	10

Calculate Performance

Hydraulic Fluid Properties taken from Mobil 1 DTE10 data sheet (meets specification of Rexroth RE 90220)

Pump speed and pressure ranges taken to match performance parameters from Rexroth technical specification sheet

Bosch Rexroth PGZ4-1X/080RA07VE4:

Build of GDS model – Fluid / Material / Pump Properties

From Mobil 1 DTE10 MSDS

IMPORTANT HEALTH, SAFETY, AND ENVIRONMENTAL INFORMATION

Relative Density (at 15 °C): 0.84
Flash Point [Method]: >175°C (347°F) [ASTM D-92]
Flammable Limits (Approximate volume % in air): LEL: 0.9 UEL: 7.0
Autoignition Temperature: N/D
Boiling Point / Range: > 316°C (600°F) [Estimated]
Vapor Density (Air = 1): > 2 at 101 kPa [Estimated]
Vapor Pressure: < 0.013 kPa (0.1 mm Hg) at 20 °C [Estimated]
Evaporation Rate (n-butyl acetate = 1): N/D
pH: N/A
Log Pow (n-Octanol/Water Partition Coefficient): > 3.5 [Estimated]
Solubility in Water: Negligible
Viscosity: 32.5 cSt (32.5 mm2/sec) at 40 °C | 6.6 cSt (6.6 mm2/sec) at 100°C
Oxidizing Properties: See Hazards Identification Section.

DTE_10_Excel_32

Properties of Mobil DTE 10 Excel 32

From www.wolfram.com website

This is a record with the media properties of Mobil DTE 10 Excel 32 hydraulic oil.

Limitations

- ~~Media properties are constant~~
- Assumed value for the bulk modulus, the actual value depends on the base stock (mineral oil), typical reference values of 2.2 to 2.8e+5 Psi.
- ~~Viscosity measured at 313.2 K~~
- Density measured at 288.2 K

- **Youngs Modulus from www.engineeringtoolbox.com**
  - **Value is for high strength steel at 20-90°C**
- **Poissons Ratio from www.engineeringtoolbox.com**
  - **Value is for high strength steel**
- **Coefficient of Friction from average of internet sources (dynamic friction; steel and lubricated aluminium)**

Performance

Fluid Properties

Fluid Density (Kg/m^3)	847
Kinematic Viscosity (cSt)	30
Vapour Pressure (mmHg)	0.1
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Calculate Performance

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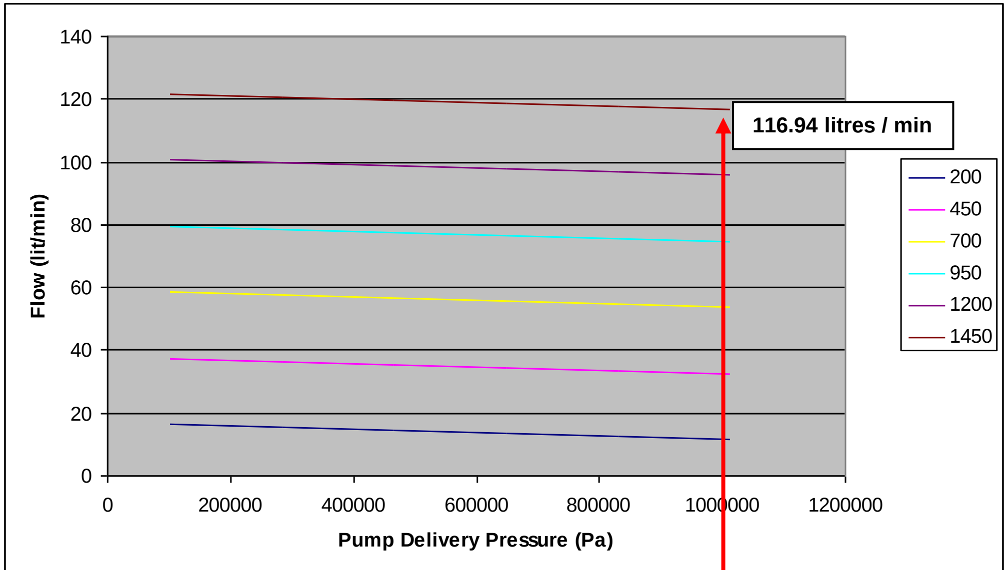
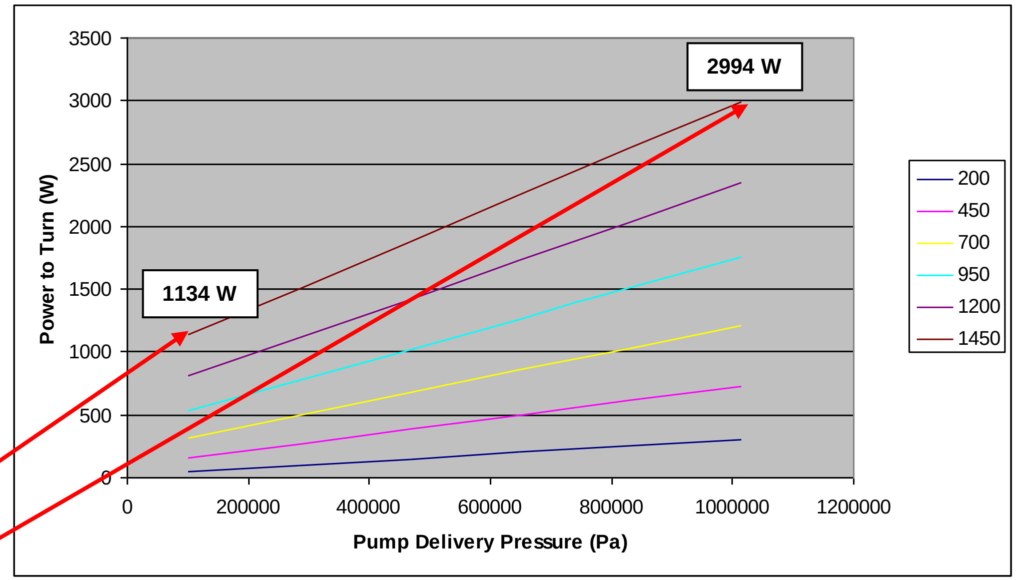
Bosch Rexroth PGZ4-1X/080RA07VE4:

Results – Flow and Drive Power





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Parker Hannifin
Model PGG20010

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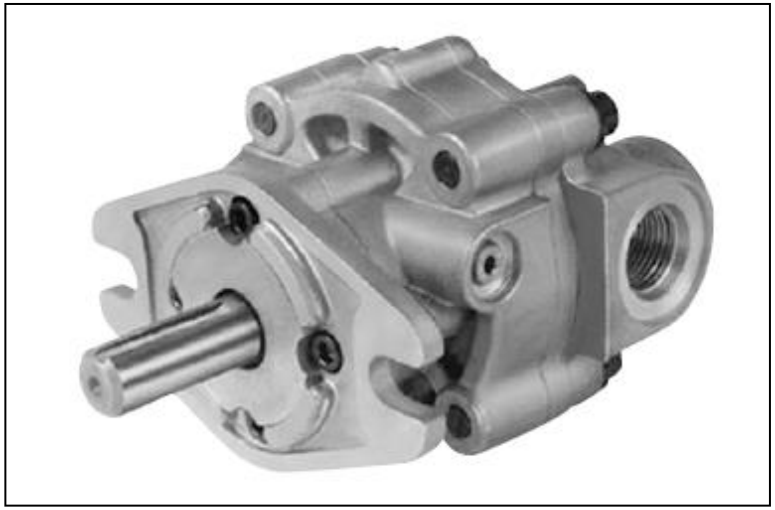
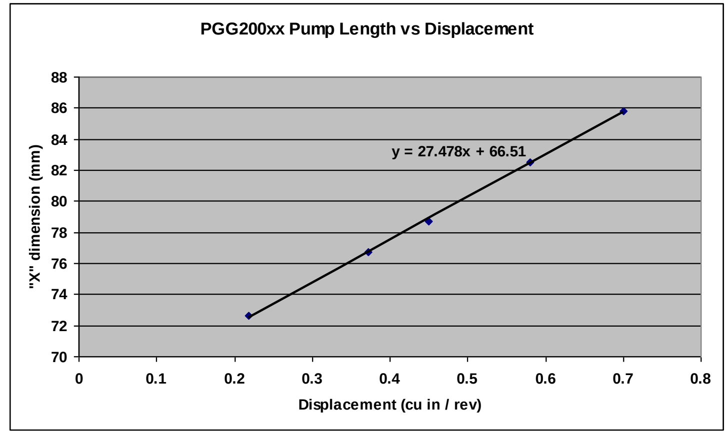
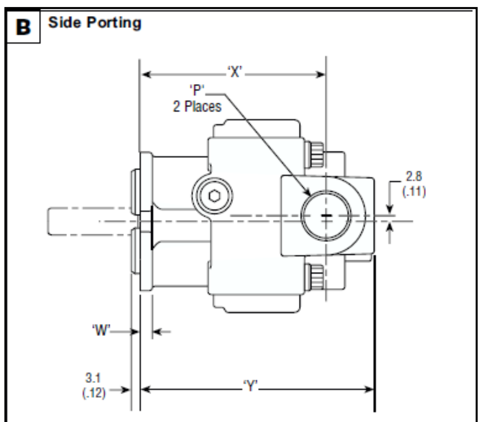
Parker Hannifin PGG20010:





Pump Model	Displacement/Revolution (Theoretical)					Maximum Pressure		Maximum Speed
	US Gallons	Cubic Inches	Liters	Cubic Centimeters	Imperial Gallons	PSI	BAR	RPM
PGG20010	.0010	.218	.0039	3.572	.0008	2000	138	3500
PGG20016	.0016	.372	.0062	6.096	.0013	2000	138	3500
PGG20020	.0020	.450	.0078	7.374	.0016	2000	138	3500
PGG20025	.0025	.580	.0097	9.505	.0021	2000	138	3500
PGG20030	.0030	.700	.0116	11.471	.0025	1500	104	3000

- Series of pumps based on same basic dimensions
  - Only dimension change is length (X and Y values)
- Conclude that rotor set is the same, only different in length
- Plot of Displacement vs Length shows linear relationship
  - Theoretical ‘zero’ displacement is at X=66.5mm
  - Therefore rotor length for PGG20010 pump should be
    - 72.6-66.5 = 6.1mm



MODEL NO.	DIMENSIONS	
	'X'	'Y'
PGG20010	2.86 (72.6)	3.62 (91.9)
PGG20016	3.02 (76.7)	3.78 (96.0)
PGG20020	3.10 (78.7)	3.87 (98.3)
PGG20025	3.25 (82.5)	4.00 (101.6)
PGG20030	3.38 (85.8)	4.14 (105.1)

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Parker Hannifin PGG20010:

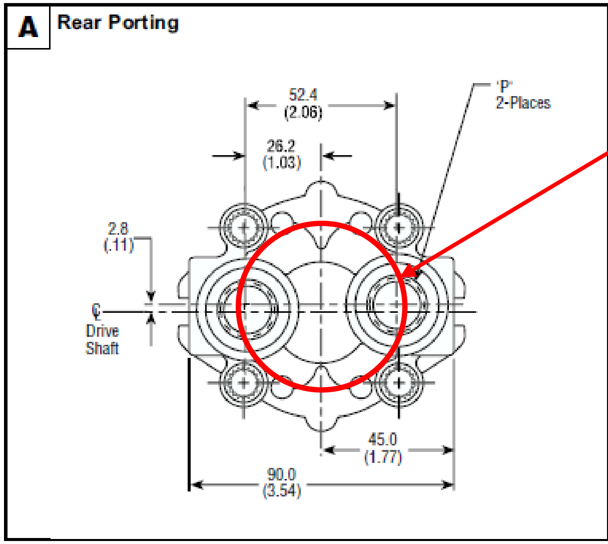
- Pump will undoubtedly have Nichols Portland Gerotor set
  - NP are part of the Parker Hannifin group
- Examination of NP standard gerotor sets shows 2 likely candidates for gerotor forms:
  - 4086 – 4 x inner lobes; 0.86in³/rev per inch of length
  - 6095 – 6 x inner lobes; 0.95in³/rev per inch of length
- However, 6095 has minimum OD of 57.10mm
  - Likely not to fit inside pump housing (from scaling of drawings)

Pump Size	Displacement (in3/rev)	"X" Dimension	Delta "X"	Comments
0	0	66.5	0	From calculation
10	0.218	72.6	6.1	0.218cuin for 6.1mm length = 0.908cuin/inch
20	0.45	78.7	6.1	0.232cuin for 6.1mm length = 0.966cuin/inch
30	0.7	85.8	7.1	0.25cuin for 7.1mm length = 0.894cuin/inch

Nichols Portland Standard Gerotors and Specifications*

(Metric Units Table)

Gerotor Type	Maximum Operating Speed**	Thickness Min.	Nominal Range Max.	Nominal O.D. Standard	Nominal O.D. Minimum Recommended***	Nominal I.D. Standard	Nominal I.D. Maximum Recommended***
	(rpm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
6010	21556	2.5	9.1	20.40	20.40	5.10	5.10
10010	17250	3.175	12.7	25.35	22.17	7.95	9.53
6020	16000	3.175	19.1	28.52	28.52	7.95	7.95
6022	14500	3.175	15.9	28.52	28.52	7.95	7.95
8030	11250	3.175	15.9	38.05	34.87	12.70	15.88
10060	7250	4.8	31.8	57.10	53.92	15.88	25.40
6063	9000	4.8	31.8	50.75	44.40	15.88	17.48
4065	10000	4.8	31.8	44.40	41.25	12.70	12.70
4086	7850	4.8	31.8	50.01	50.01	12.70	12.70
6095	7250	4.8	38.1	57.10	57.10	19.05	19.05
12131	4500	6.4	50.8	82.50	79.32	25.40	44.45
4158	6250	6.4	34.9	62.81	62.81	13.79	22.23
14162	3750	6.4	38.1	101.55	95.20	41.28	53.98
6170	5500	6.4	50.8	76.15	72.97	25.40	28.58
6166	5000	6.35	34.9	76.15	76.15	25.40	28.58
4180	6000	6.4	34.9	66.73	66.73	14.30	22.23
6280	4250	6.4	76.2	101.55	95.25	31.75	38.10
8369	3250	6.4	76.2	114.25	114.25	44.45	53.98
8384	3250	6.4	44.45	114.25	114.25	44.45	53.98
10397	2800	9.5	25.4	127.00	127.00	50.80	60.96



57.10mm rotor set would allow no clearance to bolt bosses.

Therefore assumption is 4086 rotor set is used for PGG20010 (diameter 50.01mm)

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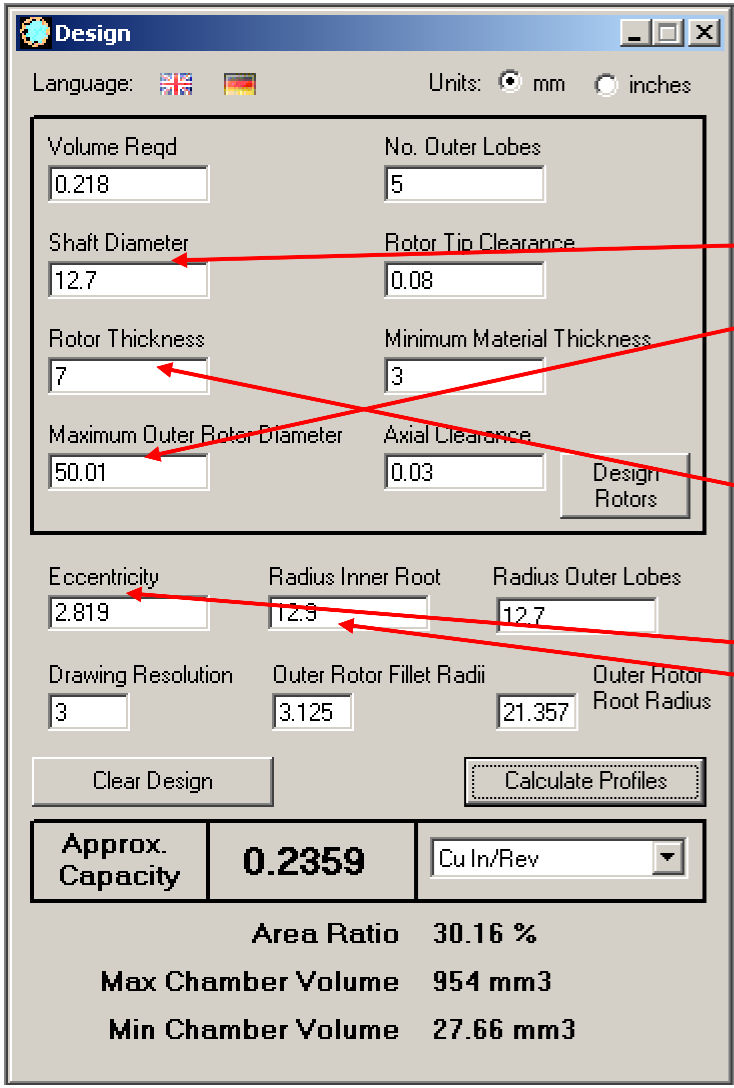
Parker Hannifin PGG20010:

Build of GDS model – Gerotor Design



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6010	21556	2.5	9.1	20.40	20.40	5.10	5.10
10010	17250	3.175	12.7	25.35	22.17	7.95	9.53
6020	16000	3.175	19.1	28.52	28.52	7.95	7.95
6022	14500	3.175	15.9	28.52	28.52	7.95	7.95
8030	11250	3.175	15.9	38.05	34.87	12.70	15.88
10060	7250	4.8	31.8	57.10	53.92	15.88	25.40
6063	9000	4.8	31.8	50.75	44.40	15.88	17.48
4065	10000	4.8	31.8	44.45	41.25	12.70	12.70
4086	7850	4.8	31.8	50.01	50.01	12.70	12.70
6095	7250	4.8	38.1	57.10	57.10	19.05	19.05
12131	4500	6.4	50.8	82.50	79.32	25.40	44.45
4158	6250	6.4	34.9	62.81	62.81	13.79	22.23
14162	3750	6.4	38.1	101.55	95.20	41.28	53.98
6170	5500	6.4	50.8	76.15	72.97	25.40	28.58
6166	5000	6.35	34.9	76.15	76.15	25.40	28.58
4180	6000	6.4	34.9	66.73	66.73	14.30	22.23
6280	4250	6.4	76.2	101.55	95.25	31.75	38.10
8369	3250	6.4	76.2	114.25	114.25	44.45	53.98
8384	3250	6.4	44.45	114.25	114.25	44.45	53.98
10397	2800	9.5	25.4	127.00	127.00	50.80	60.96

Standard Gerotor Porting Information (See Figure 4)

Gerotor Type	Nominal Porting Dimensions: Radius A	Radius B	Ecc. C	Width D	Land E	Land F	Angle G	Port Area
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(degrees)	(mm^2)
6010	5.0	7.9	0.9	2.6	5.0	2.8	52.4	44.0
10010	6.9	9.2	0.660	2.0	4.4	3.0	34.5	49.0
6020	6.6	10.8	1.321	4.0	6.8	2.9	54.0	88.4
6022	7.3	11.5	1.321	4.0	7.5	3.4	54.0	94.8
8030	10.6	14.8	1.321	4.0	8.4	3.6	42.0	138.1
10060	17.3	22.6	1.651	5.0	11.0	5.6	34.5	277.4
6063	11.0	19.1	2.286	6.9	12.6	4.7	55.0	263.2
4065	9.3	17.9	2.794	8.4	14.0	6.5	79.5	236.1
4086	12.9	21.6	2.819	8.5	18.7	10.4	79.5	206.5
6095	14.7	23.4	2.794	8.4	15.5	6.0	55.0	391.6
12131	27.2	34.3	2.286	6.9	14.2	5.9	28.5	601.3
4158	15.1	27.9	4.191	12.6	22.2	11.9	77.5	551.6
14162	34.1	41.2	2.286	6.9	15.2	7.9	24.5	748.4
6170	19.1	30.7	3.810	11.4	19.8	8.1	54.0	692.3
6166	22.2	32.7	3.429	10.3	22.3	14.6	52	649.7
4180	14.6	29.2	4.775	14.3	22.1	9.8	79.0	638.7
6280	25.4	39.9	4.775	14.3	26.7	10.2	55.0	1125.8
8369	34.9	49.5	4.775	14.3	28.1	8.5	43.0	1572.3
8384	36.6	51.2	4.775	14.3	29.7	9.4	43.0	1638.7
10397	42.9	57.4	4.343	12.7	27.4	10.4	34.5	1740.0

Tip and axial clearances obtained from Nichols Portland design guidelines "Gerotor Selection & Pump Design v1.2"

Operating Conditions And Clearances For Some Typical Applications

High Pressure Pump

Pressures:	800 to 1200 psi	(5500 to 8300 kPa)
Speeds:	1800 to 3600 rpm	(1800 to 3600 rpm)
Displacements:	0.5 to 1.5 in^3/rev	(8.2 to 24.5 cc/rev)
Temperature range:	100 to 250°F	(40 to 120°C)
Axial clearance:	.0002 to .0012 inches	(0.005 to 0.030 mm)
O.D. clearance:	.003 to .005 inches	(0.08 to 0.13 mm)
Gerotor tip clearance:	.003 inches max.	(0.08 mm max.)
Eccentricity tolerance:	± .0008 inches	(± .020 mm)

Rotor Thickness greater than calculated 6.1mm.

To obtain a displacement of 0.700cuin/rev with this gerotor set, a thickness of 21mm is required (i.e. for '30' size pump). Therefore an assumption of 7mm was used for this '10' size pump.
This gives a theoretical 'over capacity' (0.236cu in/rev) but will compensate for greater leakage losses with a smaller gerotor, so would be feasible for the actual pumping elements.

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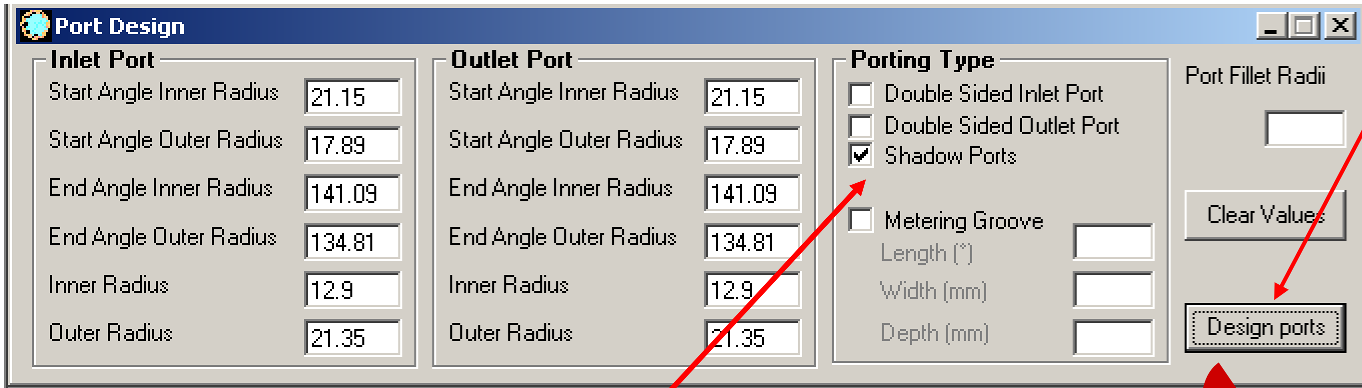
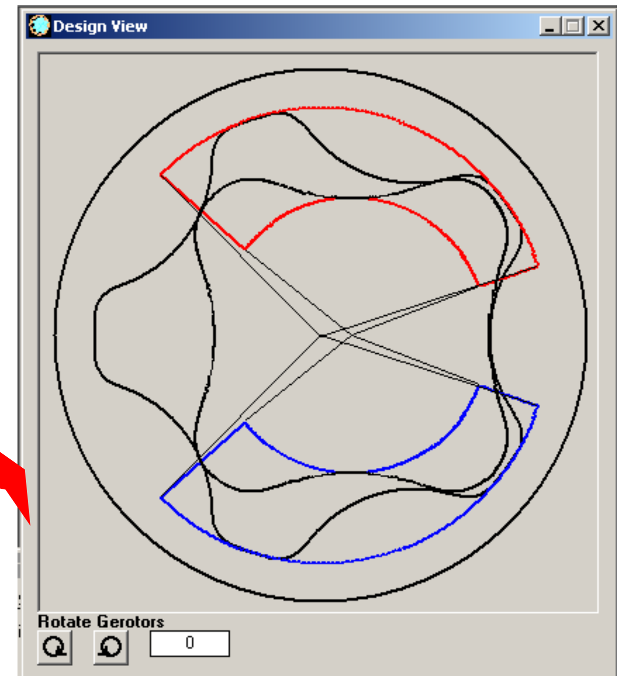
Parker Hannifin PGG20010:

Build of GDS model – Porting Design



Actual Port Design was not known, therefore the GDS 'Design Ports' feature was used to generate porting based on the gerotor dimensions.

Shadow porting is not shown on any sectional drawings, but is assumed based on the recommendation given in the Nichols Portland's own design guide



Parker Hannifin PGG20010:

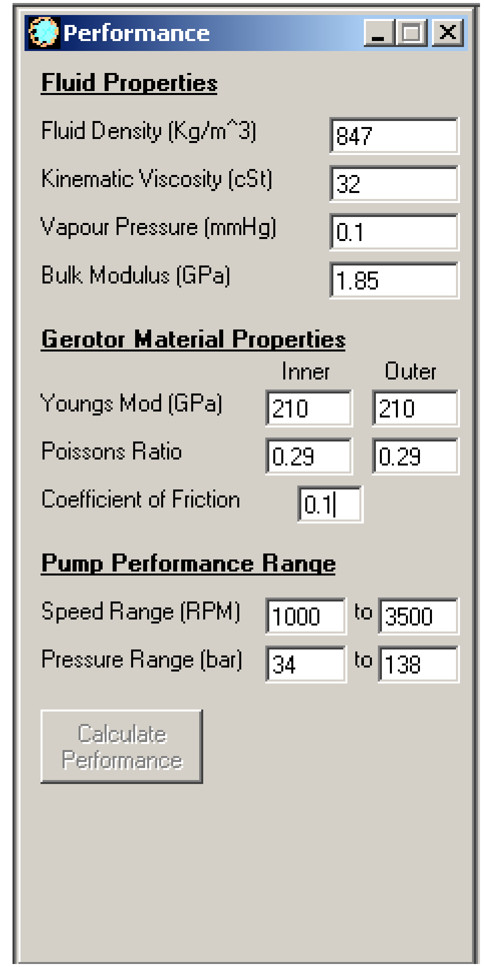
Build of GDS model – Fluid / Material / Pump Properties

Only fluid property given in the Parker Hannifin product guide is a viscosity of 32cSt, for determination of the flow characteristics.

All other fluid and material properties were assumed to be as for the Bosch Rexroth pump design

Speed and pressure ranges taken to be consistent with the pump performance characteristics published by Parker Hannifin

OIL VISCOSITY: Recommended viscosity 150 SUS (3.65 engler). (32 centistokes) Minimum recommended viscosity 60 SUS (2.1 engler) (13 centistokes)



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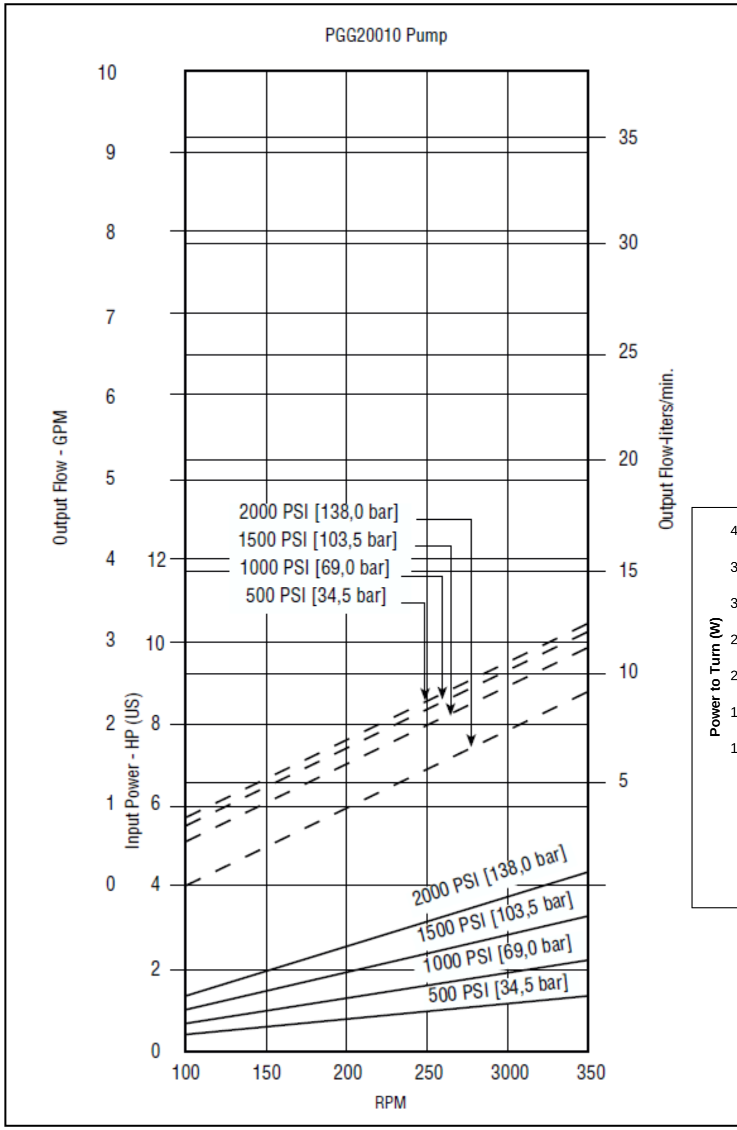
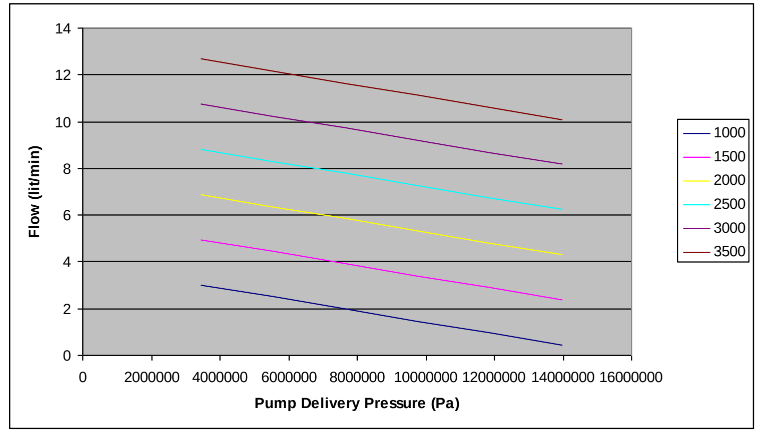
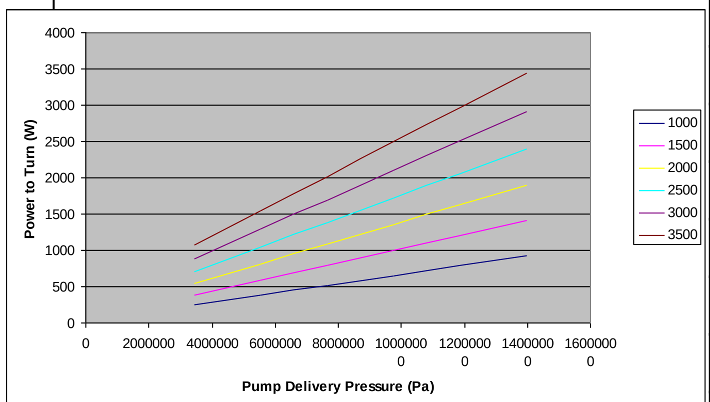
Parker Hannifin PGG20010:

Results – Flow and Drive Power







Characteristic	PGG20010 Results	GDS Results	Difference	Error (%)
Flow @ 3500rpm 34.5bar	12.5	12.67	0.17	1.36
Flow @ 3500rpm 138bar	9.16	10.09	0.93	10.15
Flow @ 1000rpm 34.5bar	3.33	3.02	-0.31	-9.31
Flow @ 1000rpm 138bar	0.25	0.4	0.15	60.00
Power @ 3500rpm 34.5bar	973	1069	96	9.87
Power @ 3500rpm 138bar	3252	3444	192	5.90
Power @ 1000rpm 34.5bar	324	246	-78	-24.07
Power @ 1000rpm 138bar	1005	924	-81	-8.06

Miniature Gerotor – Fluid Power Research Laboratory, University of Turin, Italy

"Miniature Gerotor Pump Prototype for Automotive Applications" – S. Manco; N. Nervegna; M. Rundo; M. Margaria
The Fluid Power Research Laboratory at Polytechnic of Turin, Italy

Presented at 3rd International Fluid Power Conference, March 5-6 2002, Aachen, Germany

Gerotor Design Studio

Miniature Gerotor Pump Prototype:

www.gerotordesignstudio.com

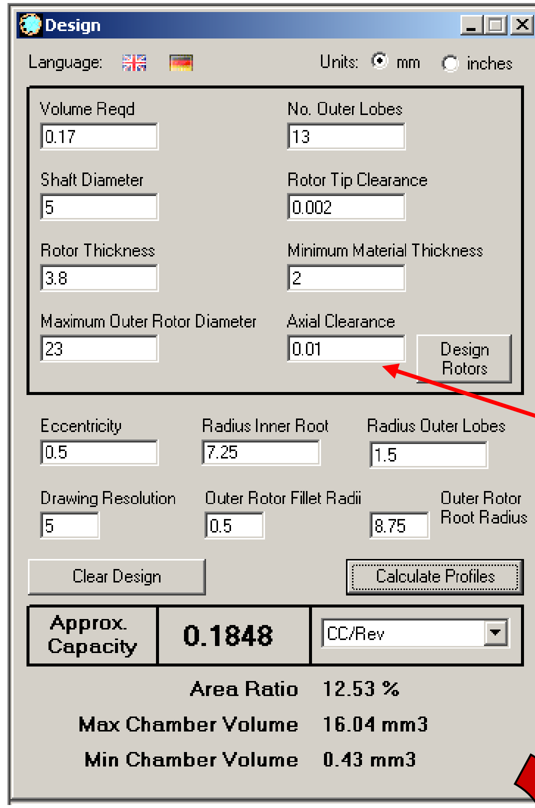
Pump Specifications

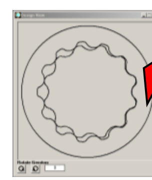
ABS Specs

- Displacement 0.17 cm^3/rev
- Maximum pressure 150 bar
- Volumetric efficiency 85%
- Fluid viscosity 2 cSt

- **Assumed working fluid: DOT4 Brake Fluid**

Very small Gerotor

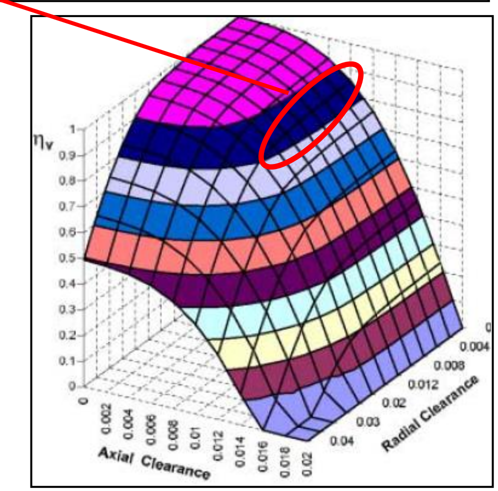




Known parameters:
- **Required volume**
- **No. Outer Lobes**
- **Thickness**
- **Outer Diameter**

'Design Rotors' feature used to create remaining design parameters

- **Iterations of Eccentricity and Radius Inner Root used to bring Approx Capacity into correct range (allowance for some leakage loss)**



Miniature Gerotor Pump Prototype:

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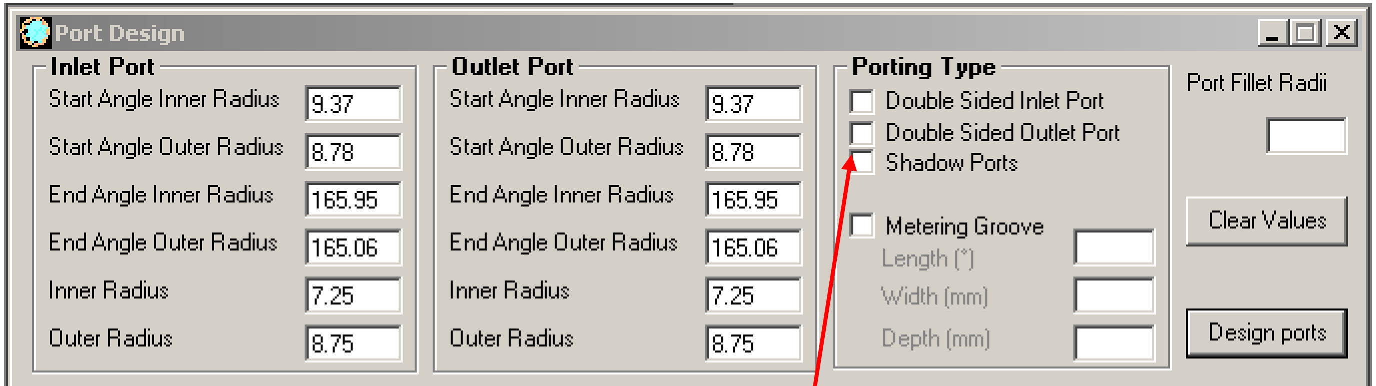
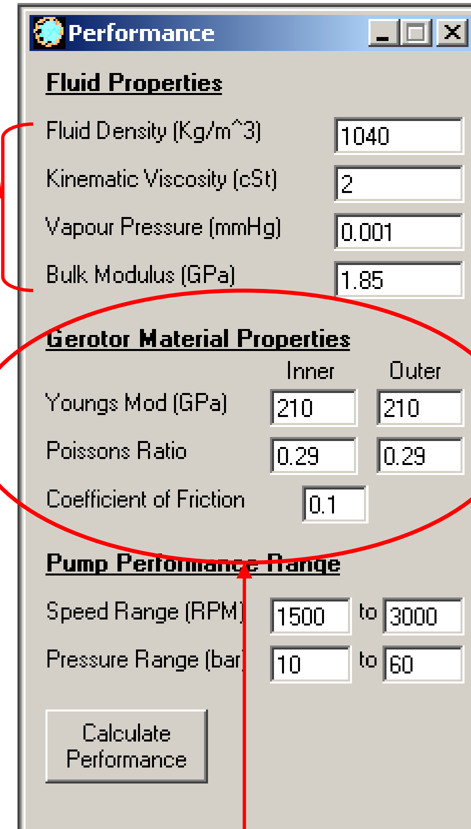
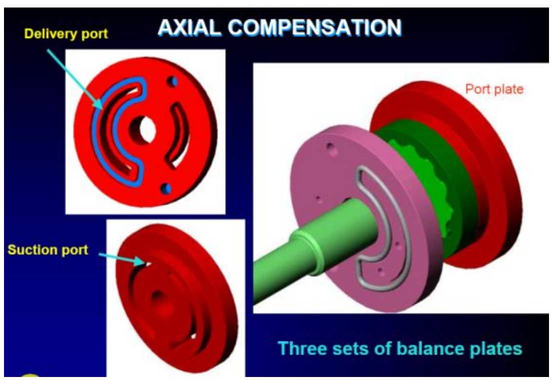
Pump Specifications

DOT4 Fluid Properties





Porting designed using GDS 'Design Ports' feature
No shadow porting or double sided porting selected



Content of part of the technical paper was to show the effect of 'balance plates' on volumetric efficiency. The balance plates allow high pressure fluid behind the rotor housing to close the axial clearance gap at high pressures (reduce leakages) – but it still allows a rotor to housing contact, so is not the same as shadow or double sided porting! Hence the boxes are not checked.

Values used are assumed the same as for other pump designs – no indication given in the technical paper for other values

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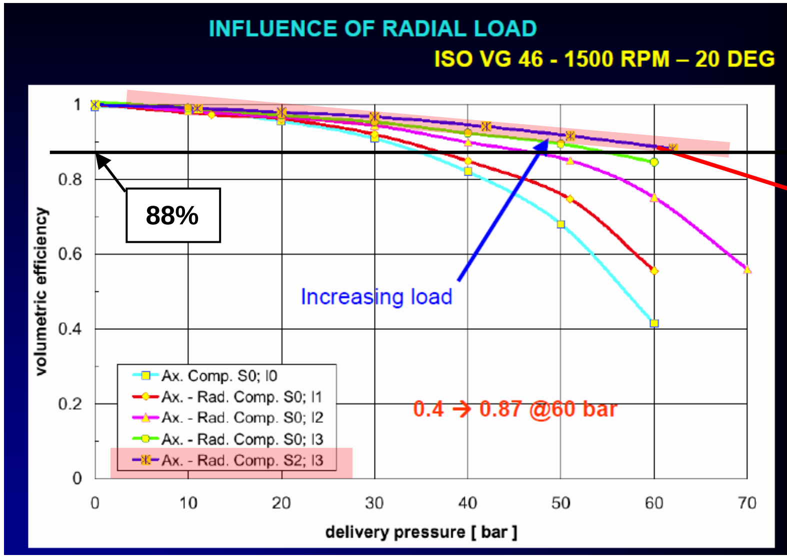
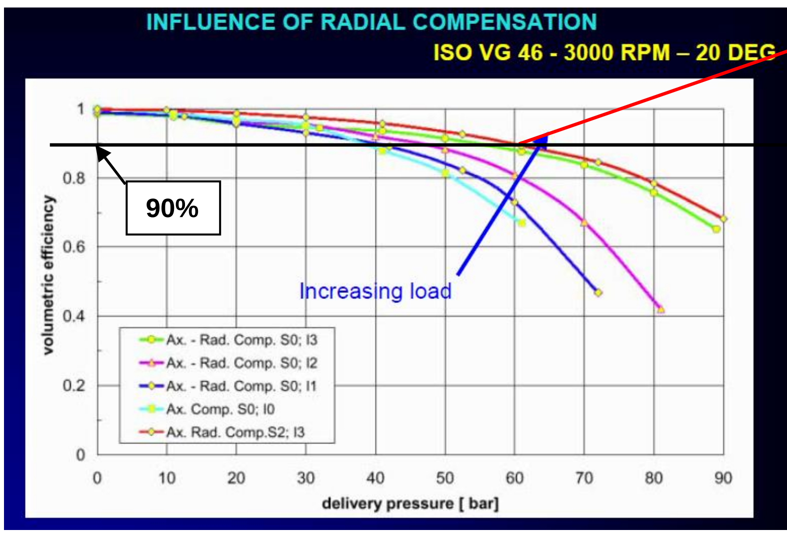
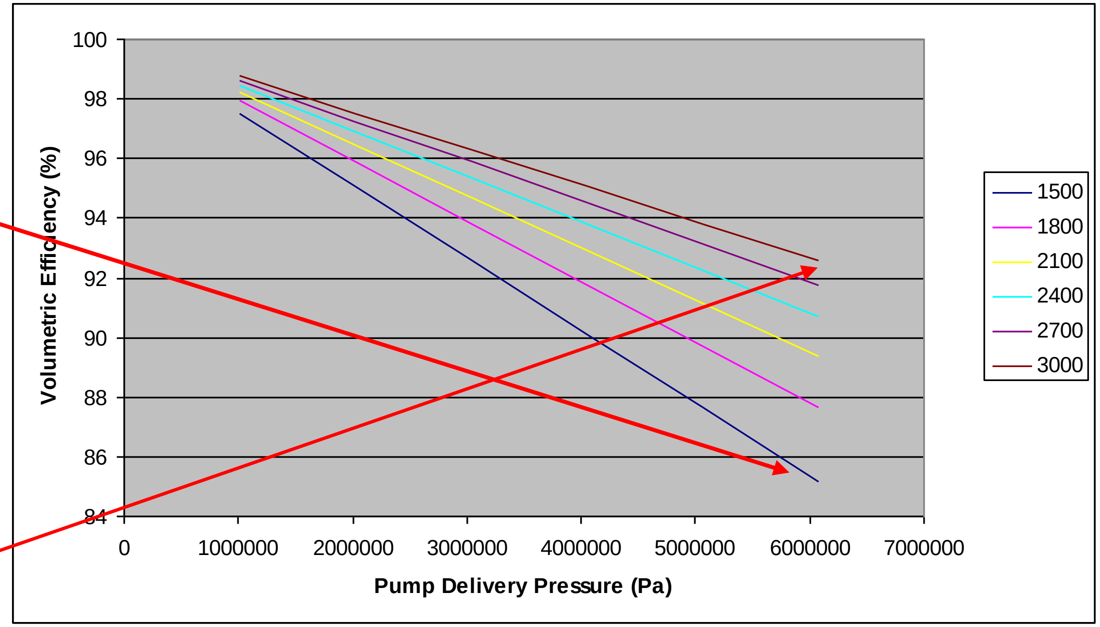
Miniature Gerotor Pump Prototype:

Results







- GDS assumes the outer rotor remains concentric to the housing bore at all times
  - Therefore the results of 'Radial Load' compensation are meaningless in GDS and the results should be compared to the highest level of radial compensation tested in the technical paper (assumption is this is closest to the concentric condition)

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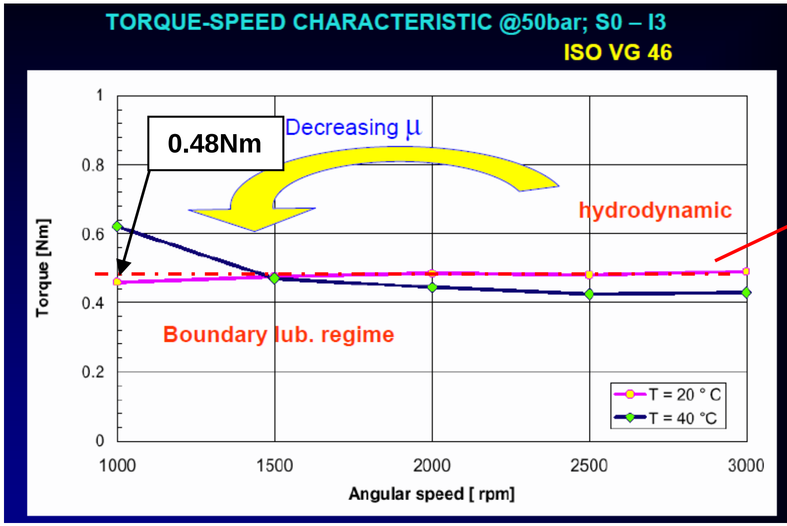
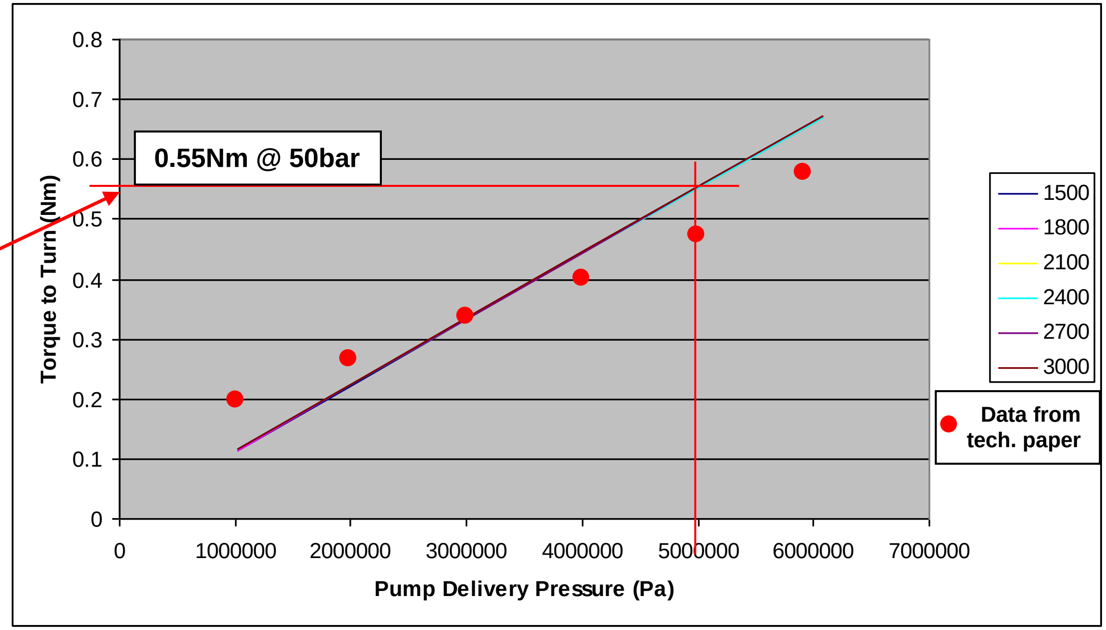
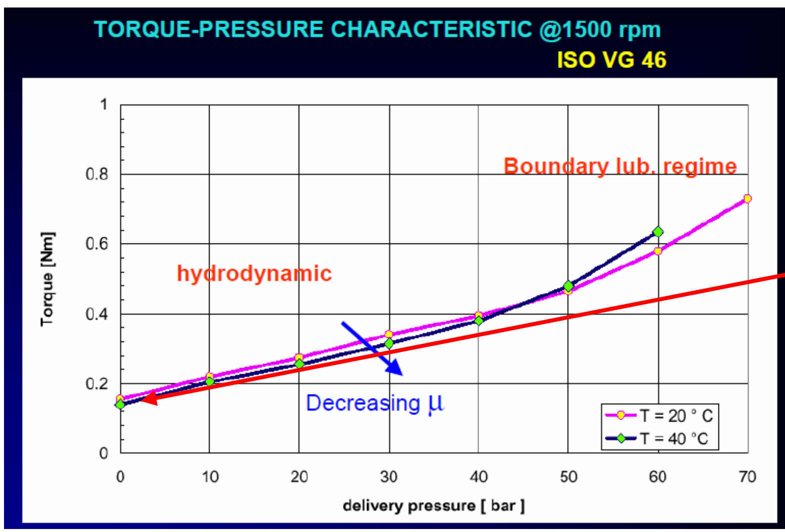
Miniature Gerotor Pump Prototype:

Results







- The values for drive torque are not as aligned as with the larger rotor sets
- Slope of the line is different (see next slide) and would normally cut the Y axis at 0 torque, however the results from the actual tests show a torque of 0.14Nm at no delivery pressure
  - Possibly cause is a high friction (seals or the radial compensation mechanism used in the experiment) which is not modelled in GDS

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Miniature Gerotor Pump Prototype:

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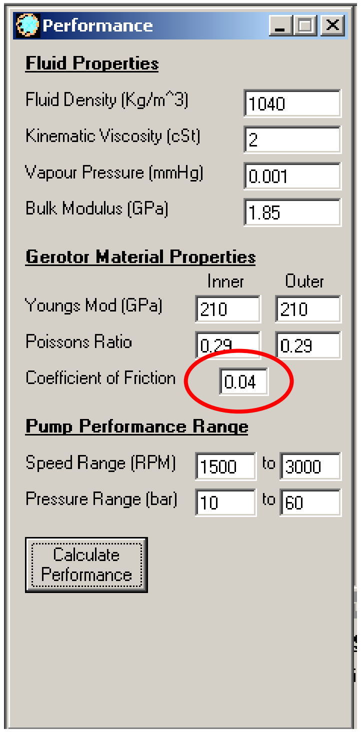
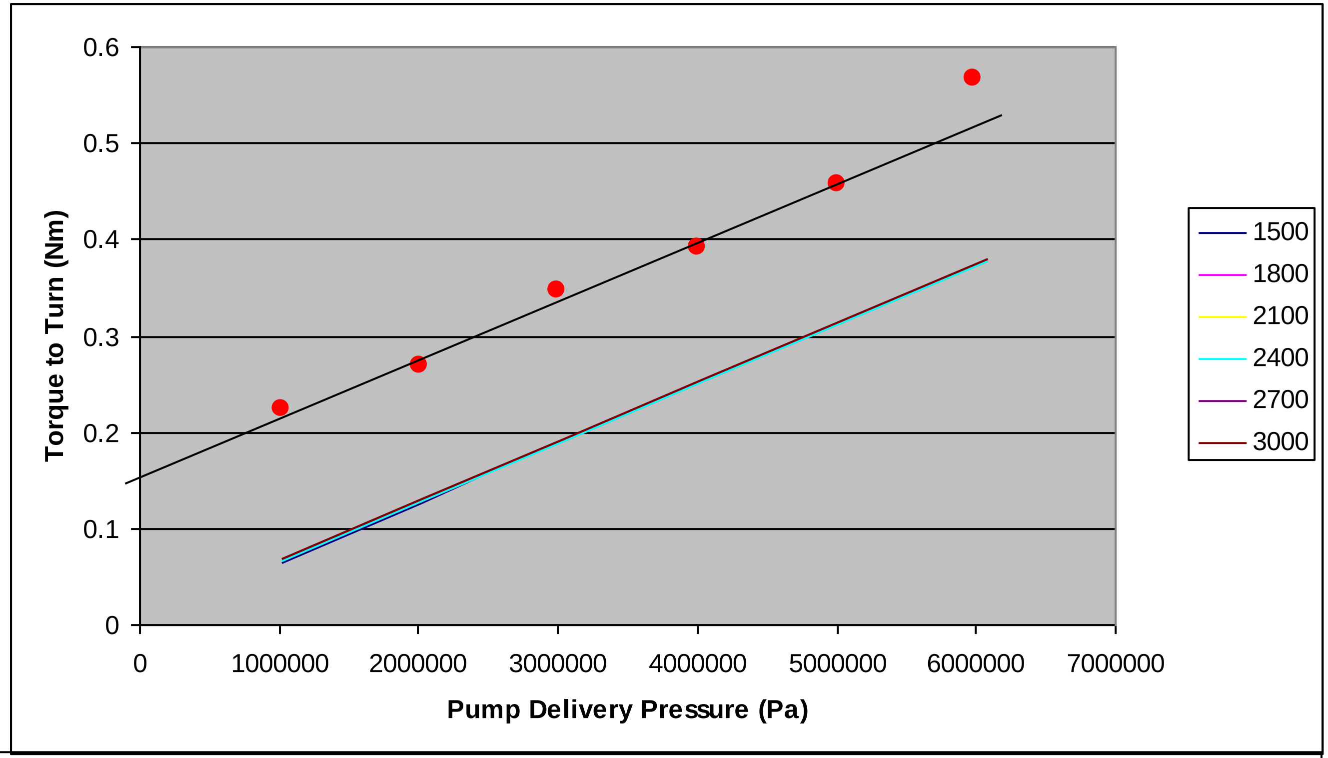
Results





- •The slope of the Torque vs Pressure line is directly related to the friction in the system
- •Friction for a non shadow or double-ported pump is mainly dictated by the face friction

- •By changing the value of the coefficient of friction in GDS to 0.04 the slope of the line is replicated, however the offset of 0.14Nm still exists (other, non pump related friction as previously mentioned)

Summary

Gerotor Design Studio

Summary:

www.gerotordesignstudio.com

	Rexroth PGZ4-80	Parker PGG20010	Miniature Gerotor
Displacement	84.2	0.218	0.17
Shaft Diameter	42	12.7	5
Thickness	39	7	3.8
Outer Rotor OD	110	50.01	23
Number of Lobes	9	5	13
Rotor Tip Clearance	0.1	0.08	0.002
Axial Clearance	0.07	0.03	0.01
Eccentricity	4.4	2.819	0.5
Radius of Inner Rotor Root	35	12.9	7.25
Radius of Outer Rotor Lobes	20	12.7	1.5
Porting Geometry (detailed)	NO	NO	NO
Shadow or Double Porting?	YES	YES	YES
Fluid Properties	YES	NO	NO
Material Properties	NO	NO	NO
Coefficient of Friction	NO	NO	NO
Speed Range	YES	YES	YES
Pressure Range	YES	YES	YES

BLACK text	= Known Parameter for this study
RED text	= Unknown Parameter for this study
LARGE text	= Big influence on the calculated results

Thickness: Affects Capacity and Power Consumption

Rotor Tip Clearance: High Influence for Volumetric Efficiency

Axial Clearance: High Influence for Volumetric Efficiency and Power Consumption

Eccentricity: Direct influence on Capacity

Fluid Properties: High Influence for Volumetric Efficiency and Power Consumption

Coefficient of Friction: High Influence for Non Shadow or Non Double Ported Applications for Power Consumption

Gerotor Design Studio

www.gerotordesignstudio.com

Summary:

	Rexroth PGZ4-80
Displacement	84.2
Shaft Diameter	42
Thickness	**39**
Outer Rotor OD	110
Number of Lobes	9
Rotor Tip Clearance	**0.1**
Axial Clearance	**0.07**
Eccentricity	4.4
Radius of Inner Rotor Root	35
Radius of Outer Rotor Lobes	20
Porting Geometry (detailed)	NO
Shadow or Double Porting?	YES
Fluid Properties	YES
Material Properties	NO
Coefficient of Friction	NO
Speed Range	YES
Pressure Range	YES

Thickness ← Affects Capacity and Power Consumption

Rotor Tip Clearance ← High Influence for Volumetric Efficiency

Axial Clearance ← High Influence for Volumetric Efficiency and Power Consumption

BLACK text = Known Parameter for this study
RED text = Unknown Parameter for this study
LARGE text = Big influence on the calculated results

Very good correlation of results to published figures

- ~1% error for flow and power consumption
- Rotor thickness not known precisely, but derived from scaling of given dimensions and other pump sizes in the PGZ4 family
- Tip and axial clearances taken from other pumps of similar size

Gerotor Design Studio

www.gerotordesignstudio.com

Summary:

	Parker PGG20010
Displacement	0.218
Shaft Diameter	12.7
Thickness	7
Outer Rotor OD	50.01
Number of Lobes	5
Rotor Tip Clearance	0.08
Axial Clearance	0.03
Eccentricity	2.819
Radius of Inner Rotor Root	12.9
Radius of Outer Rotor Lobes	12.7
Porting Geometry (detailed)	NO
Shadow or Double Porting?	YES
Fluid Properties	NO
Material Properties	NO
Coefficient of Friction	NO
Speed Range	YES
Pressure Range	YES

BLACK text = Known Parameter for this study
RED text = Unknown Parameter for this study
LARGE text = Big influence on the calculated results

Thickness: Affects Capacity and Power Consumption

Fluid Properties: High Influence for Volumetric Efficiency and Power Consumption

Good correlation of results to published figures

- <10% error for flow and power consumption
  - Greater %age errors at lower value results (normal)

- Main assumption for this model was that a 4086 rotor set was used
  - Values could be very different if a different rotor set is actually used!

Summary:

	Miniature Gerotor
Displacement	0.17
Shaft Diameter	5
Thickness	3.8
Outer Rotor OD	23
Number of Lobes	13
Rotor Tip Clearance	0.002
Axial Clearance	0.01
Eccentricity	0.5
Radius of Inner Rotor Root	7.25
Radius of Outer Rotor Lobes	1.5
Porting Geometry (detailed)	NO
Shadow or Double Porting?	YES
Fluid Properties	NO
Material Properties	NO
Coefficient of Friction	NO
Speed Range	YES
Pressure Range	YES

Rotor Tip Clearance: High Influence for Volumetric Efficiency

Eccentricity: Direct influence on Capacity

Fluid Properties: High Influence for Volumetric Efficiency and Power Consumption

Coefficient of Friction: High Influence for Non Shadow or Non Double Ported Applications for Power Consumption

BLACK text = Known Parameter for this study
RED text = Unknown Parameter for this study
LARGE text = Big influence on the calculated results

Possibly too many unknowns for accurate simulation…

- Actual tip clearance not known but assumed very small
  - Small gerotor size means incorrect data can have bigger influence on the results, especially at low speeds and flows
- Study with actual gerotor set included radial compensation via application of load to the outer rotor – affects drive torque significantly
- Coefficient of friction not known due to little detail on housing material and unknown influence of 'balance plates'
  - General 'trend' of results is still valid, if not absolute values