

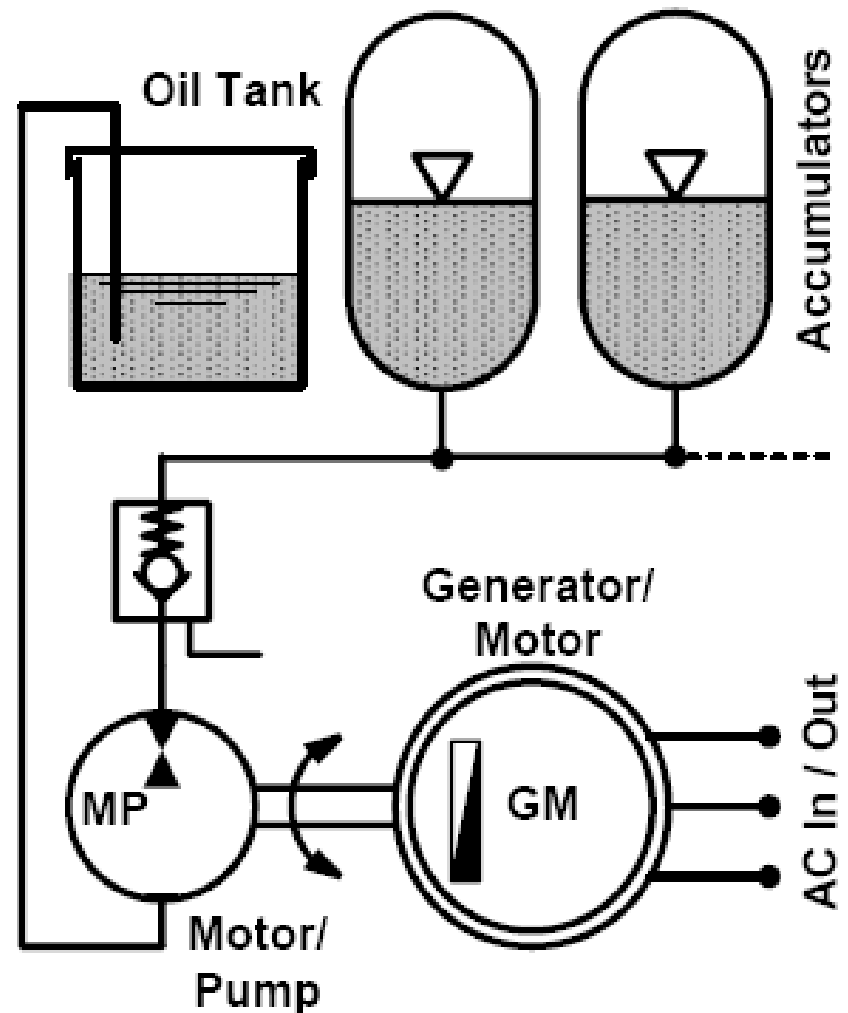
Hydraulic Pneumatic Energy Storage

An Alternative Energy Storage
Approach

Robert Blevins

Pneumatic Hydraulic Storage

- Accumulators charged for storage
- Discharged for generation



Storage Side

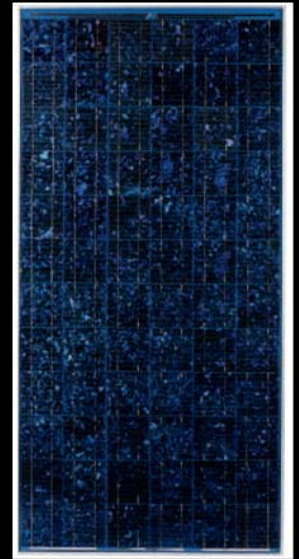


8 SPR – 215

Maximum Efficiency: 21.5%

4 BP SX 120

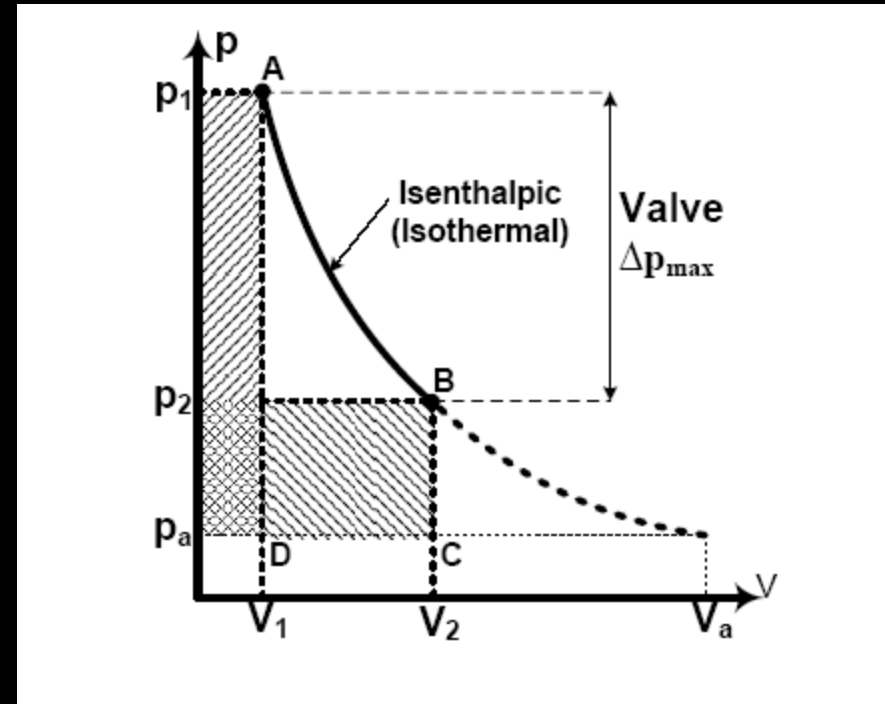
Maximum Efficiency: 12.0%



- $8 * 1000 \text{ W} * 0.215 + 4 * 1000 \text{ W} * 0.12$
- $= 2.200 \text{ KW}$

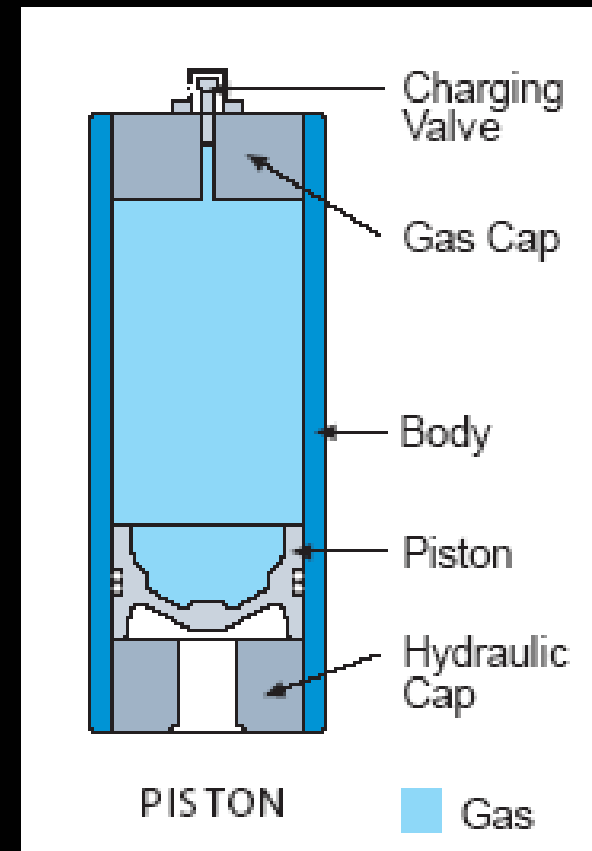
Pressure Control Valve

- Creates Losses
- Not included in this design
- Motor must run from P_{\max} to P_{\min}



Accumulator Storage

- Charged from 52 to 210 bar
- Expensive
- Possibly up to 50 Gal.



Bosch Rexroth PR4 8.00 - 700

50 bar	200 bar
16.83 L/min	16.55 L/min
2.07 KW	6.76 KW
7.6 Nm	30.5 Nm



Fill 14 Gal in 3m12s neglecting pulsing

Briggs & Stratton Etek Motor

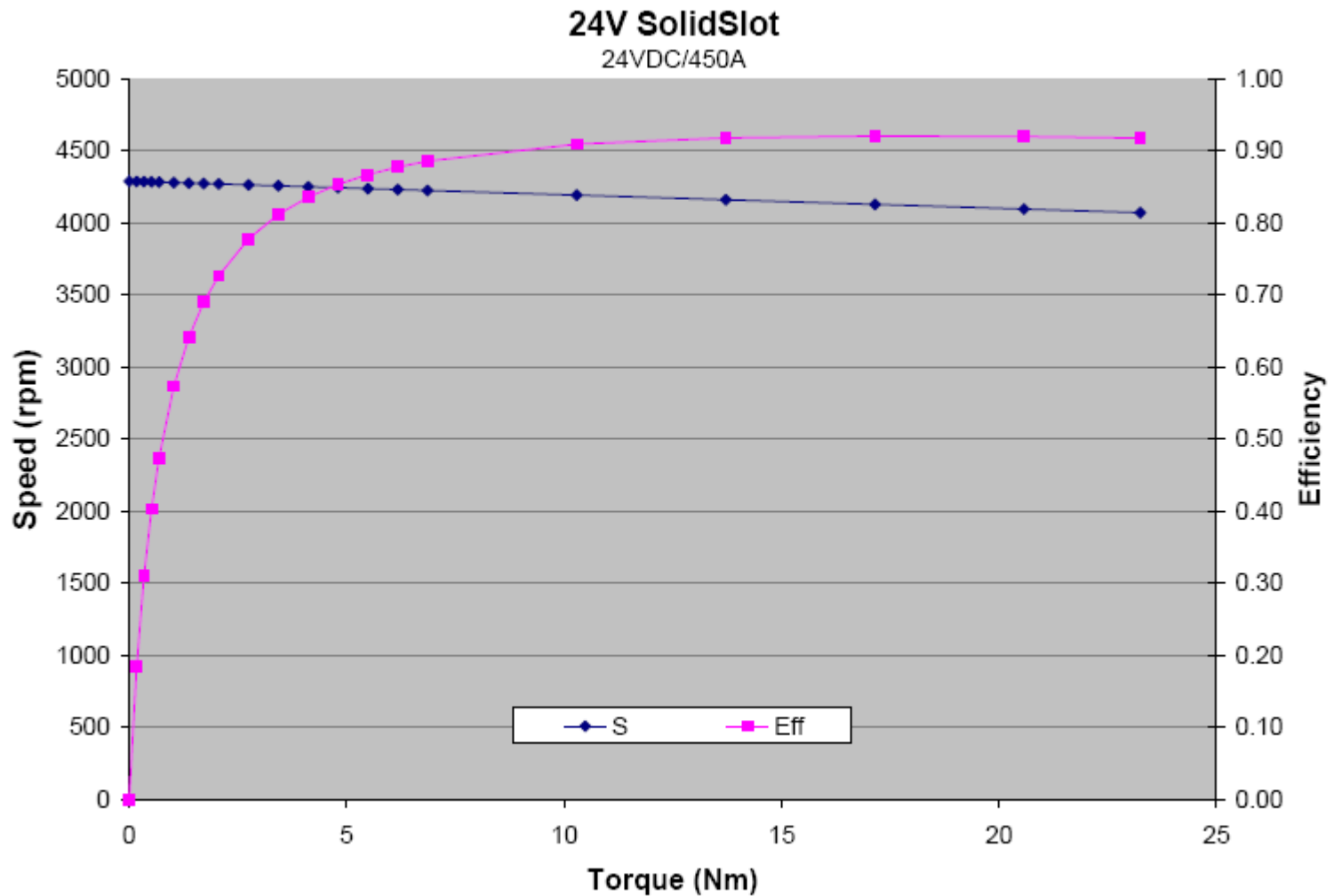


186.4 A @ 24 V Continuous
0.13 Nm/A
72 RPM / Volt

$$2000 \text{ RPM} / 72 = 27.778 \text{ V}$$

50 Bar	200 Bar
74.48 A	243.31 A

Ecycle Generator



Bosch Rexroth A2FM-5.00

- 210 bar
 - 16.48 Nm
 - 20.71 L/m
 - 7.25 KW
- 52 bar
 - 4.08 Nm
 - 20.71 L/m
 - 1.79 KW



Ecycle Generator

High Efficiency around 4200RPM

	Volts	Amps
1.79 KW	24	74.58
7.25 KW	24	302.08



Ultracapacitors

2700F each

2.7 V Each

11 in Series gives a
maximum voltage of 29.7 V

Using in the range of 20 V to
29.7 V gives:

58 kJ of storage



Results

- $58/7.25 = 8.0$ s to charge
 - 0.729 gal to charge
 - Can charge $14/0.729 = 19.20$ times
- 100 W Load
 - 580s per cycle
 - Just over 3 hours on storage system
 - Less in practice

Single Accumulator & Gas Bottle

- One accumulator
- Gas bottles on manifold
- Pressure changes less



Volume Ratios

- 30 Gal Gas Bottle
- 15 Gal Accumulator
- Precharged pressure raised by 50% when compressed.
 - 136 Bar to 204 Bar (2000psi to 3000psi)

Bosch Rexroth PR4 – 4.00 - 700

150 bar	200 bar
6.65 L/min	6.62 L/min
2.16 KW	2.70 KW
11.5 Nm	15.26 Nm



Motor Currents



150 Bar	200 Bar
80.08 A	117.38

Bosch Rexroth A2FM-5.00

- 210 bar
 - 16.48 Nm
 - 20.71 L/m
 - 7.25 KW
- 150 bar
 - 11.77 Nm
 - 20.71 L/m
 - 5.18 KW



Conclusion

- Gas Bottles improve storage capacity
 - Allow system to operate more easily with a smaller pump.
 - Operation with less pressure variation

Partners

Rexroth
Bosch Group

