節約能源於油壓控制系統之探討

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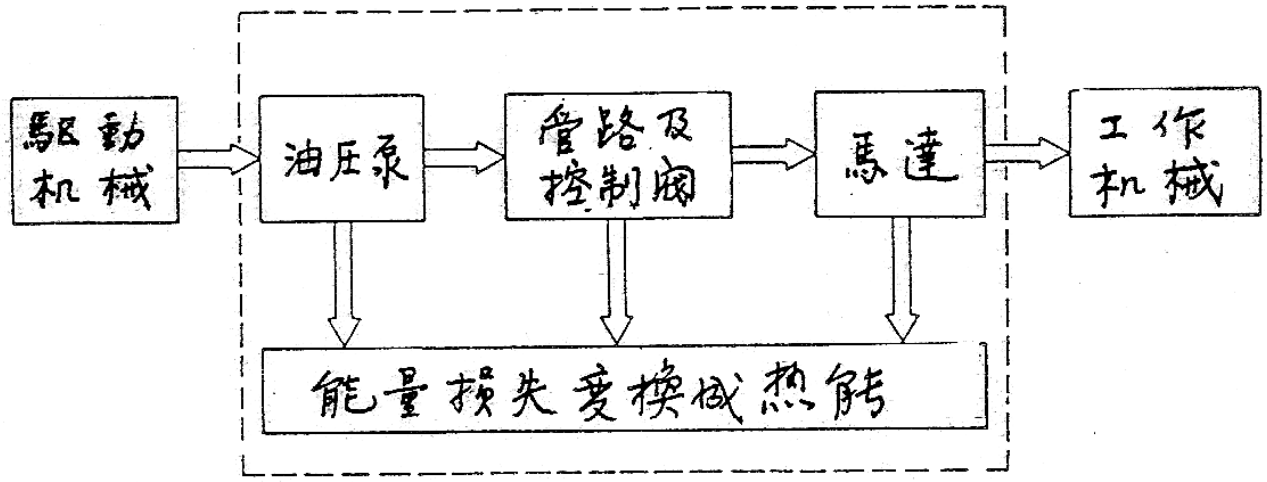
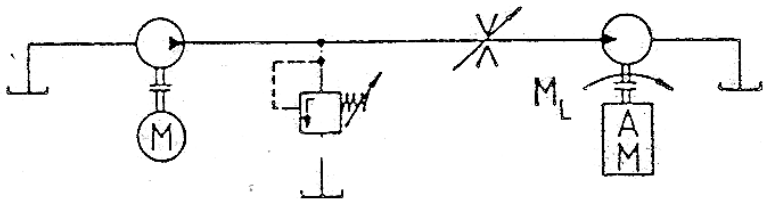
內容大綱

1. 前言
2. 管路配置對系統效率之影響
3. 液壓閥、泵/馬達系統之節能設計
4. 蓄壓器之介紹與應用
5. 新型液壓泵/馬達之設計與應用
6. 結論

1. 前言





2. 管路配置對系統效率之影響

- 管路系統之損失
- 油之黏滯係數對效率之影響

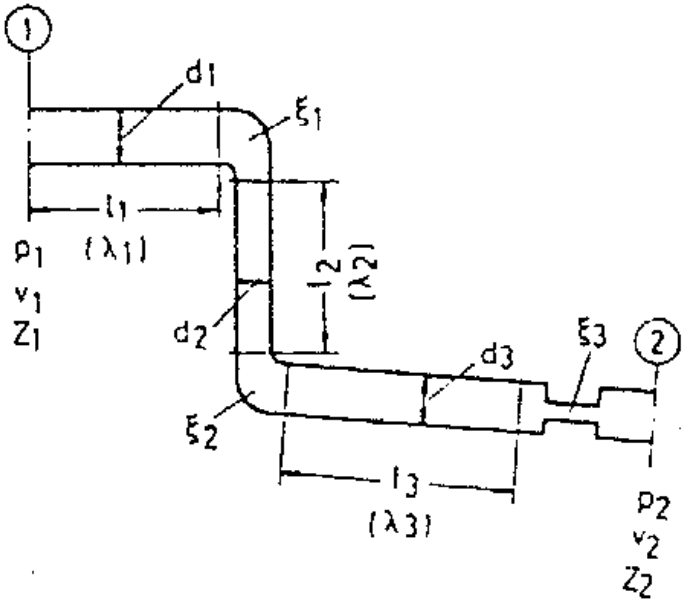
管線之次要損失(minor loss)

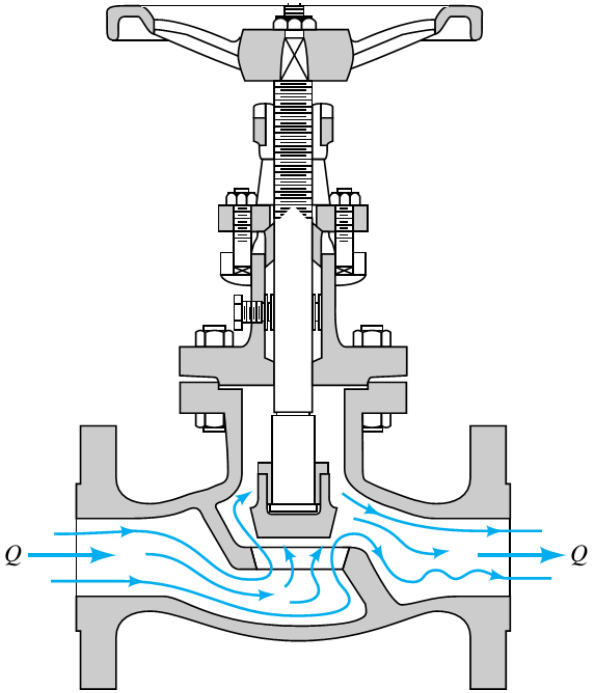
- 因管線出入口、控制閥、管徑改變、彎管以及管線合流或分流造成之能量損失

$$\Delta P = K_L \frac{1}{2}\rho V^2$$

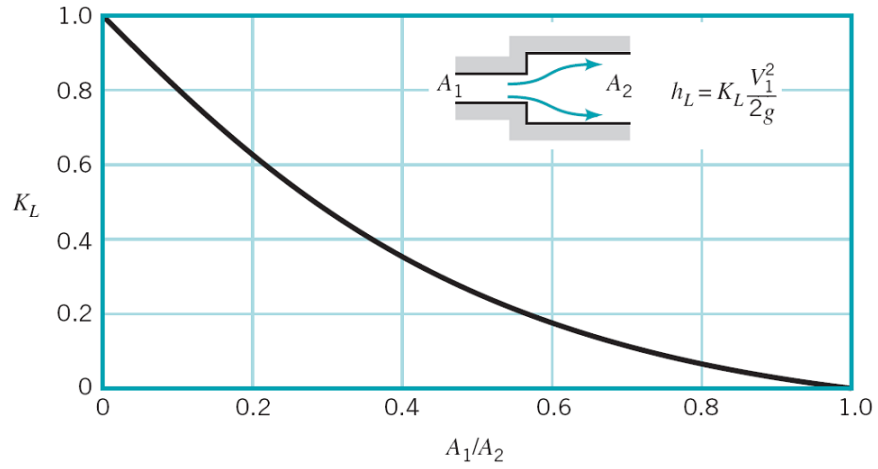
K_L：損失係數

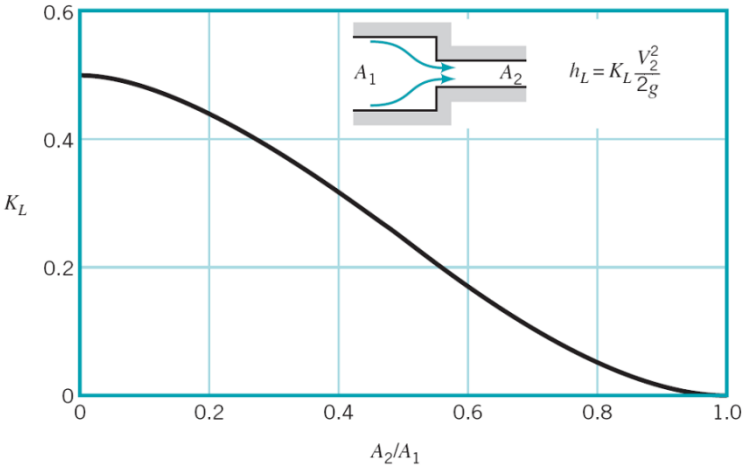
ΔP：壓力差

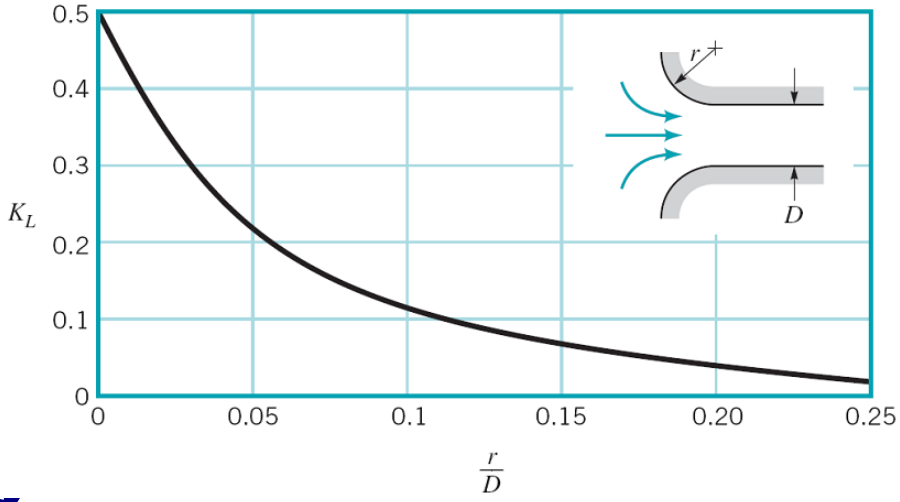


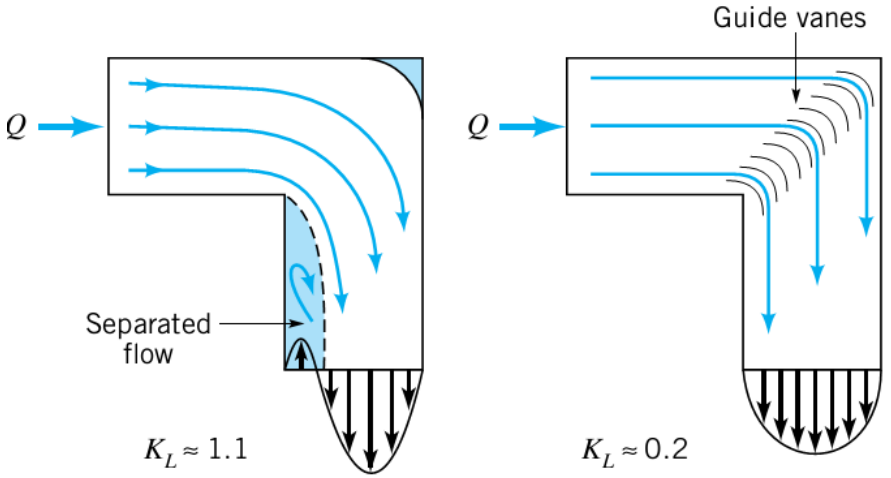


管徑變化與彎曲造成之損失

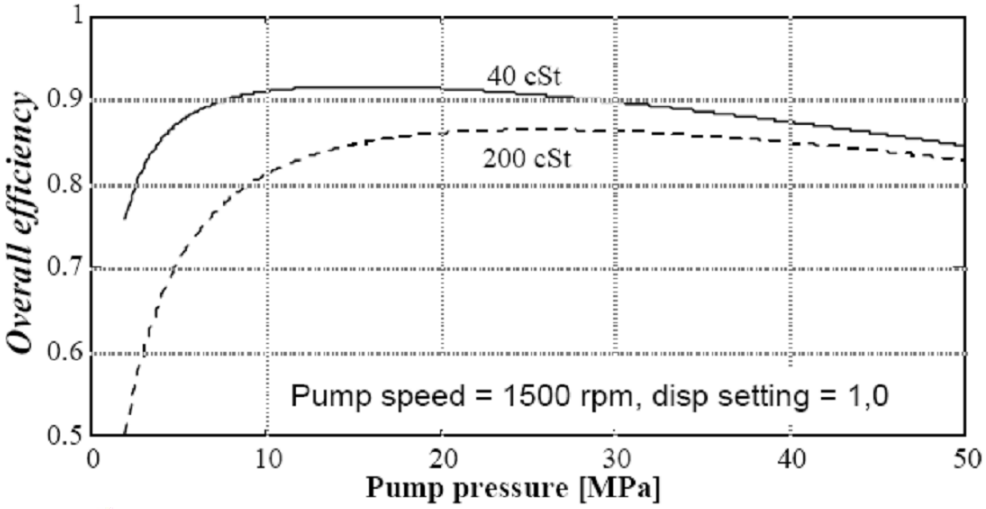


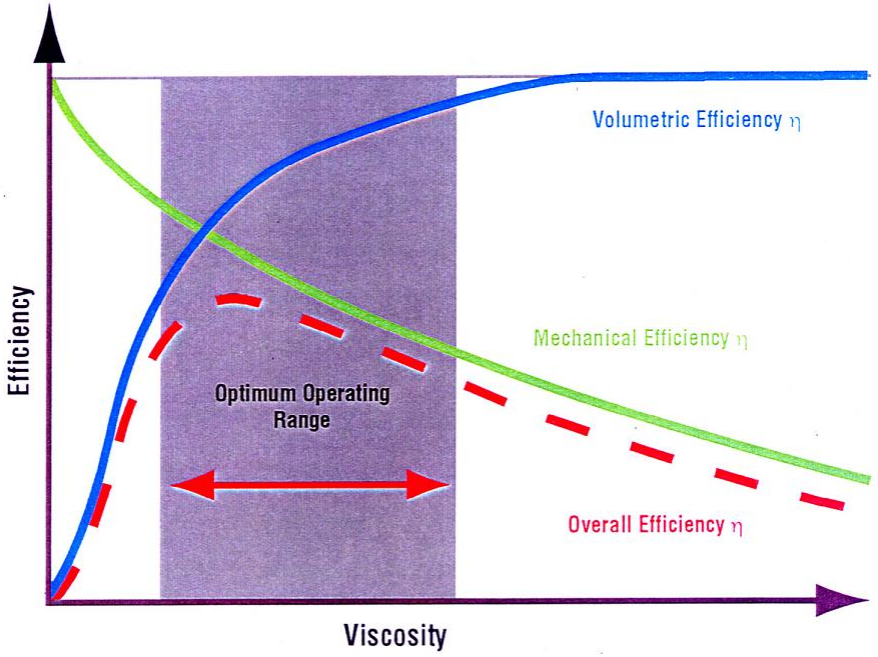






油之黏滯係數對泵整體效率之影響



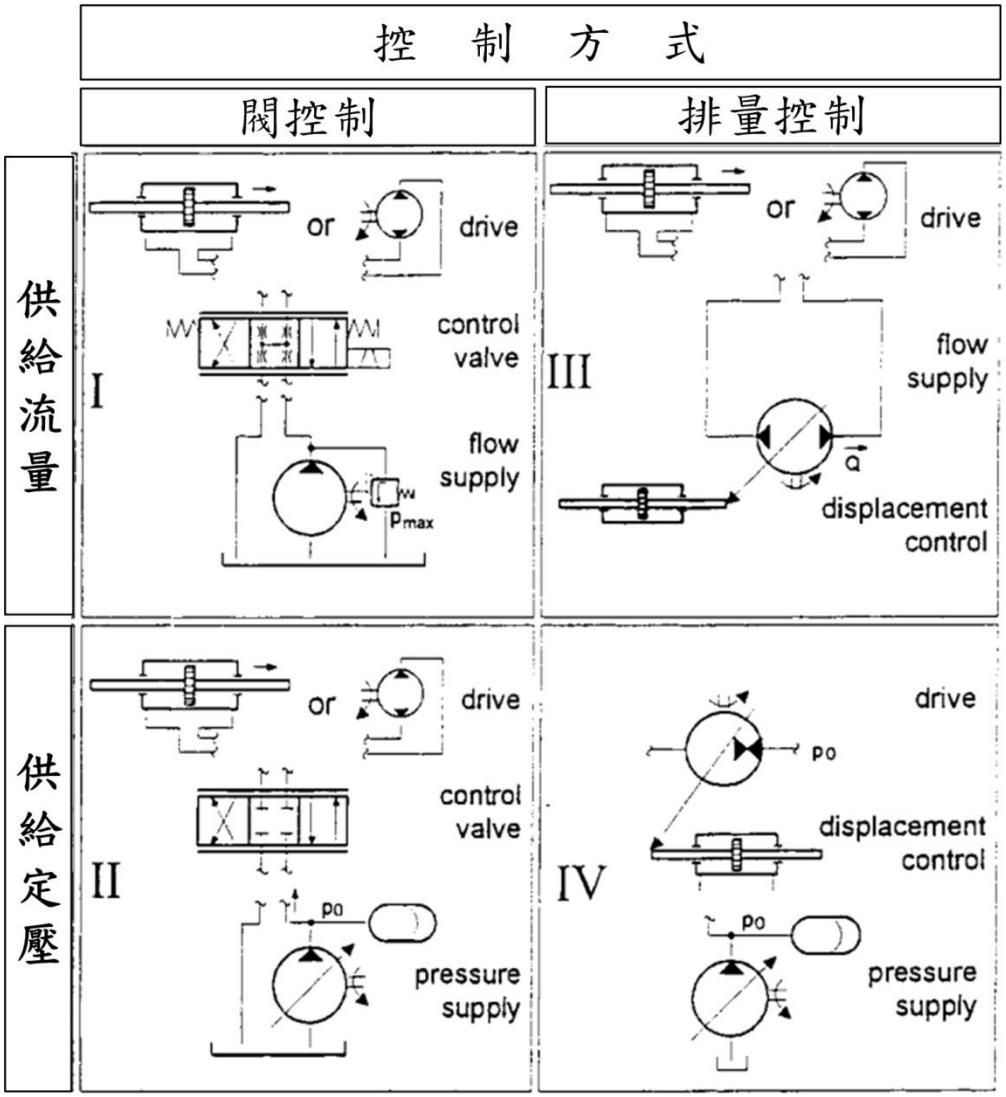


Ref: K-E Rydberg

3-1. 液壓閥、泵/馬達控制系統之節能設計

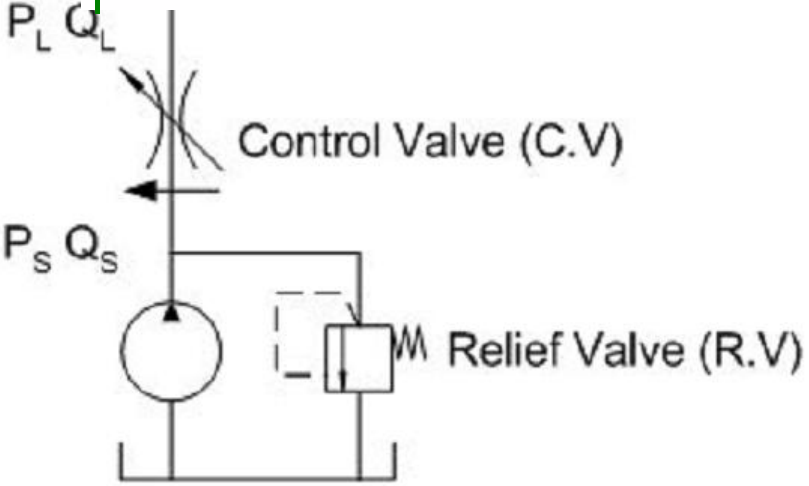
- 閥控系統之節能設計
- 泵控系統之節能設計

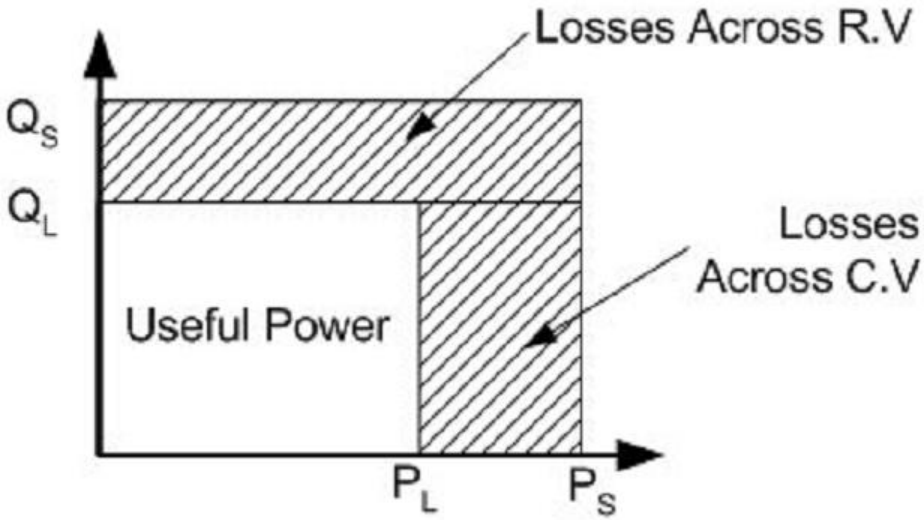
液壓傳動與控制之分類

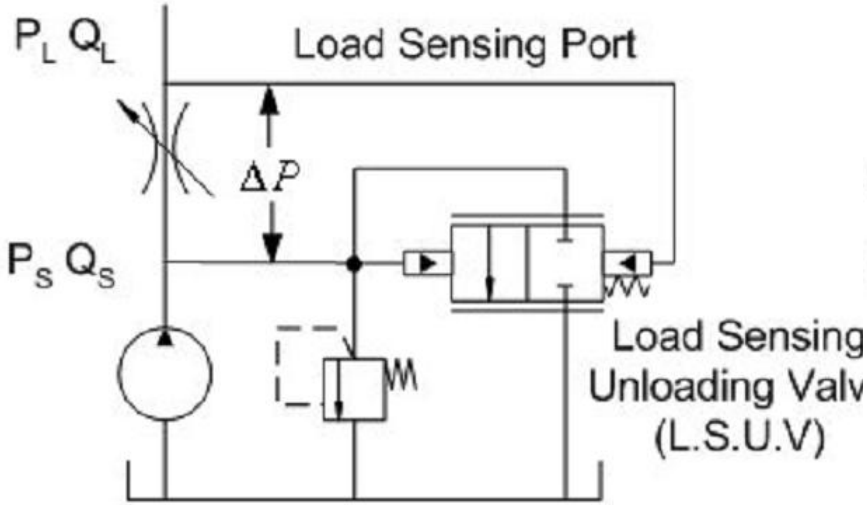


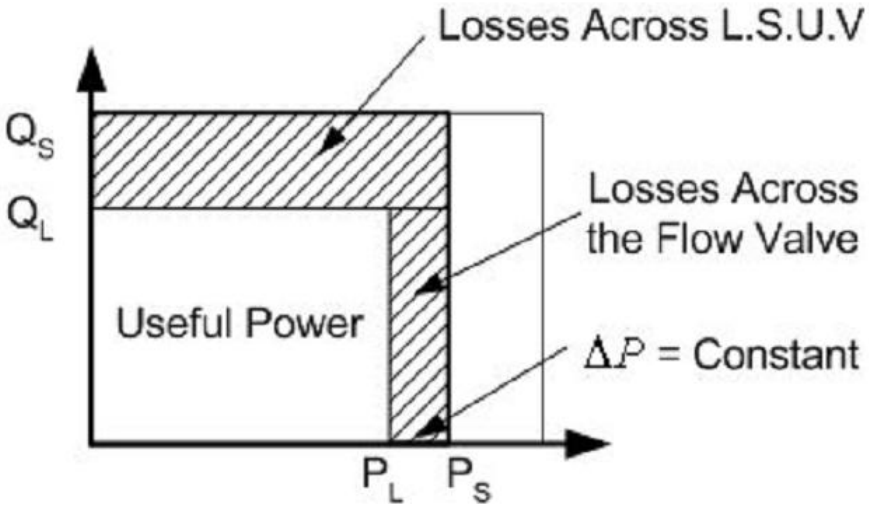
Ref: Murrenhoff, H

閥控系統之功率損失(I)



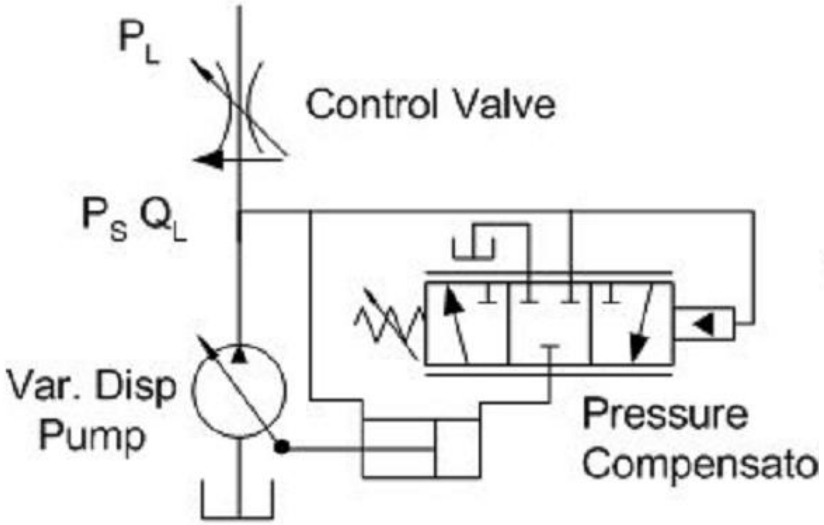


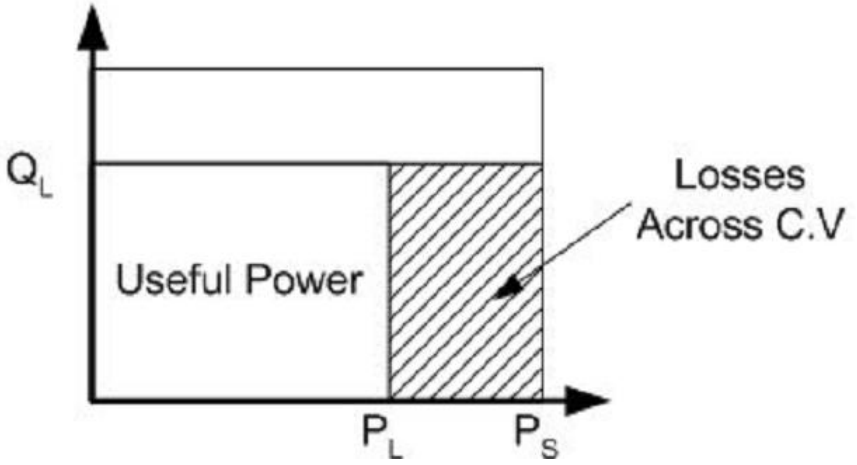


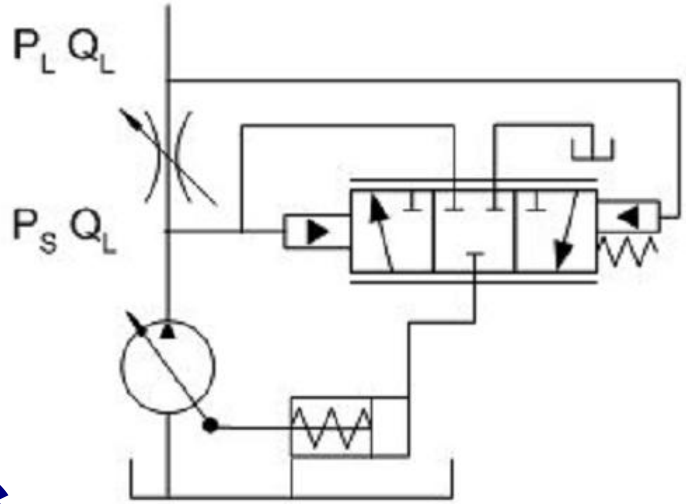


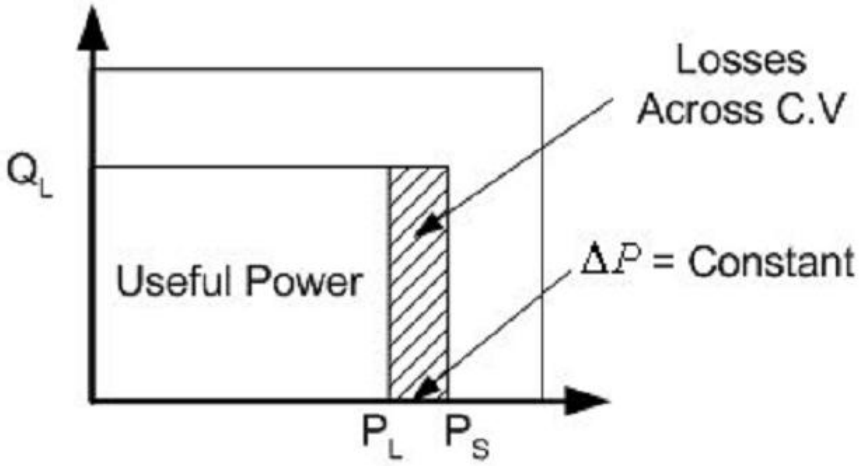
Ref: Tonglin Shang

閥控系統之功率損失(II)



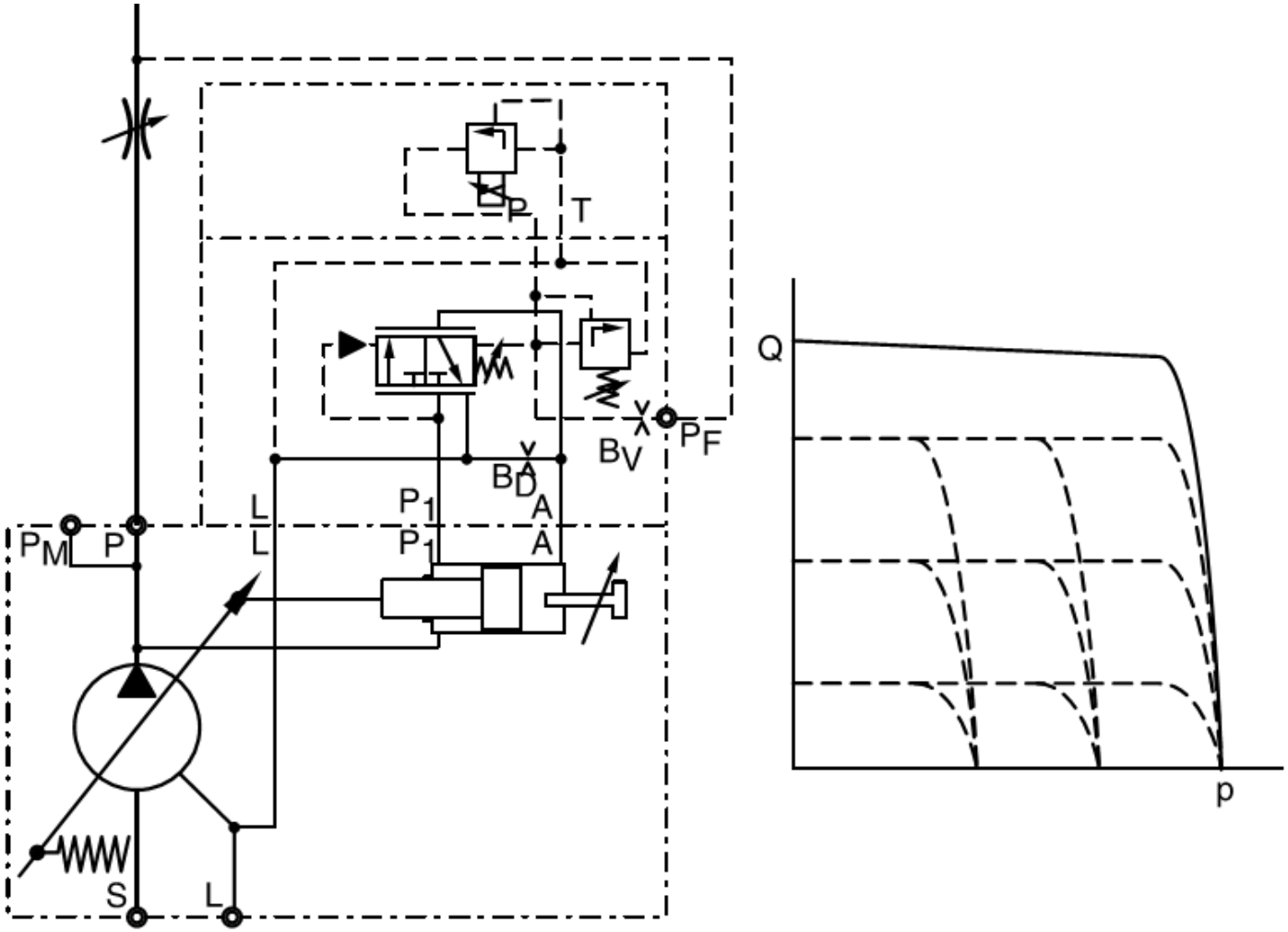






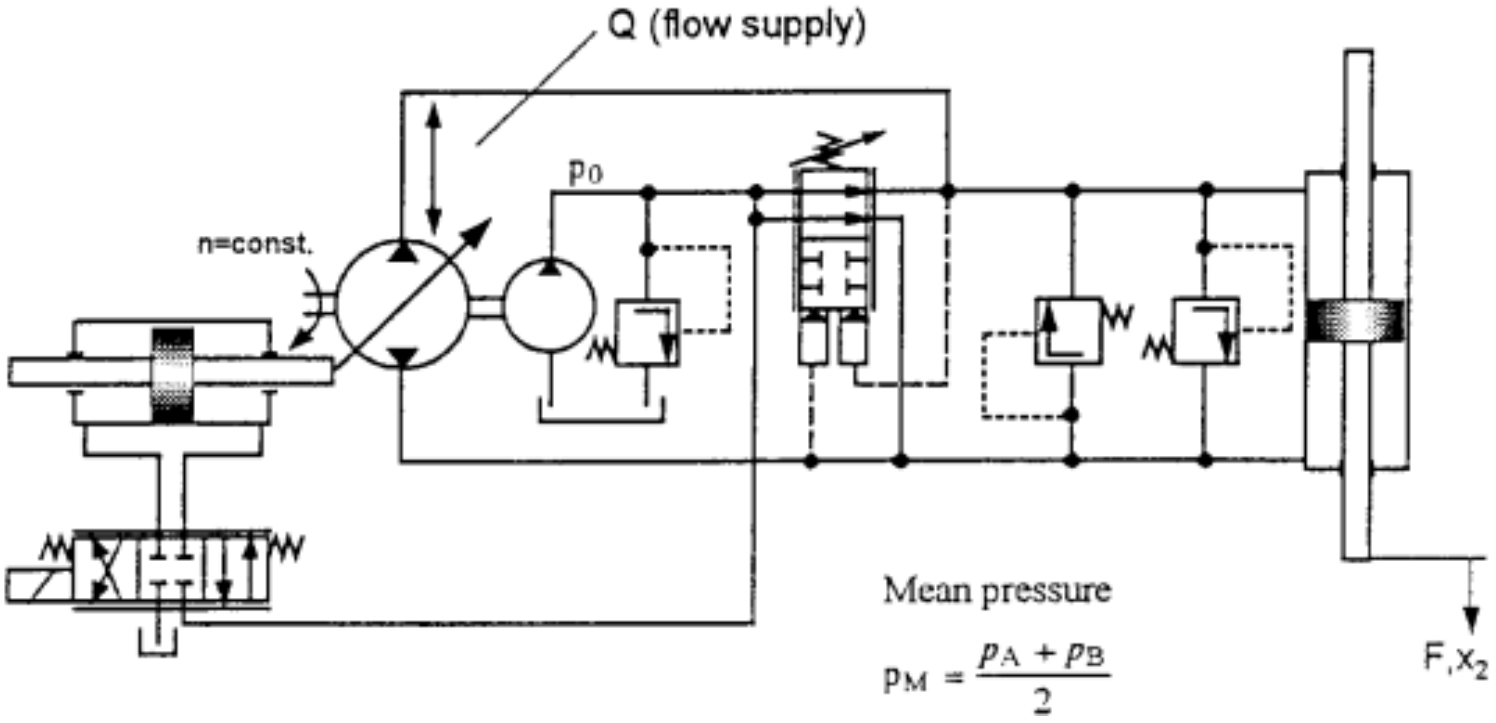
Ref: Tonglin Shang

具負載補償之斜盤式泵浦比例排量控制



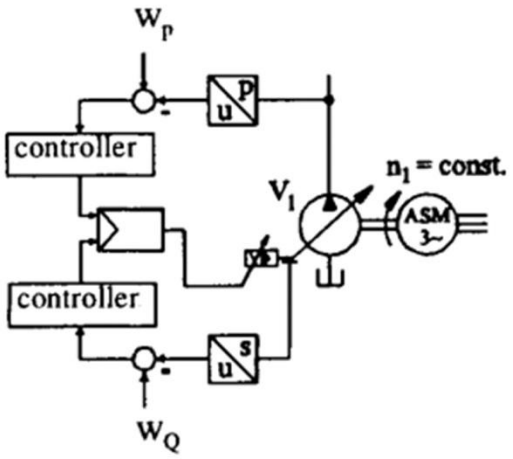
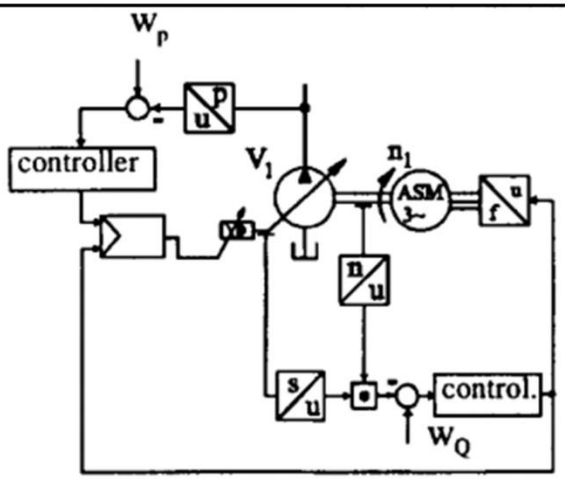
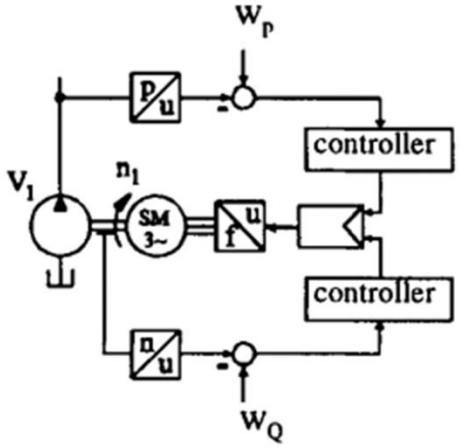
Ref: Parker.

伺服液壓二次控制系統之迴路



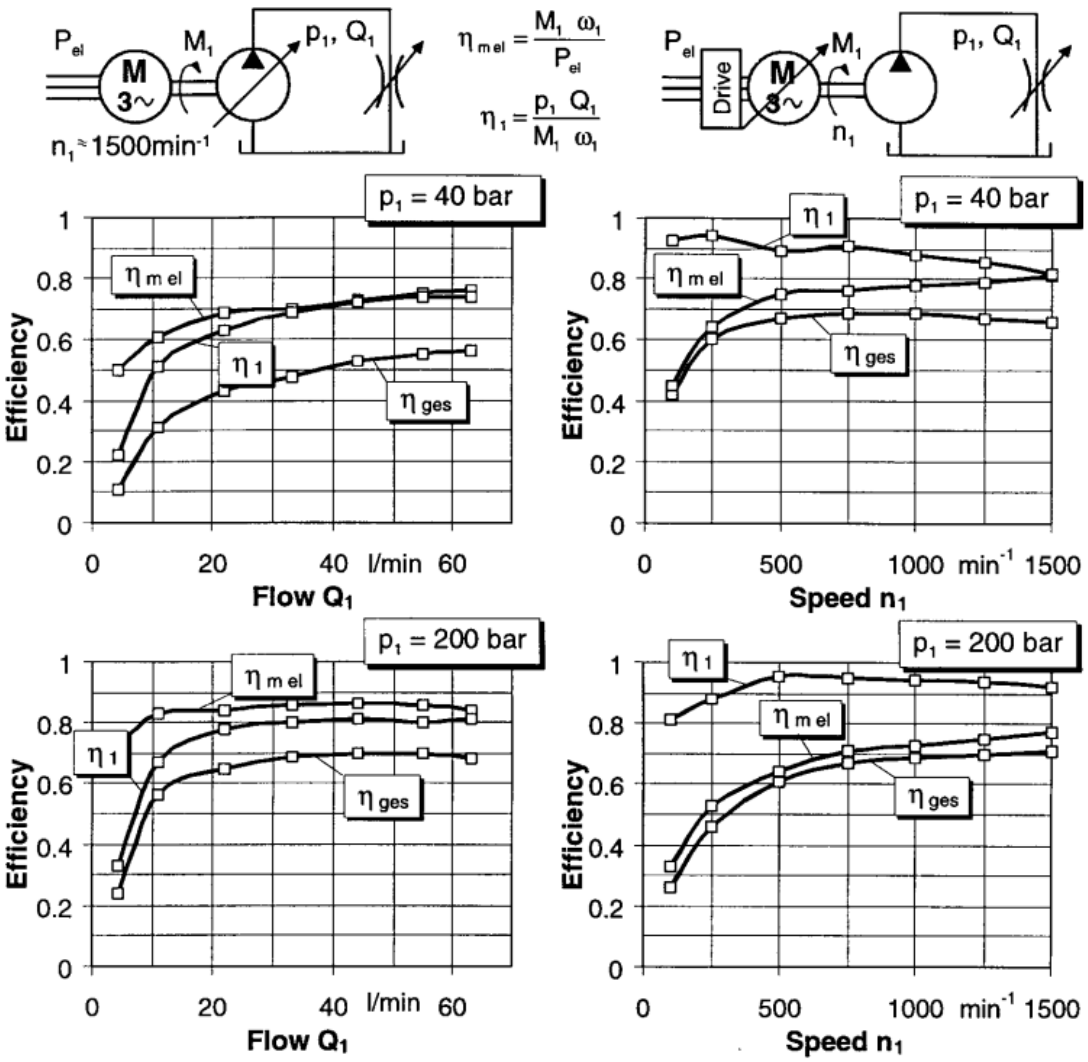
Ref: Murrenhoff, H

液壓泵之功率控制方法

AC感應馬達定速 驅動變排量泵	AC感應馬達變速 驅動變排量泵	AC伺服馬達變速 驅動定排量泵
		
- *constant speed n_1,* - *flow and pressure control with ΔV_1 ,* - *low efficiency at $P < P_{max}$*	- *speed control,* - *flow and pressure control with Δn_1 and ΔV_1 ,* - *better efficiency at $P < P_{max}$,* - *no idling losses ($n_1 = 0$),* - *low noise ($n_1 < n_{1\ max}$)*	- *speed control,* - *flow and pressure control with Δn_1 ,* - *better efficiency at $P < P_{max}$,* - *no idling losses ($n_1 = 0$),* - *low noise ($n_1 < n_{1\ max}$)*

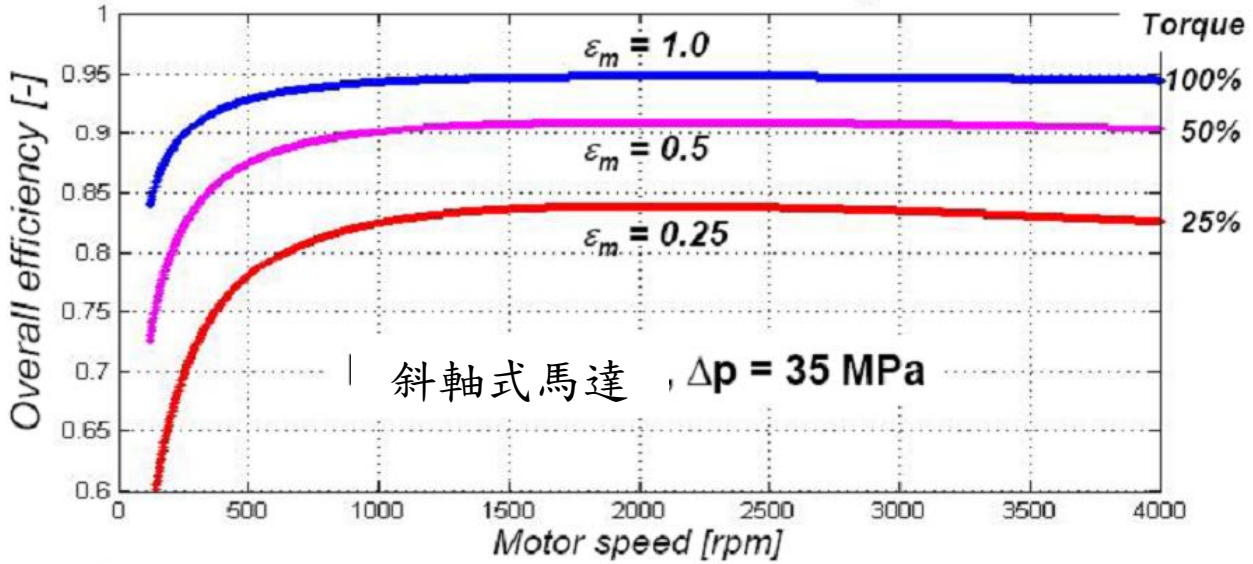
Ref: Helduser, S.

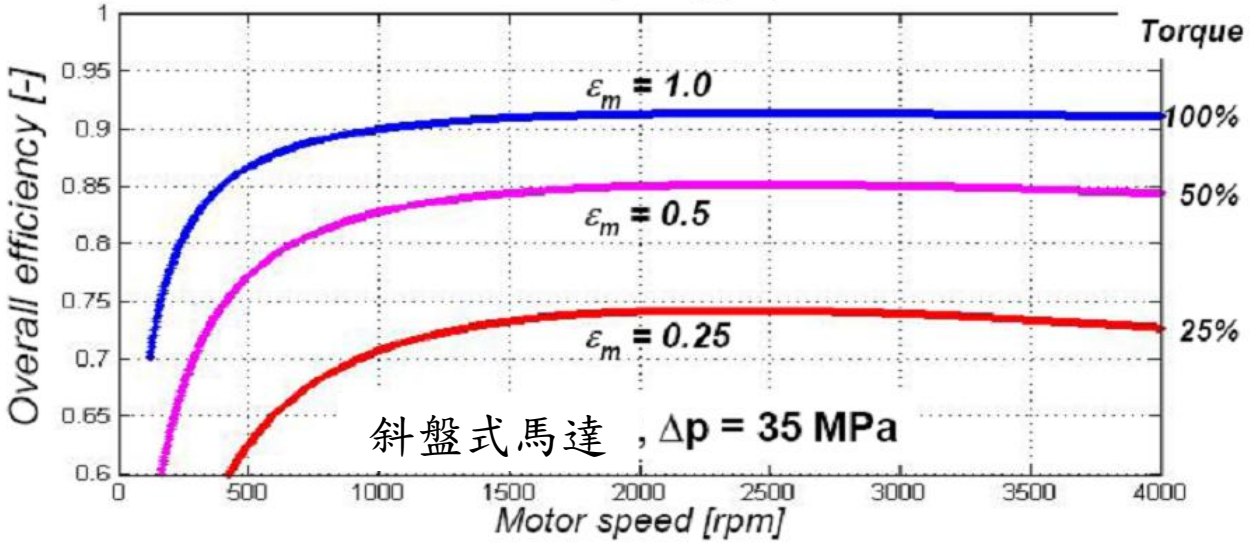
伺服液壓排量控制與速度控制系統之效率比較



Ref: Helduser, S

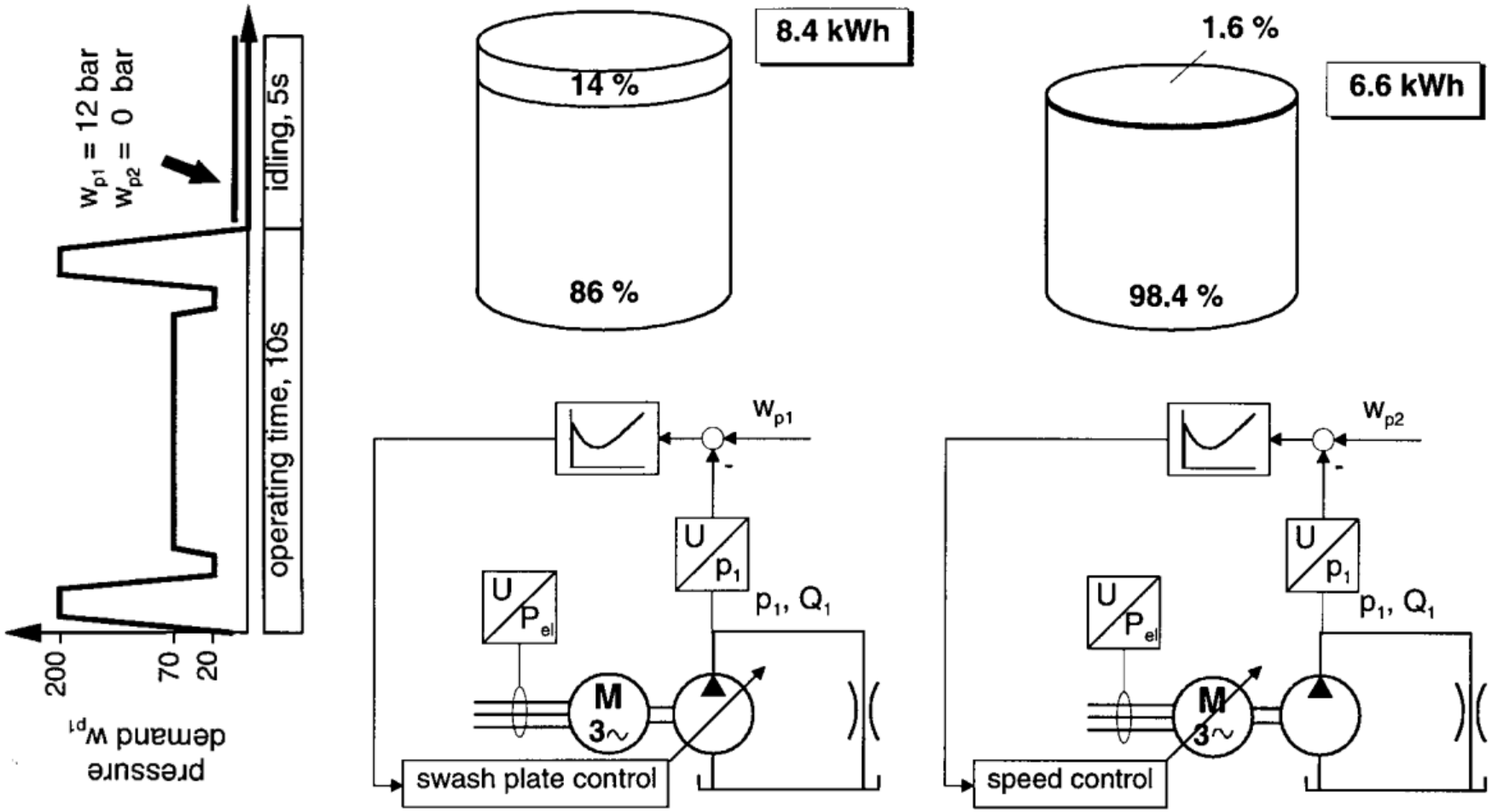
可變排量之斜軸式與斜盤式液壓馬達之效率比較





Ref: K-E Rydberg

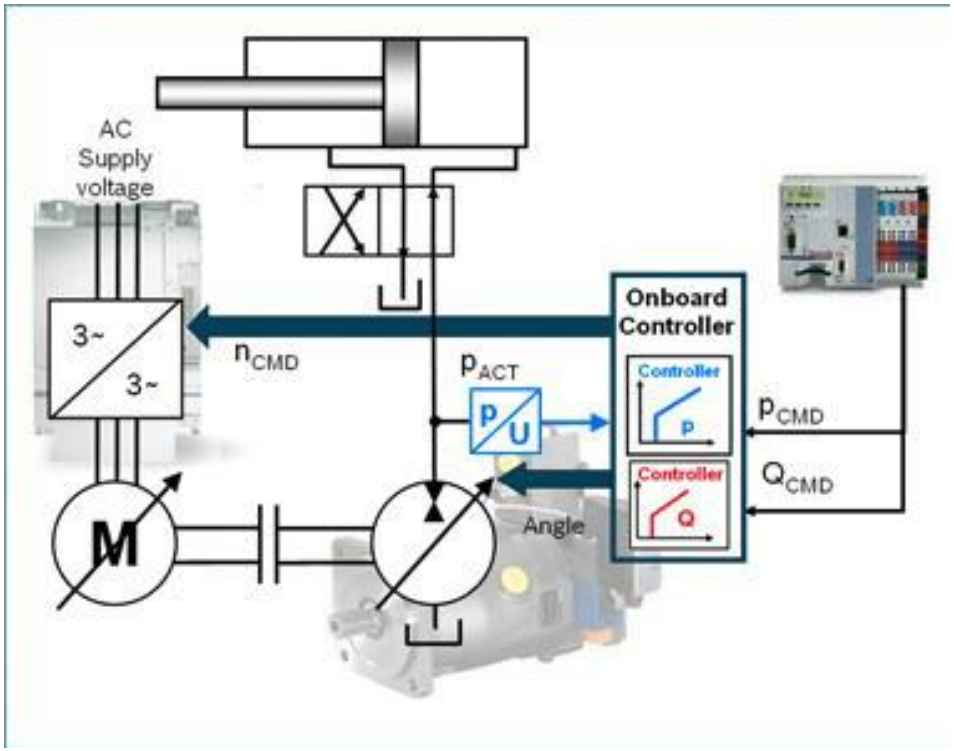
泵之變排量控制與馬達變速控制系統效率之比較



Ref: Helduser, S.

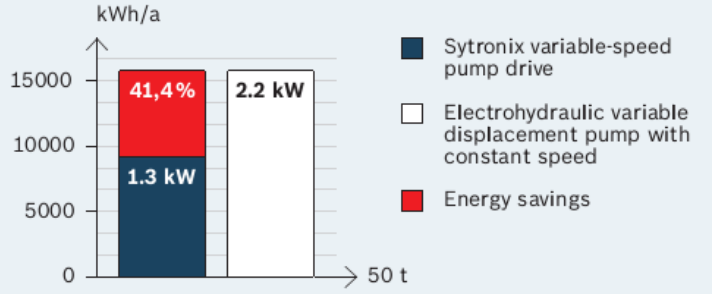
3-2. 液壓泵/馬達節能控制系統之應用

AC馬達變速控制驅動可變排量泵控迴路 <630kW

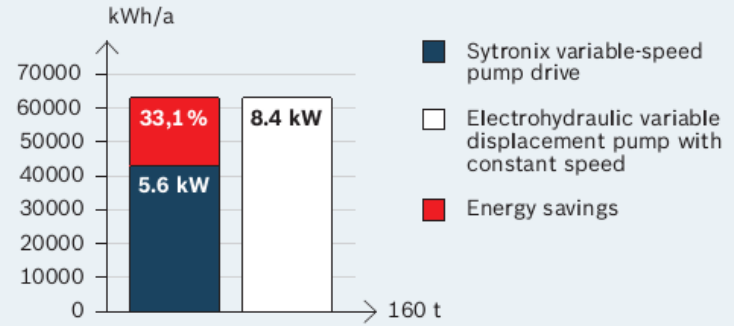


Rexroth
Bosch Group

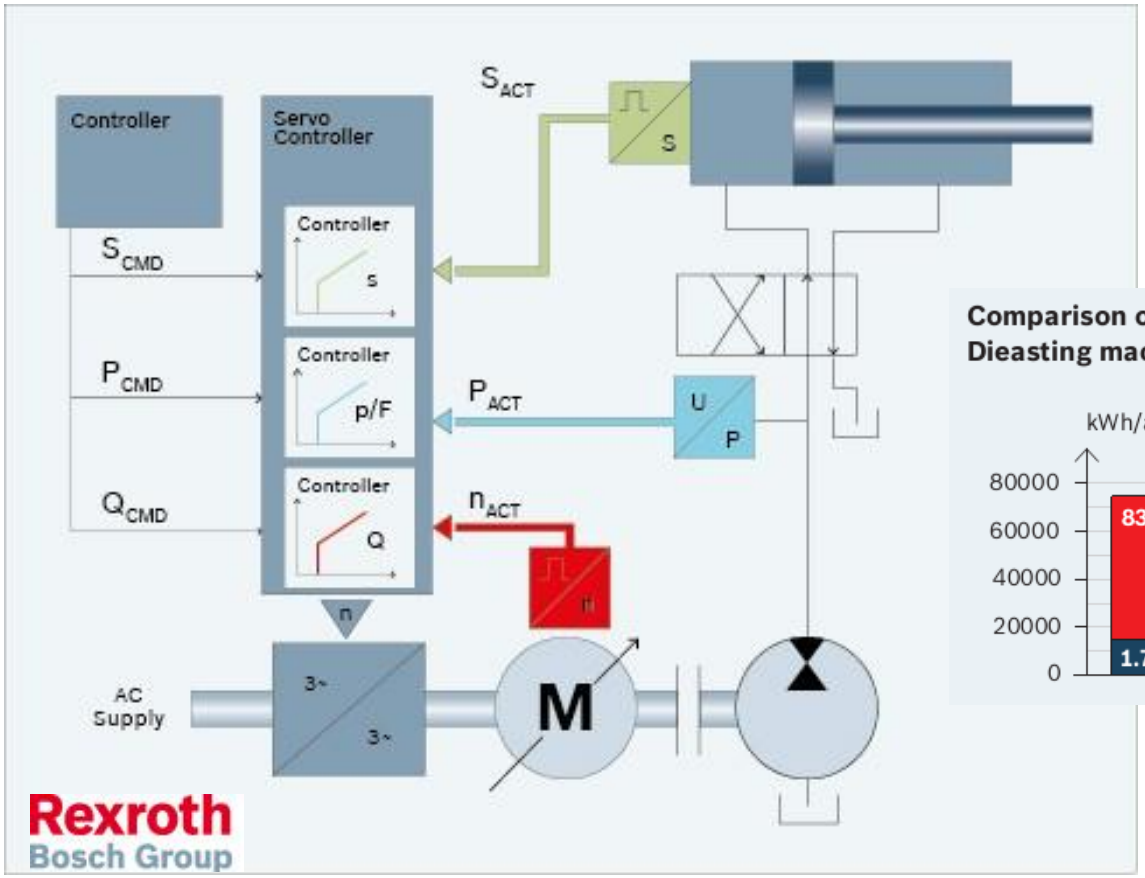
Comparison of energy consumption of plastics machinery 50 t, 30 s

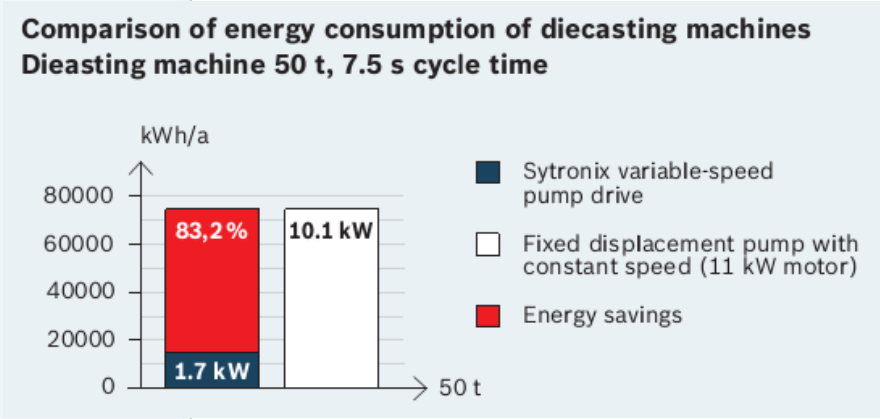


IMM 160 t, 15 s cycle time



伺服變速控制驅動泵控迴路 <60kW



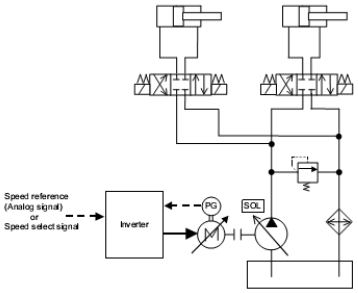


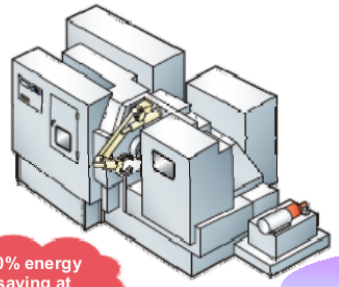
Typical Examples of KAWASAKI ECO SERVO

Kawasaki Precision Machinery

Typical Examples of Open Circuit with Inverter Drive

◆Application examples:
Press machine, forming machine, packing machine, etc.
(Control system: Speed control)





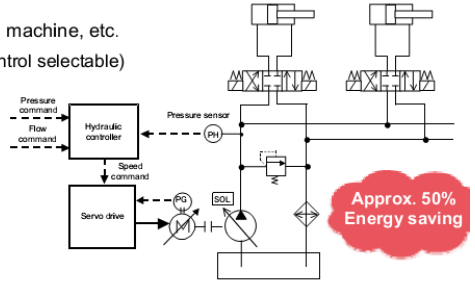
60% energy saving at maximum

- The pump is run as long as possible.
  →Dramatic energy saving is realized, as compared with conventional hydraulic system!
  (10 to 30% energy saving even when a variable displacement pump is used)
  →Lower average noise level
- Inverter control contributes to improved operability, as well as controllability at lower speed range.

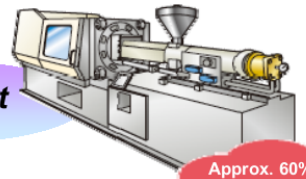
Typical Examples of Open Circuit with Servo Drive

◆Application examples: Injection molding machine, etc.
(Control system: Pressure control-speed control selectable)

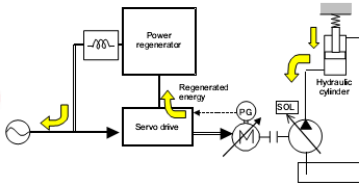
- Improved functionality and performance, compared with pump control systems
- Response speed, energy saving and low noise level, comparable with those obtained from full electric control system.



Approx. 50% Energy saving



Approx. 60% of power consumption during pressurizing is recovered.



◆Application examples:
Testing machine
(Control system: Pressure control, power regeneration)

- When the load is moving upward, energy consumption is decreased through reduction in pressure loss.
- When the load is moving downward, energy consumption is further decreased as the motion energy of the load is converted into electric power.

Open circuit

Inverter Drive

Servo Drive

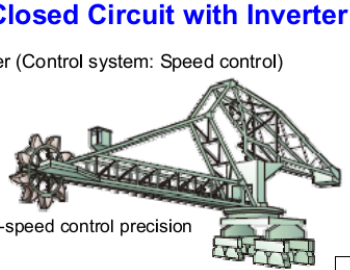
Close circuit

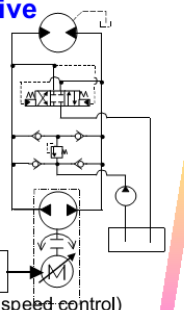
Typical Examples of Closed Circuit with Inverter Drive

◆Application examples: Reclaimer (Control system: Speed control)

●Hydraulic system renewal work
[Conventional system]
(pump control system)
- Pilot piping is needed.

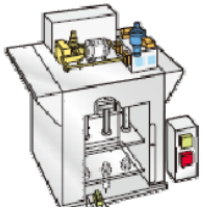
[ECO SERVO]
- No pilot piping is needed.
- Improved repeatability and low-speed control precision
- Easy maintenance

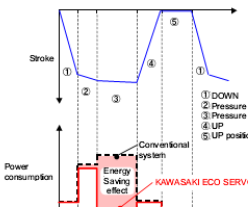




◆ Application examples: Press machine, etc. (Control system: position control, speed control)

●Energy saving effects on press machine





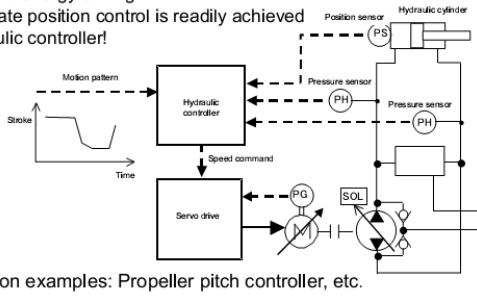
Reduction of approx. 27 tons of CO2 emission annually
(40% (approx. 8.6 kW) energy saving, compared with the conventional system)

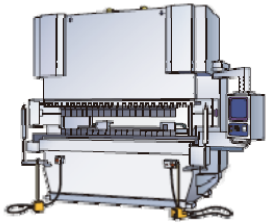
Motor : 55kW
Max.flow : 280L/min
Max. operating : 21MPa

Typical Examples of Closed Circuit with Servo Drive

◆Application examples: Press machine
(Control system: Position control-pressure control selectable)

- Use of a two-step variable displacement pump leads to smaller electric motor size and energy saving.
- Highly accurate position control is readily achieved with a hydraulic controller!





Cylinder position control accuracy as high as 5 μm (press machine)

◆Application examples: Propeller pitch controller, etc.
(Control system: Position control)

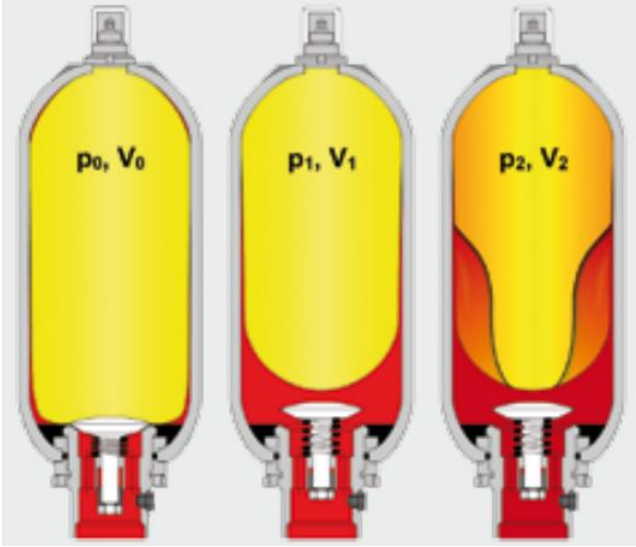
- When the load is moving upward, energy consumption is decreased through reduction in pressure loss.
- When the load is moving downward, energy consumption is further decreased as the motion energy of the load is converted into electric power.

4. 蓄壓器之介紹與應用

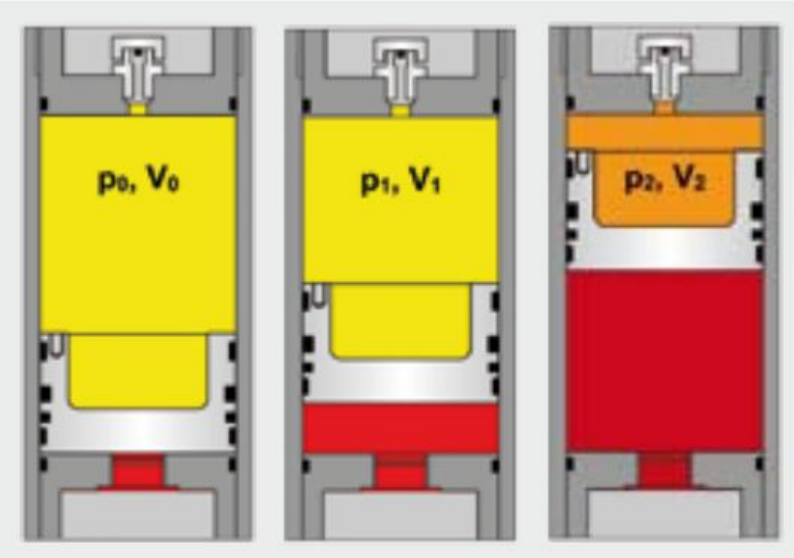
- 蓄壓器之介紹
- 蓄壓器於混合車之應用
- 液壓與電子儲能方案之比較

充氣式蓄壓器之介紹

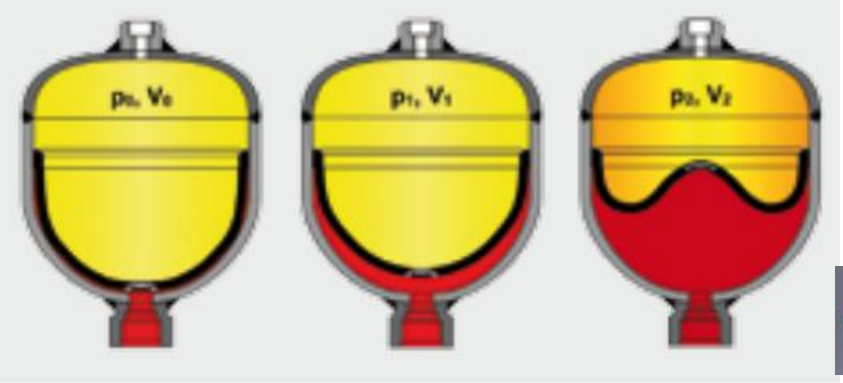
- 液壓皮囊式蓄壓器



- 液壓柱塞式蓄壓器



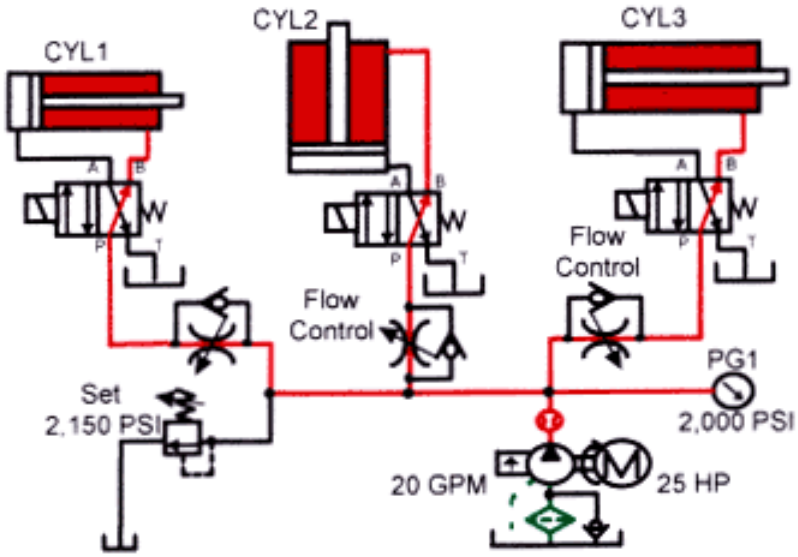
- 隔膜式蓄壓器



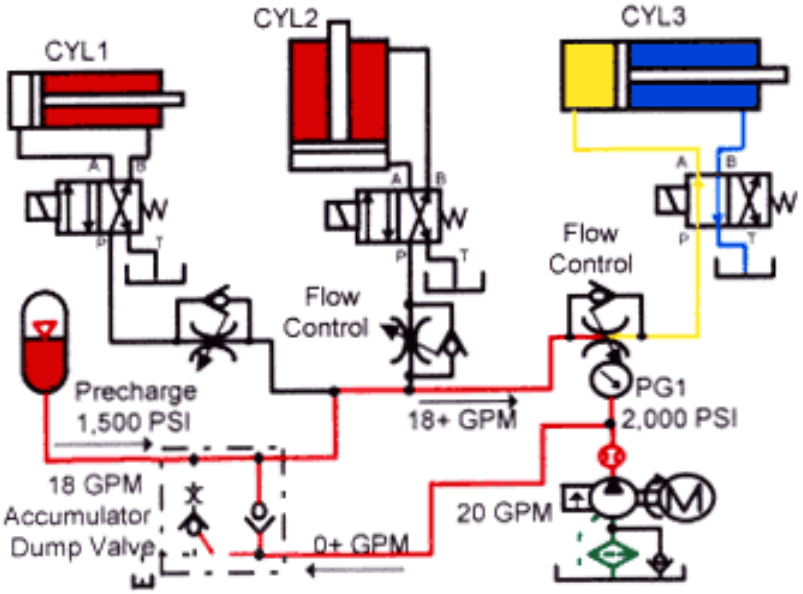
HYDAC

充氣式蓄壓器於液壓迴路之應用

- 具負載補償液壓泵之控制迴路



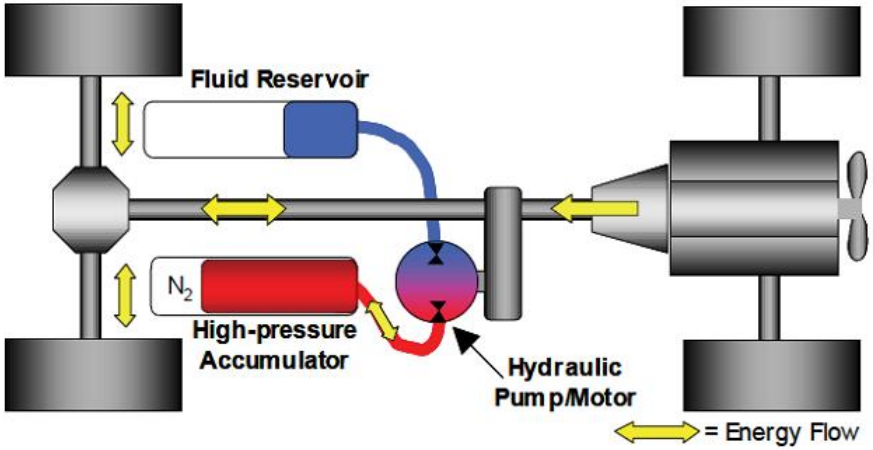
- 等壓控制迴路

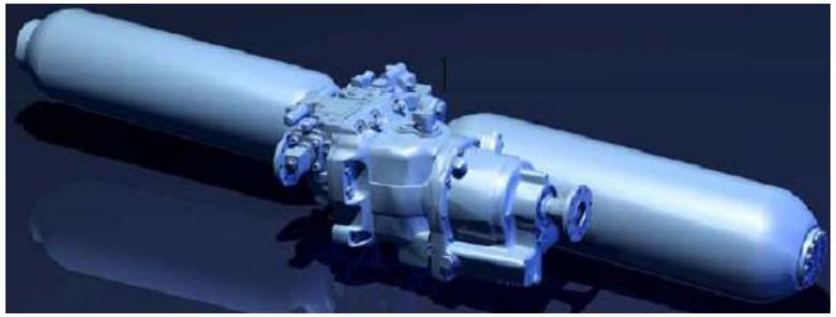


Ref: Bud Trinkel

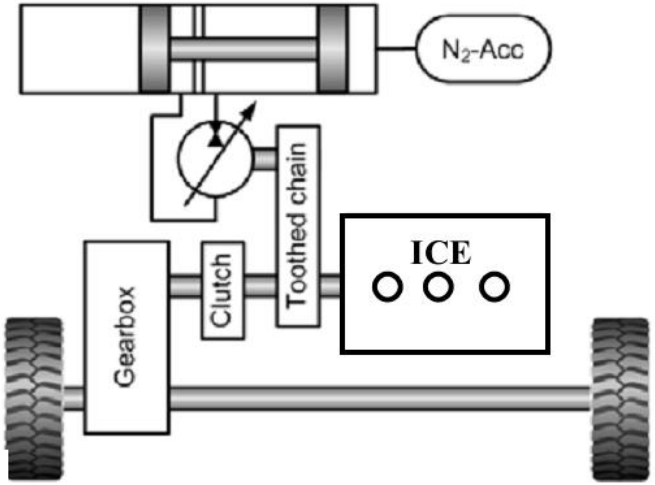
並聯式液壓混合車

- Eaton HLA drivetrain, 2002





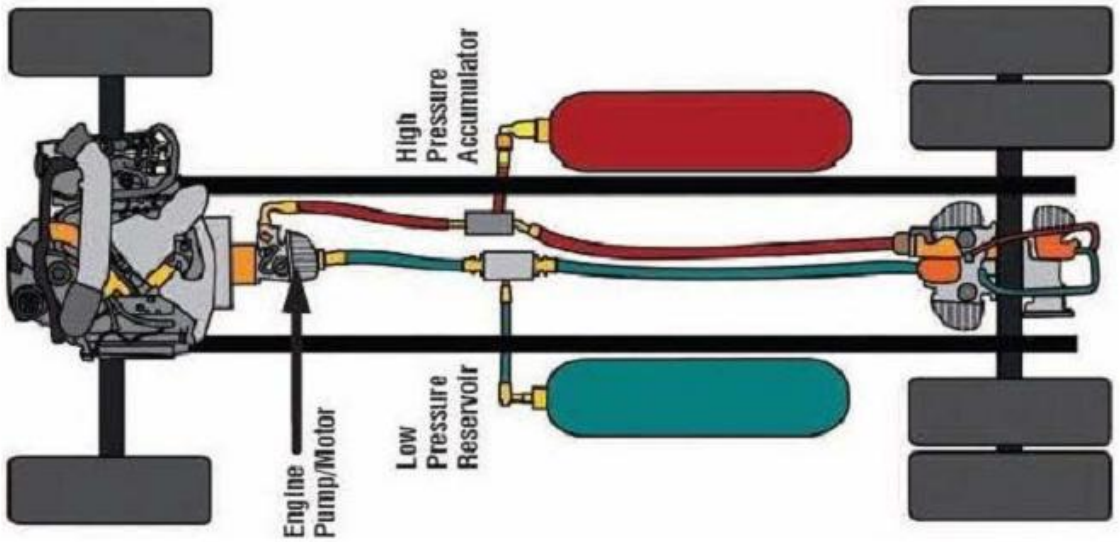
- IFASter, IFAS of RWTH Aachen University



Ref: Mohamed Saber Ahmed Ibrahim-Sokar

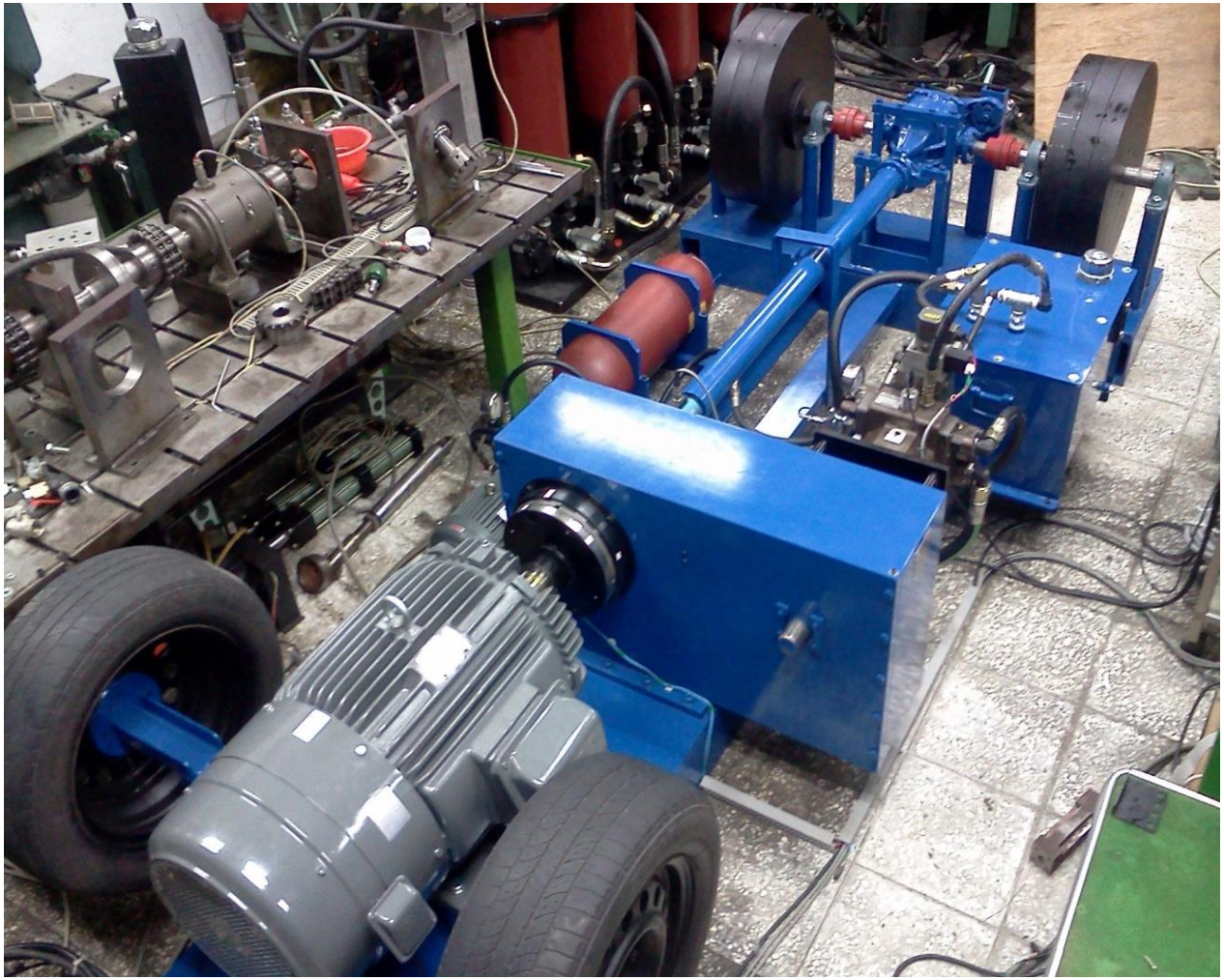
串聯式液壓混合車

- UPS full hydraulic hybrid drivetrain, 2006



Ref: Mohamed Saber Ahmed Ibrahim-Sokar

並聯式混合車傳動系統



串聯式混合車傳動系統

液壓與電子儲能方案之比較

	Accumulator	Li-Ion Battery			Super-cap
					
	Carbon Fibre	Stated	Rated	Peak	
Power density - kW/kg	14	3.2	0.4	1.3	2.1
Energy density - kJ/kg	13	475			14.4
Round trip efficiency - %	94	81			92
Cost - €/kJ	1.6	0.24			9
Cost - € /kW	0.75	21	170	51	10
Cycle life	1,000,000	3000 – 7000			1,000,000

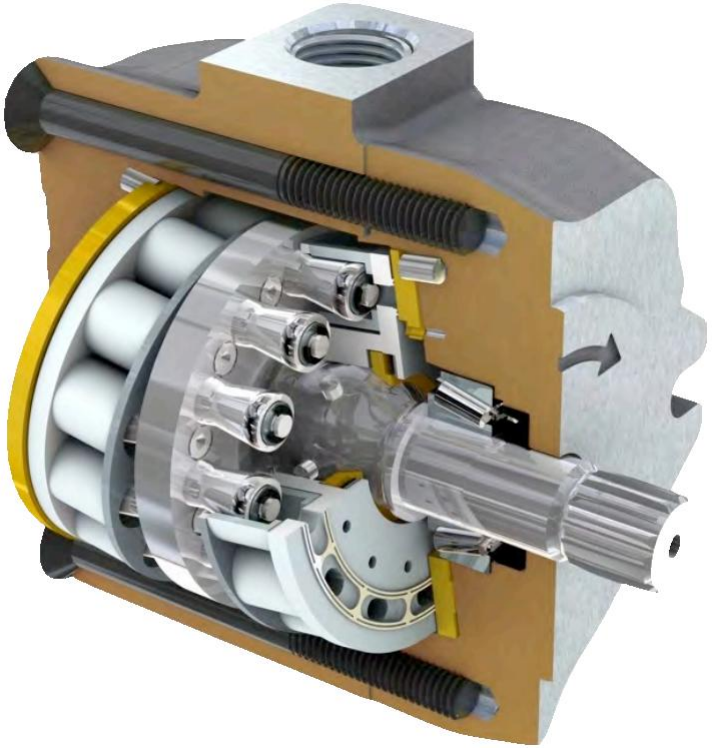
Ref: Jamie Taylor

5. 新型液壓泵/馬達之設計與應用

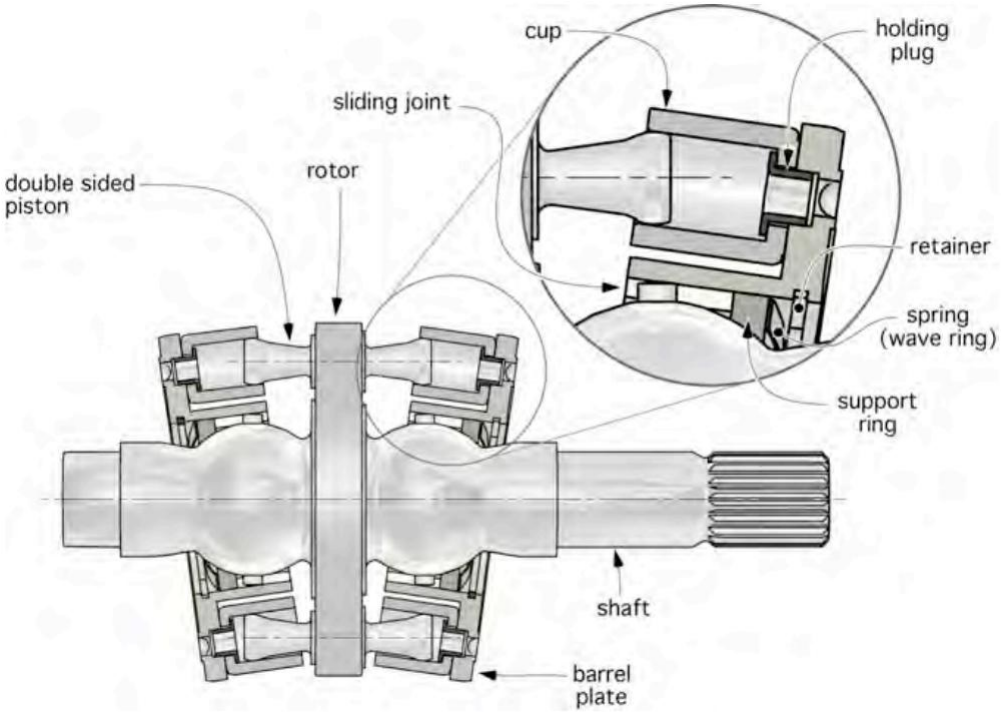
- Floating Cup 泵之設計與應用
- 數位排量泵(DDPump/Motor)之設計與應用
- 液壓回收效率與除能之探討

Floating Cup 泵/馬達

- Floating Cup 泵之剖面圖



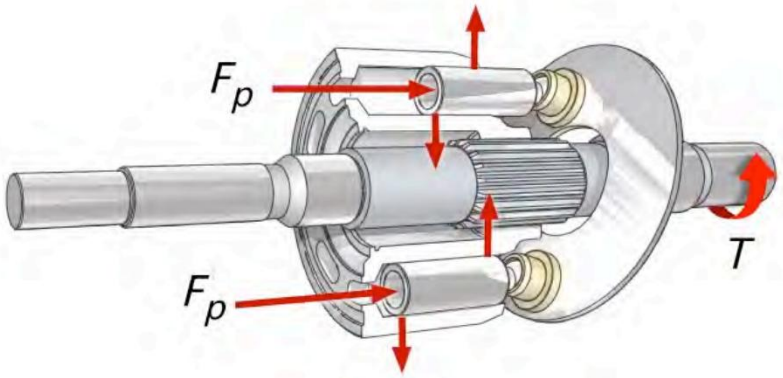
- Floating Cup 泵之旋轉組件



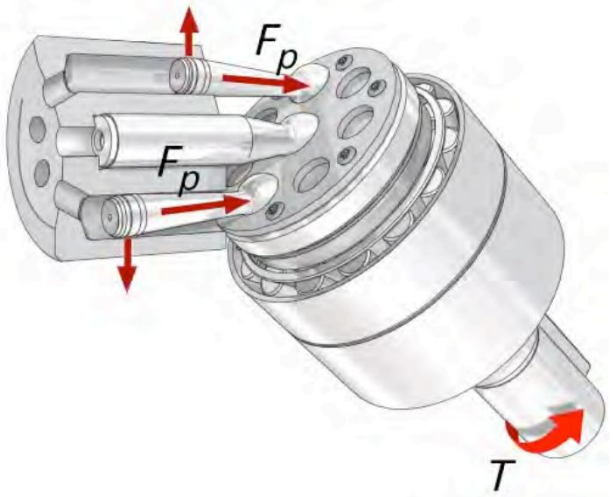
Ref: (1) Innas BV (2) Peter A.J. Achten

三種軸向柱塞式液壓泵/馬達之結構比較

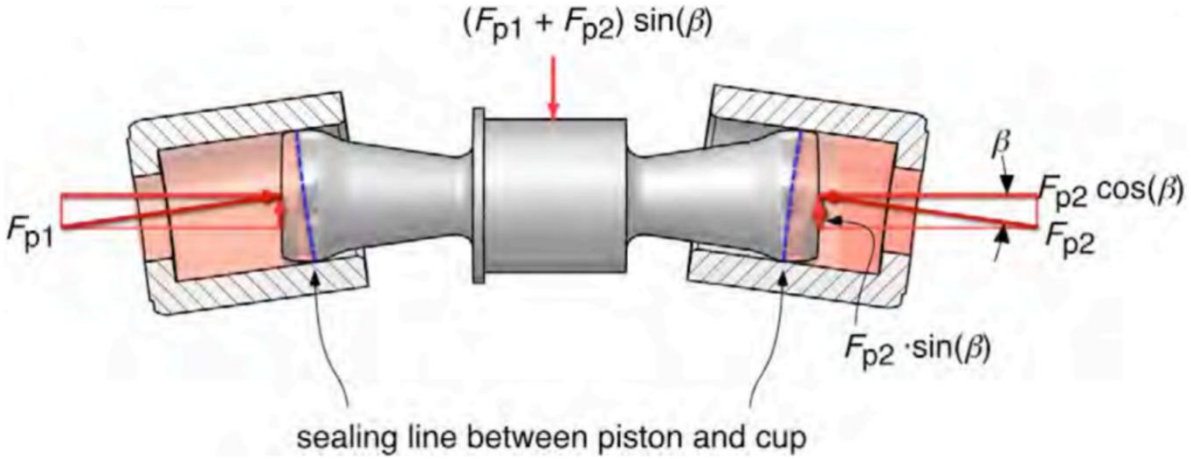
- 斜盤式液壓泵



- 曲軸式液壓泵



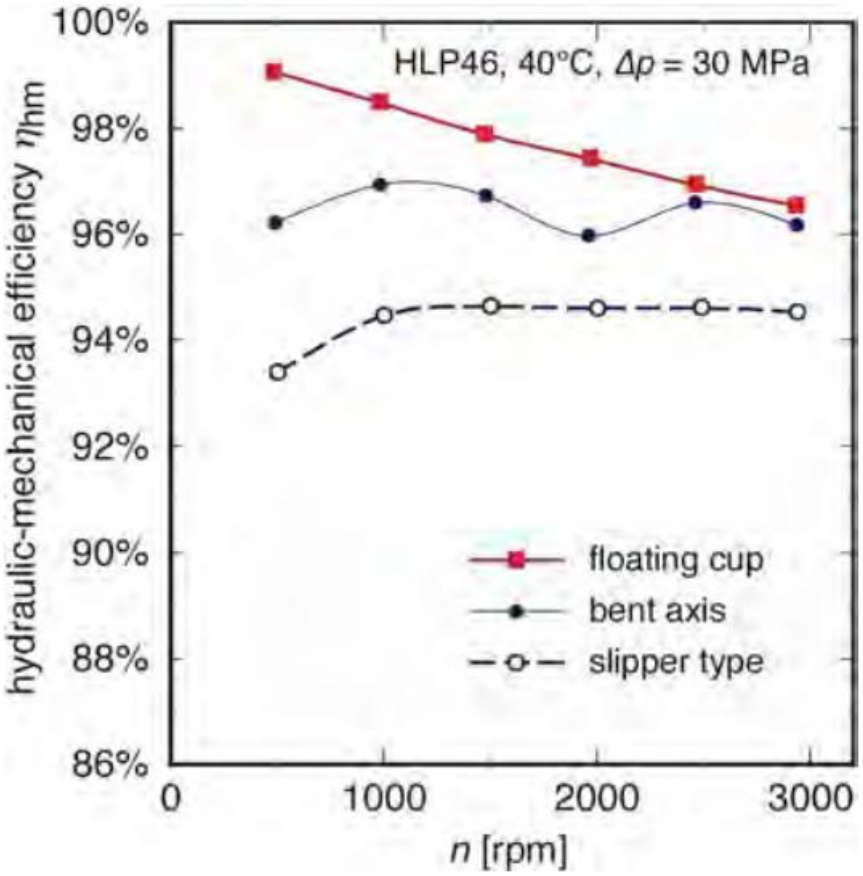
- Floating Cup 液壓泵



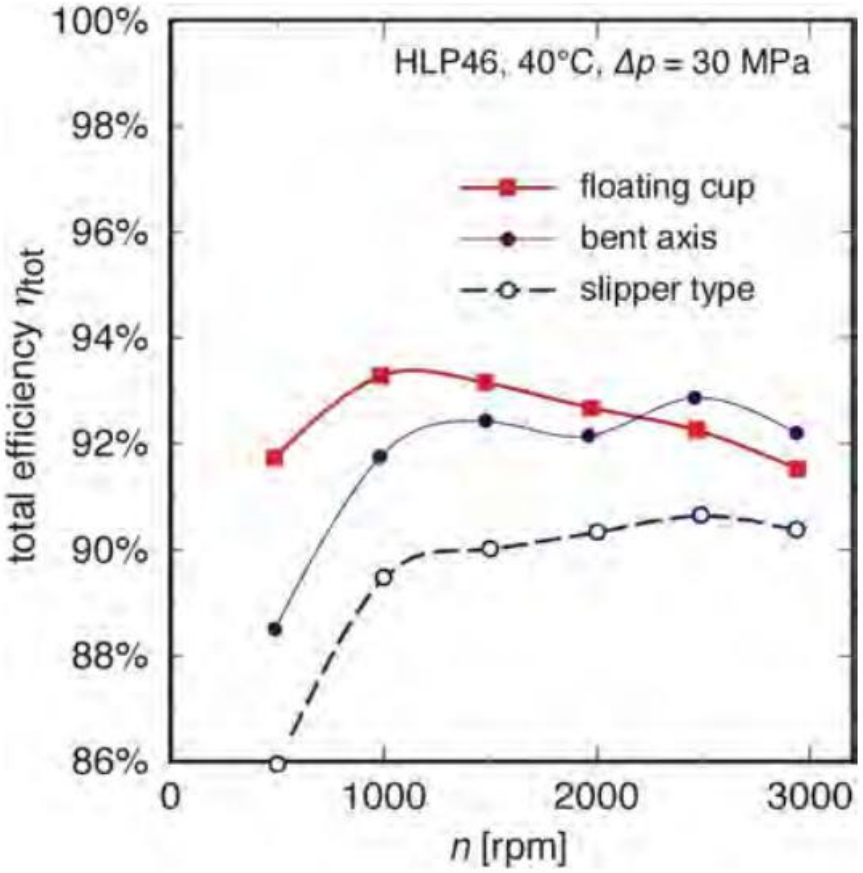
Ref: Peter A.J. Achten

三種軸向柱塞式液壓泵/馬達之效率比較

- 軸向柱塞式液壓泵機械效率

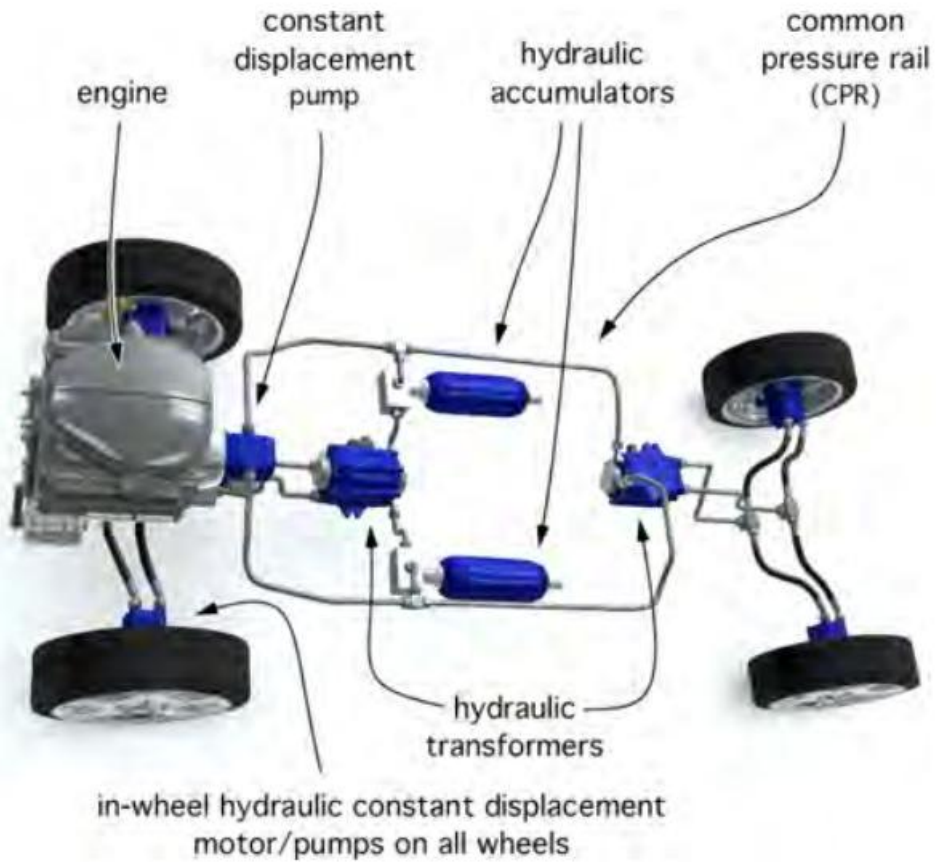


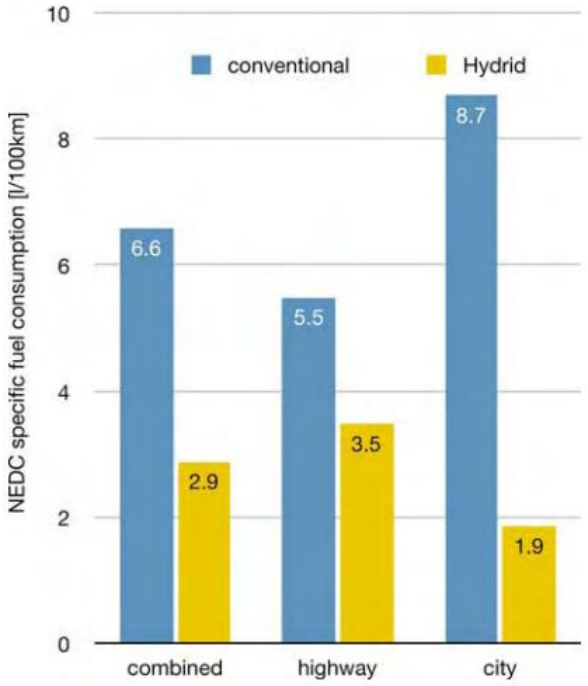
- 軸向柱塞式液壓泵總效率



Ref: Peter A.J. Achten

Floating Cup 泵/馬達於串聯式油壓混合車之應用

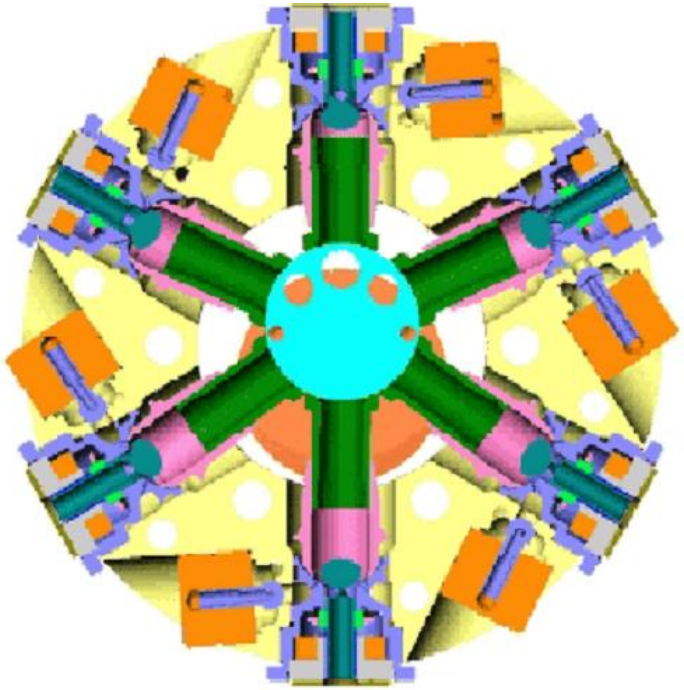




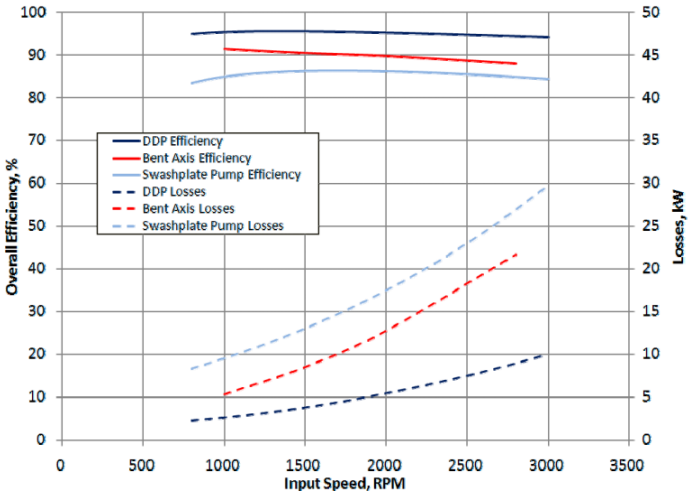
Ref: P. ACHTEN, G. VAEL, M.I. SOKAR and T. KOHMASCHER

數位排量式、曲軸式以及斜盤式液壓馬達之效率比較

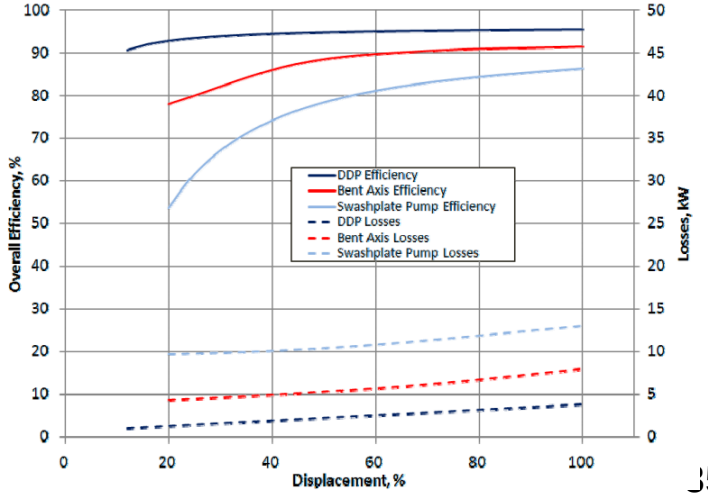
Digital Displacement Pump/Motor



- 100% Displacement

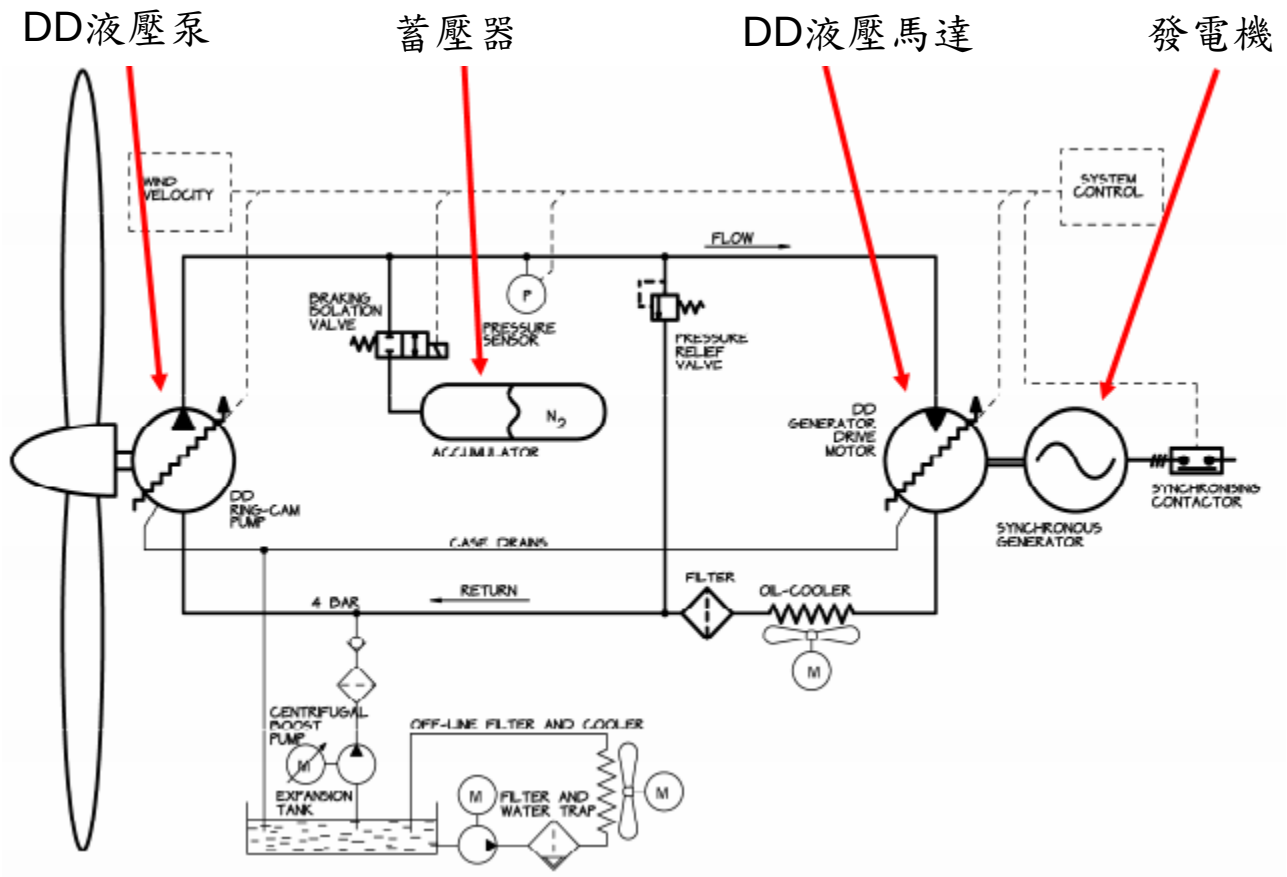


- 1500 RPM



Ref: Luke Wadsley

DD液壓泵/馬達於風力發電之應用



Ref: Jamie Taylor

6. 結　論

1. 適當之管路配置與油品選擇可提高系統效率。
2. 閥控系統較泵控系統之反應速度快但效率較低。
3. 馬達控制結合泵之排量控制可有效節能。
4. 使用高效率之液壓泵/馬達可有效提高整體效率。
5. 液壓混合車可有效回收煞車能量以降低油耗。
6. 蓄壓器雖具有高功率密度但能量密度低，故僅能做輔助能源用。