VARIABLE SPEED FAN DRIVE ANALYSIS

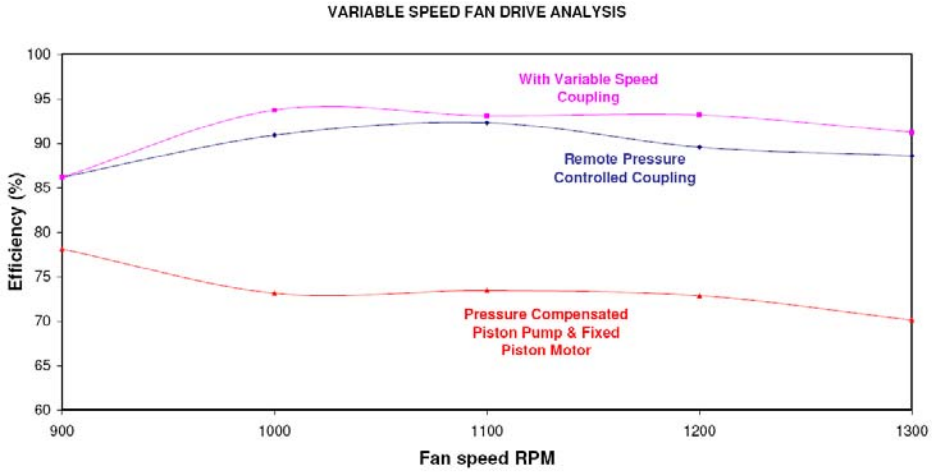
PURPOSE OF TEST

Proof of concept of newly developed Variable coupling for fan drive applications. Test for power Draw at constant input speed and variable output speed and compare efficiencies.

Test Comments

Performance data is using standard intra vane rotor with 10 vanes. These components are not made for high volumetric efficiencies at low speeds, but offer sufficient data for proof of concept.

The 12 vane design offers efficiency increases. The prototype 12 vane fluid coupling can be viewed on youtube.com (search for Mathers Hydraulics) which offers 95% efficiency. The Fan used is a 30'' diameter plastic constructed unit from a Mack MP8 470 Hp diesel engine.



Test 1 Results: Remote Pressure(speed)controlled coupling			Results: Fan directly coupled to electric motor		Overall Efficiency
Input RPM	Output RPM	Power Kw	Input RPM	Power Kw	Eff%
1400	900	4.4	900	3.8	**86**
1400	1000	5.0	1000	4.5	**91**
1400	1100	5.9	1100	5.4	**92**
1400	1200	7.2	1200	6.5	**90**
1400	1300	8.6	1300	7.6	**89**
The above Coupling style would suit mobile machinery and on highway vehicles.					

Test 2 Results: With Variable speed coupling			Results: Fan directly coupled to electric motor		Overall Efficiency
Input RPM	Output RPM	Power Kw	Input RPM	Power Kw	Eff%
1400	900	4.4	900	3.8	**86**
1400	1000	4.8	1000	4.5	**94**
1400	1100	5.8	1100	5.4	**93**
1400	1200	7.0	1200	6.5	**93**
1400	1300	8.3	1300	7.6	**91**
The above Coupling style would suit very high power stationary and mobile equipment.					

Test 3 Results: Pressure compensated Piston Pump and Fixed Piston Motor in open loop.			Results: Fan directly coupled to electric motor		Overall Efficiency
Input RPM	Output RPM	Power Kw	Input RPM	Power Kw	Eff%
1400	900	4.8	900	3.8	**78**
1400	1000	6.2	1000	4.5	**73**
1400	1100	7.4	1100	5.4	**73**
1400	1200	8.9	1200	6.5	**73**
1400	1300	10.8	1300	7.6	**70**

Patent pending. Coupling can be viewed on the Mathers Hydraulics YouTube channel. On YouTube website, type in “Mathers Hydraulics” to search.
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Mathers Hydraulics Pty Ltd
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Phone: +61 7 3267 0065 Fax: +61 7 3267 0056
Web: www.mathershydraulics.com.au
Email: sales@mathershydraulics.com.au

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VARIABLE SPEED FAN DRIVE

MATHERS HYDRAULICS TECHNOLOGY

VARIABLE FAN DRIVE EFFICIENCIES EXPLAINED

Some people will struggle to accept the test figures (attached) until they can fully understand how the fluid coupling actually works and/or see it for themselves. I will attempt to clarify frequently asked questions and the principals of operation. The fluid coupling cannot be viewed as a pump because the majority of energy transfer is through pressurized oil forcing the ring and output shaft to rotate. Yes, some oil can be bleed off to reduce torque and/or output speed but the majority of power is from compressed oil on the ring contour forcing the ring and output shaft assembly to rotate.

In hydraulics there are 2 inefficiencies, volumetric and mechanical. Volumetric is how much internal leakage there is from the pressure areas to lower pressure areas. We have reduced this leakage by improving tolerances and using thicker oil. It needs to be noted that when pumping of oil in these couplings occurs it is at the differential speed of input and output, for example 1400 Rpm in and 900 Rpm out can be viewed as a pump operating at 500 Rpm. Because the relative speeds are low, but centrifugal forces remain high, the manufacturing tolerances can be reduced. As the relative speed of the pump is low, inlet issues with high viscosity oils is not a problem.

Mechanical inefficiencies are the frictional forces between the rotor, vanes, ring and pressure plates (bearing efficiency has been ignored as a vane pump has balance pressure quadrants producing no side loads and uses low friction ball bearings). In a standard vane pump this is a loss of power as the ring and pressure plates are stationary, however in a coupling where power is being transferred through to the rotating ring and pressure plates from the rotor and vanes, it actually improves our efficiency by assisting drive. IE: Any frictional forces help to drive the ring and output shaft.

The Pressure Controlled Coupling speed is controlled by bleeding some oil off at a controlled pressure. This bleed off oil is a loss of power, however, in a fan drive, the power required is the cube of the speed so as speed reduces the pressure greatly reduces and the frictional gains spoken about above are a larger proportion of the transferred energy further reducing the required pressure. The higher the volume of bleed off volume the lower the output speed, the lower power the fan draws and pressure becomes even less with friction supplying a larger portion of the power, hence the high efficiency.

The Variable Speed Coupling speed is controlled by bleeding some oil off through a variable displacement motor that is mechanically connected to the coupling output and fan drive shaft. By setting the variable motor swash angle at zero, no oil can pass through it. As no oil can escape from the coupling pressure chambers all power is transferred from the rotor and vanes to the ring contour and output shaft assembly via compressed oil. This offers maximum speed to the fan blade. The efficiency here is only affected by internal leakage and as with the above the frictional forces are helping to rotate the output shaft assembly. Effectively the variable motor does nothing in this mode, but as the displacement is increased two effects occur. Firstly the oil is bleed off from the coupling and metered out across the motor reducing output speed. This energy is not lost as the motor is connected to the fan drive shaft. Secondly the total displacement is now the coupling plus the variable motor displacements. The fan speed having reduced requires less power, as discussed earlier, the torque requirement has reduced and we have increased displacement which greatly reduces the pressure requirement. This greatly reduced pressure reduces the internal leakage and frictional forces are still helping to drive the fan, hence the high efficiency.

This new technology can be difficult to comprehend, and if you are still not convinced, please contact Rob Price (rob@mathershydraulics.com.au or on +61 (0)7 3267 0065) with any questions or to organise a visit to our facilities for an in depth practical demonstration.

MH-FSVPRoGen-A/DS

Patent pending. Coupling can be viewed on the Mathers Hydraulics YouTube channel. On YouTube website, type in “Mathers Hydraulics” to search.
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16 Armada Place, Banyo, QLD 4014, Australia
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Web: www.mathershydraulics.com.au
Email: sales@mathershydraulics.com.au

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PRESSURE CONTROLLED (SPEED) FAN DRIVE COUPLING

PURPOSE OF TEST

Proof of concept of newly developed pressure controlled coupling.

Test for power draw at constant input speed and variable output speed.

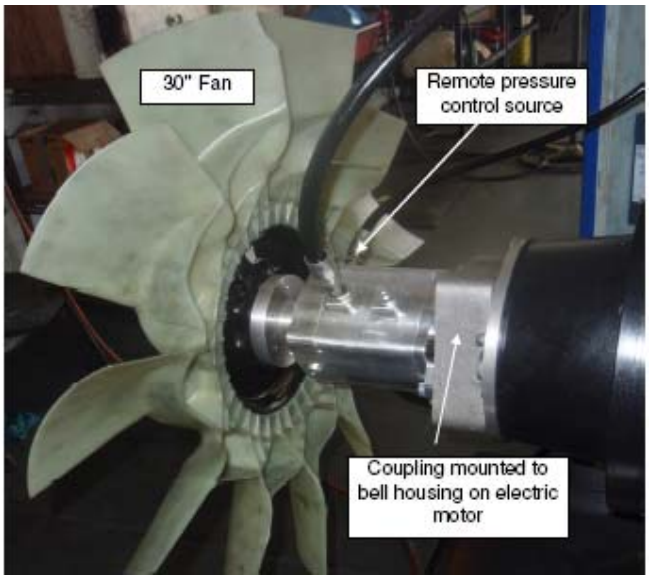
TEST CONDITIONS

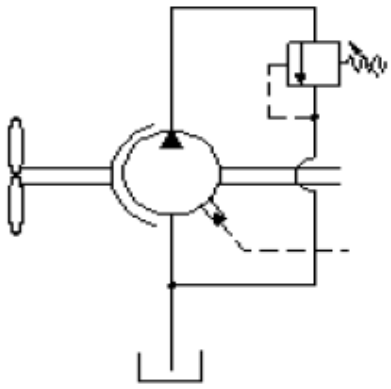
- Fan Blade: 30” plastic construction from a Mack MP8 470 Hp Diesel Engine.
- Electrical Motor Power: 15KW.
- Power draw readings from VSD readout.
- Oil: 80W90
- Temp: 30^{o} C

Test Comments

Early trial Data. These components are not made for high volumetric efficiencies at low speeds, but offer sufficient data for proof of concept. The fluid coupling can be viewed on youtube.com (search for Mathers Hydraulics) which offers 95% efficiency and improvements are still possible.

Results: Remote Pressure (speed) controlled			Results: Fan directly coupled to electric motor		Overall Efficiency
Input RPM	Output RPM	Power Kw	Input RPM	Power Kw	Eff%
1400	900	4.4	900	3.8	**86**
1400	1000	5.0	1000	4.5	**91**
1400	1100	5.9	1100	5.4	**92**
1400	1200	7.2	1200	6.5	**90**
1400	1300	8.6	1300	7.6	**89**





Remote pressure controlled fan coupling. Main relief can be incorporated in the coupling

Patent pending. Coupling can be viewed on the Mathers Hydraulics YouTube channel. On YouTube website, type in “Mathers Hydraulics” to search.

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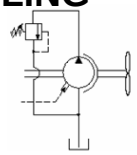
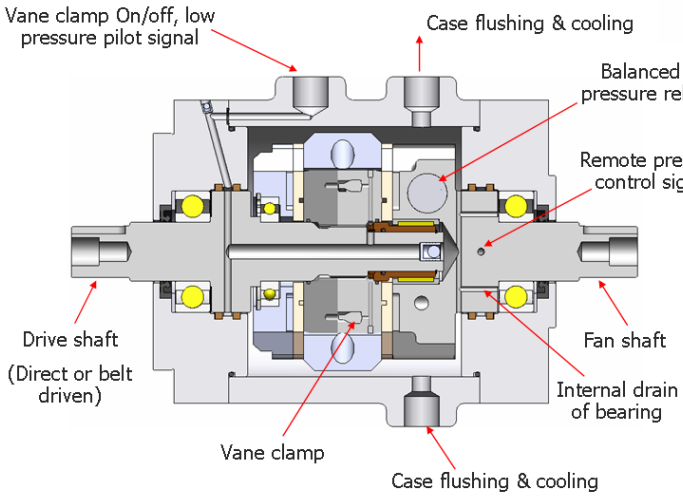
REMOTE PRESSURE CONTROLLED FAN DRIVE

VARIABLE SPEED FAN DRIVE COUPLING

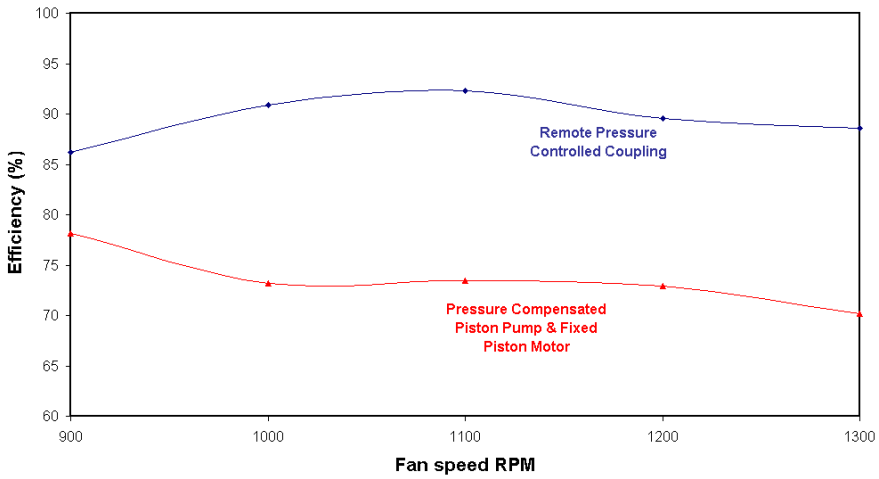
REMOTE PRESSURE CONTROL

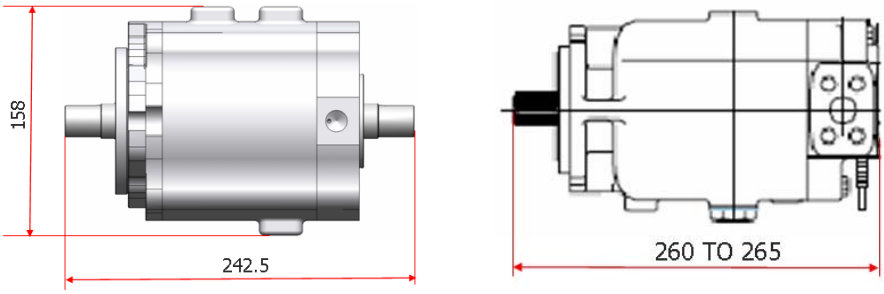




VARIABLE SPEED 10 KW FAN DRIVE TEST DATA - 760MM FAN

Increased efficiency saves fuel usage of up to 2000 litres per year





Size comparison between fan coupling & piston motor. The coupling is shorter and higher power density. No hydraulic pump source required.

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VARIABLE SPEED FAN DRIVE COUPLING TEST DATA

PURPOSE OF TEST

Test for power draw and efficiencies at constant input speed and variable output speed.

TEST CONDITIONS

- Fan Blade: 30" plastic construction from a Mack MP8 470 Hp Diesel Engine 40 CC/Rev pressure compensated piston pump.
- 33CC/Rev fixed motor.
- Electrical Motor Power: 15KW.
- Power draw readings from VSD readout.
- Oil: ISO 68
- Temp: 30^{o} C

Test Comments

Conditions are identical to the Pressure Controlled and Variable Speed coupling drives. Identical electric motor, fan and measuring equipment.

Results: Pressure compensated Piston Pump and Fixed Piston Motor in open loop.			Results: Fan directly coupled to electric motor		Overall Efficiency
Input RPM	**Output RPM**	**Power Kw**	**Input RPM**	**Power Kw**	**Eff%**
1400	900	4.8	900	3.8	**78**
1400	1000	6.2	1000	4.5	**73**
1400	1100	7.4	1100	5.4	**73**
1400	1200	8.9	1200	6.5	**73**
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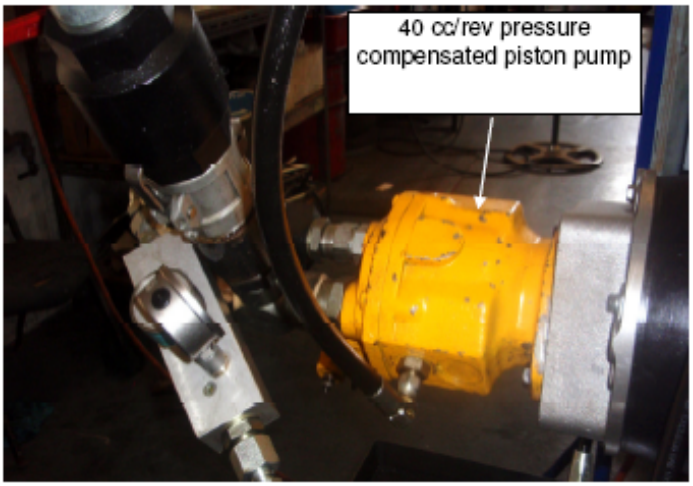

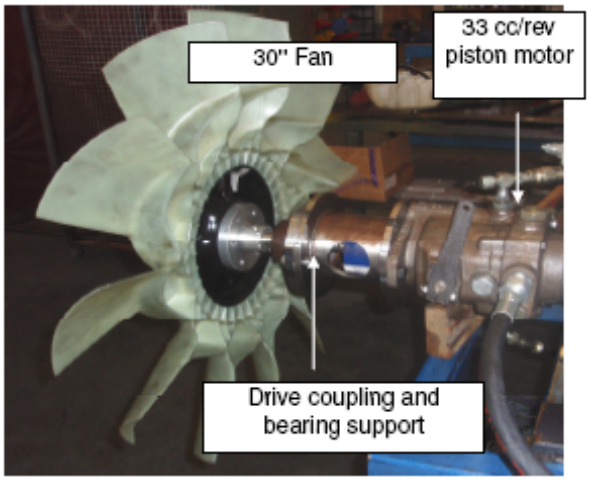

Patent pending. Coupling can be viewed on the Mathers Hydraulics YouTube channel. On YouTube website, type in "Mathers Hydraulics" to search.
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VARIABLE SPEED FAN DRIVE COUPLING

PURPOSE OF TEST

Proof of concept of newly developed Variable Coupling for fixed engine speed fan drive applications.

Test for power draw at constant input speed and variable output speed.

TEST CONDITIONS

- Fan Blade: 30” plastic construction from a Mack MP8 470 Hp Diesel Engine.
- Electrical Motor Power: 15KW.
- Power draw readings from VSD readout.
- Oil: 80W90
- Temp: 31^{o} C

Test Comments

Early trial Data. These components are not made for high volumetric efficiencies at low speeds, but offer sufficient data for proof of concept. The fluid coupling can be viewed on youtube.com (search for Mathers Hydraulics) which offers 95% efficiency and improvements are still possible.

Results: Variable Speed Coupling			Results: Fan directly coupled to electric motor		Overall Efficiency
Input RPM	Output RPM	Power Kw	Input RPM	Power Kw	Eff%
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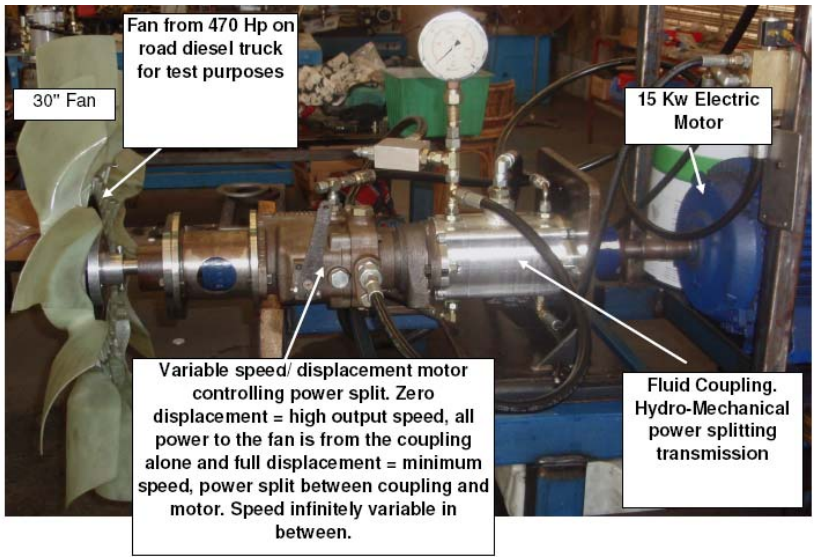

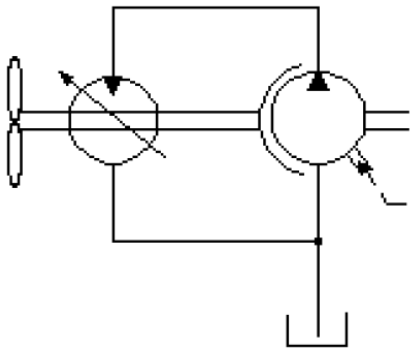

Variable speed fan coupling

Patent pending. Coupling can be viewed on the Mathers Hydraulics YouTube channel. On YouTube website, type in “Mathers Hydraulics” to search.

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Email: sales@mathershydraulics.com.au

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DIRECT COUPLED FAN DRIVE COUPLING TEST DATA

PURPOSE OF TEST

Confirm power draw of the fan at varying speeds.

TEST CONDITIONS

- Fan Blade: 30” plastic construction from a Mack MP8 470 Hp Diesel Engine.
- Electrical Motor Power: 15KW.
- Power draw readings from VSD readout.
- Oil: N/A
- Temp: 30^{o} C

Test Comments

Conditions are identical to the Pressure Controlled and Variable Speed coupling Drives. Identical electric motor, fan and measuring equipment.

Results: Fan directly coupled to electric motor		
Input RPM	**Power Draw (%)**	**Power Kw**
650	13	2.0
700	14	2.1
750	17	2.6
800	20	3.0
850	23	3.5
900	25	3.8
950	27	4.1
1000	30	4.5
1050	33	5.0
1100	36	5.4
1150	41	6.2
1200	43	6.5
1250	47	7.1
1300	50.5	7.6
1350	55	8.3

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