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# Optimization of Fluid Coupling performance for Hybrid Power Transmission System

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***Abstract:*** *This paper presents the testing of a Hybrid Fluid coupling system for effective and efficient Power transmission with fluids having different viscosities at various filling capacities. A specific prototype is designed and built to carry out the performance tests. The objective lies in developing an efficient fluid coupling which would transfer the mechanical power with minimum transmission losses. This fluid coupling would transfer the power from the two main sources, namely the Induction motor or any other source of power and then transmit it to the output shaft through the Fluid medium. The fluid coupling has an advantage over the mechanical coupling in the following aspects, like, Effective dampening of shocks, load fluctuations and torsional vibrations. Smooth and controlled acceleration without jerks in transmission of the power, wear-free power transmission system because of absence of mechanical connection [no metal-to-metal contact] between the Impeller (input) and Runner (output) element. The effect of Sources of Input power and fluid percentage in the Fluid Coupling casing on output speed is carried out and analysed.*
***Key Words:*** *Fluid coupling, Impeller, Runner and Working Fluid.*

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## I. Introduction:

Fluid couplings are used in engineering applications due to their unique features in flexible transmission of shaft torque between a pair of driving and driven shafts. Fluid coupling operates on the hydrokinetic principle without mechanical contact between driving and driven shafts. A fluid coupling principally consists of a pump impeller, turbine runner and working fluid enclosed in an oil tight chamber or casing. The driving wheel works as a pump impeller, imparting angular momentum to the working fluid, while the driven wheel works as a turbine runner, receiving the angular momentum from the fluid. Therefore, a flexible transfer of shaft torque is realized from the driving pump impeller to the driven turbine runner through the working fluid without mechanical contact. The chamber is filled with fluid, and a circulation is established in the coupling circuit which leads to exchange of angular momentum between the impeller and runner through fluid. The impellor of the fluid coupling is directly connected to the prime mover like motor or I.C.Engine by mechanical coupling. The impellor is power input component of the fluid coupling. The runner is directly connected to the machine by mechanical means like Belt drive, gear drive or a mechanical coupling. The runner is power output component of the fluid coupling.

Working fluid of the fluid coupling is the important parameter of the system. The working fluid in the fluid coupling is filled between impellor and runner which gets energies by rotation of impellor and converts impellors energy in the kinetic energy of the fluid, this kinetic energy of the fluid get absorbed while striking on runner. And by this energy the runner rotates and power transmitted to the machine.

The present investigation is aimed to analyze various factors, which affect the performance of fluid coupling. The parameters under investigation are fluid with varying viscosities, filling capacity of fluid in fluid coupling and speed ratio between driving and driven members.

## II. Model Description:

In a typical Hybrid Fluid coupling used, the pump impellers (2 Nos.) and turbine runner are geometrically identical and mounted back to back with little separation between the leading and trailing edges. A first impeller is connected with the external input shaft and a second impeller is connected with internal input shaft. The runner is connected with the output shaft which is coupled with brake dynamometer. A commonly used impeller/runner having 24 radial vanes with $15^0$ face angle is used.

Test setup for performance test consists of the following components:

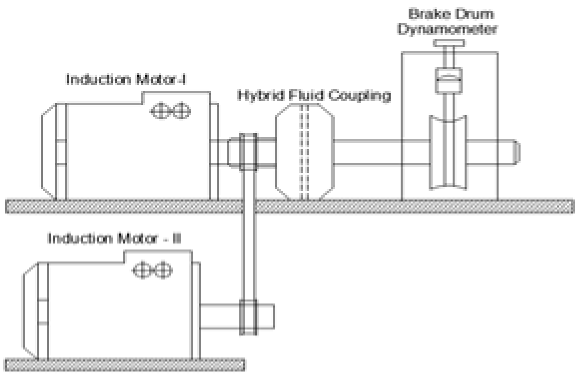



**Fig 1.** Test setup arrangement

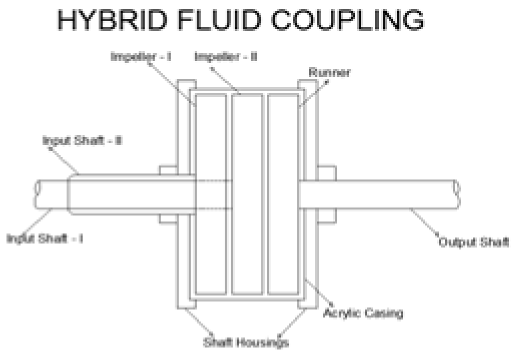



**Fig 2.** Hybrid Fluid Coupling (Line Diagram)

**Motor:** the electric motor worked as prime mover for test model. Technical specifications of the motor are as follows

| | |
|---|---|
| Input Power of the Motor-1 | 0.5 HP |
| Number of poles | 4 |
| Speed | 1500 RPM |
| Power Factor | 0.85 |
| Frequency | 50 Hz |
| No of phase | Single Phase |
| Rated voltage | 240 V |
| Rated current | 3.0 A |

| | |
|---|---|
| Input Power of the Motor-2 | 0.25 HP |
| Number of poles | 4 |
| Speed | 1500 RPM |
| Power Factor | 0.85 |
| Frequency | 50 Hz |
| No of phase | Single Phase |
| Rated voltage | 240 V |
| Rated current | 3.0 A |

**Brake Drum Dynamometer:** Design specifications of the dynamometer are as follows

| | |
|---|---|
| Speed | Upto 1500 RPM |
| Type | Brake Dynamometer-Belt |
| Cooling | Water cooled |
| Brake Drum Diameter | 120 mm |
| Belt thickness | 6mm |

**Fluid Coupling:** The fluid coupling used in this experiment is made of mild steel and its ratings are as follows.

**1. Impellers/Runner:**

| | |
|---|---|
| Outer Diameter | 127mm |
| Dia of Impeller Eye | 65mm |
| No. of Vanes | 24 |
| Length of Vane | 31mm |
| Width of Vane | 10mm |
| Thickness of Vane | 1.5mm |
| Face Angle of the Vane | $15^0$ |

2. **Casing (Acrylic)**

| | |
|---|---|
| Outer Diameter | 139mm |
| Inner Diameter | 130mm |
| Thickness | 5mm |
| Length | 49mm |

3. **Shaft (Impeller and Runner)**

| | |
|---|---|
| Length | 140mm |
| Outer Diameter | 17mm |

4. **Impeller/ Runner Housing**

| | |
|---|---|
| Outer Diameter | 170mm |
| Inner Diameter | 130mm |
| Groove depth | 5mm |

**Working Fluid:**

The viscosity grade of lube oil (Fluid) is determined by the Society of Automotive Engineers (SAE). Oils can be separated into multigrade oils and monograde oils. Multigrade oils must fulfill two viscosity specifications, their viscosity grade consists of two numbers, e.g. 10W-40: 10W refers to the low-temperature viscosity ("Winter"), 40 refers to the high-temperature viscosity ("Summer"). Currently, most automotive engine oils are multigrade oils. The oil used should be antioxidant and anti-foaming.

The properties of oils like viscosity, density, ISO Grade and equivalent SAE Grade are given in following table.

| ISO Grade | Equivalent SAE Grade | Kinematic Viscosity (*centiStokes*) | | Density (*kg/m*$^3$) |
|---|---|---|---|---|
| | | *40ºC* | *100ºC* | |
| 32 | 10 | 32 | 5.4 | 857 |
| 46 | 20 | 46 | 6.8 | 861 |
| 150 | 40 | 150 | 15 | 872 |
| 680 | 90 | 680 | 18.75 | 893 |
| 1000 | 140 | 1000 | 32.46 | 901 |

**Table 1.** Kinematic Viscosity for different ISO Grade oils with equivalent SAE Grade

**Test Procedure:**

The step-by-step performance test procedure is detailed below.

1. Fill the Hybrid Fluid coupling with oil (SAE 10) under test. The quantity of oil is taken to give a said Percentage of oil filling capacity of Fluid Coupling chamber.
2. Start the motor and wait until it reaches steady state and then apply the load on Dynamometer. Wait until the speed reaches for steady state. Note the readings of input RPM, output RPM and dynamometer load.
3. Now change the load on dynamometer and take all the readings again.
4. Stop the motor and increase the oil quantity into the fluid coupling and perform the same test procedure.
5. Now dismount the fluid coupling from the test bench and fill with different Fluids like SAE 20, SAE 40, SAE 90, SAE 140 and repeat the same test procedure.

## III. Test Results and Analysis:

The performance test is carried out with different fluids. The results observed with the fluids are as follows.

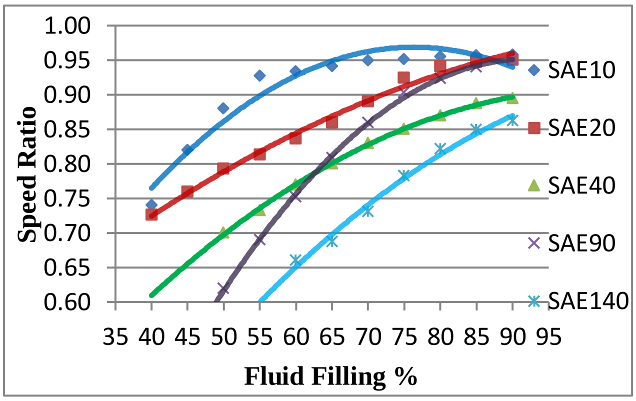
**Speed ratio for different filling capacities for various fluids:**

| Filling % | SAE10 | SAE20 | SAE40 | SAE90 | SAE140 |
|---|---|---|---|---|---|
| 40 | 0.74 | 0.73 | | | |
| 45 | 0.82 | 0.76 | | | |
| 50 | 0.88 | 0.79 | 0.70 | 0.62 | |
| 55 | 0.93 | 0.81 | 0.73 | 0.69 | |
| 60 | 0.93 | 0.84 | 0.77 | 0.75 | 0.66 |
| 65 | 0.94 | 0.86 | 0.80 | 0.81 | 0.69 |
| 70 | 0.95 | 0.89 | 0.83 | 0.86 | 0.73 |
| 75 | 0.95 | 0.92 | 0.85 | 0.90 | 0.78 |
| 80 | 0.95 | 0.94 | 0.87 | 0.92 | 0.82 |
| 85 | 0.96 | 0.95 | 0.89 | 0.94 | 0.85 |
| 90 | 0.96 | 0.95 | 0.90 | 0.95 | 0.86 |

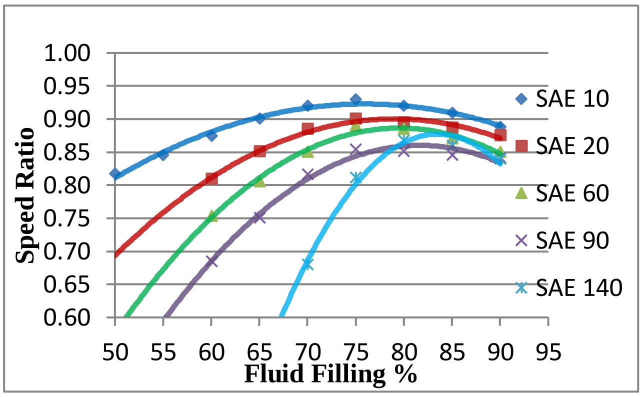
**Table 1. a:** Two Shaft Fluid Coupling

| Filling % | Speed Ratio ($N_2/N_1$) | | | | |
|---|---|---|---|---|---|
| | SAE10 | SAE20 | SAE60 | SAE90 | SAE140 |
| 50 | 0.82 | | | | |
| 55 | 0.85 | | | | |
| 60 | 0.87 | 0.81 | 0.75 | 0.68 | |
| 65 | 0.90 | 0.85 | 0.81 | 0.75 | |
| 70 | 0.92 | 0.89 | 0.85 | 0.82 | 0.68 |
| 75 | 0.93 | 0.90 | 0.89 | 0.85 | 0.81 |
| 80 | 0.92 | 0.89 | 0.89 | 0.85 | 0.87 |
| 85 | 0.91 | 0.89 | 0.87 | 0.85 | 0.86 |
| 90 | 0.89 | 0.88 | 0.85 | 0.84 | 0.84 |

**Table 1.b:** Single Shaft Fluid Coupling

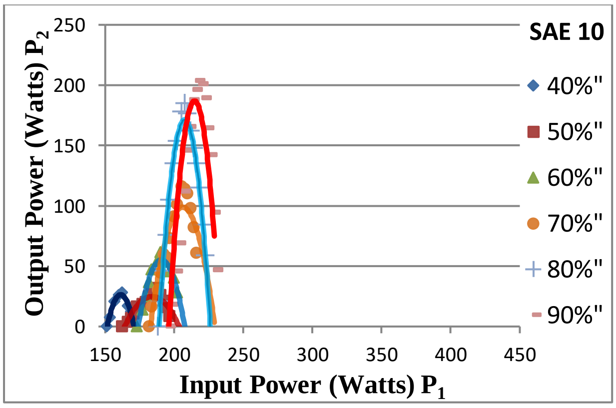



**Graph 1.a:** Two Shaft Fluid Coupling

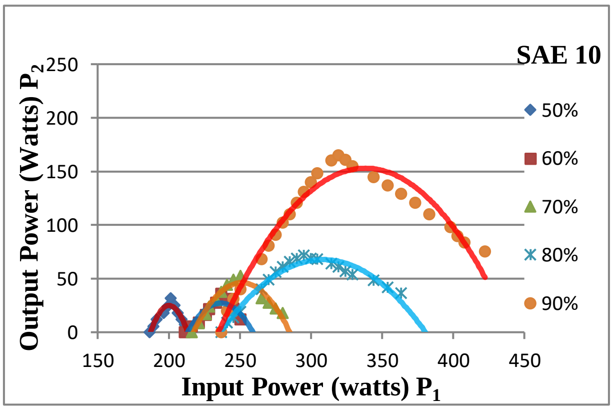



**Graph 1.b:** Single Shaft Fluid Coupling

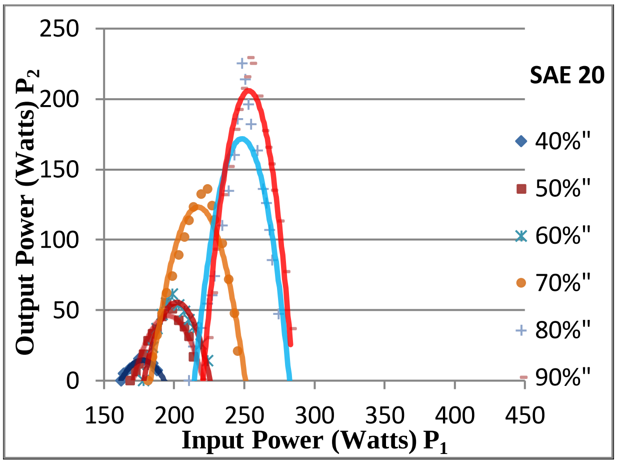
**Variation of input power with output power for different oils at different filling capacities**



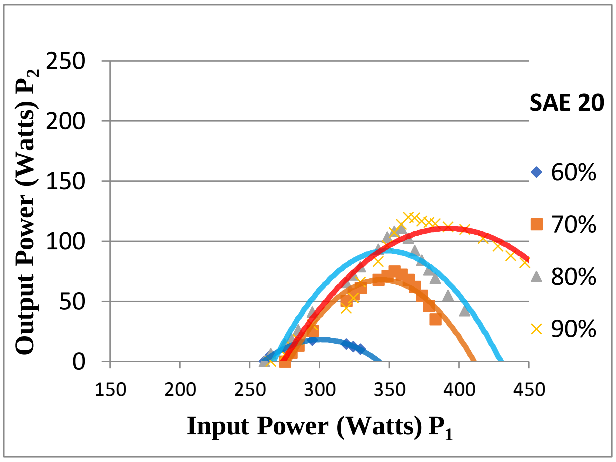

**Graph 2.a:** Two Shaft Fluid Coupling



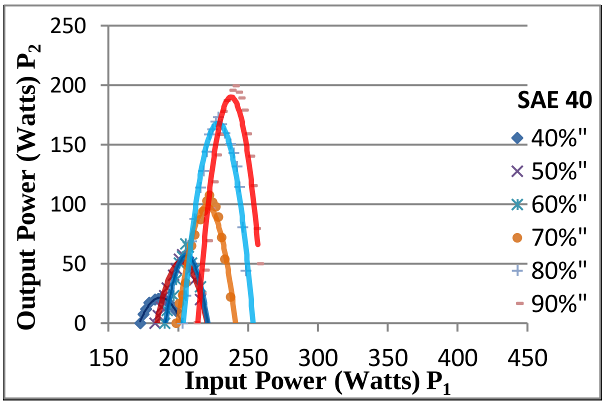

**Graph 2.b:** Single Shaft Fluid Coupling



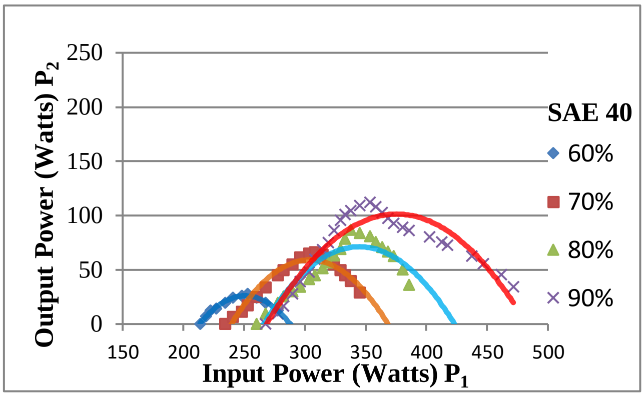

**Graph 3.a:** Two Shaft Fluid Coupling



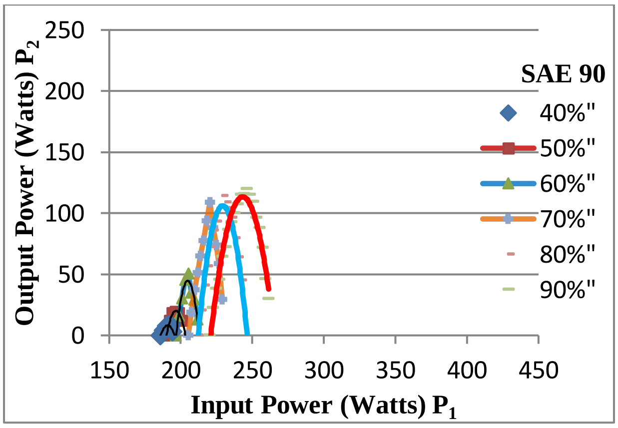

**Graph 3.b:** Single Shaft Fluid Coupling



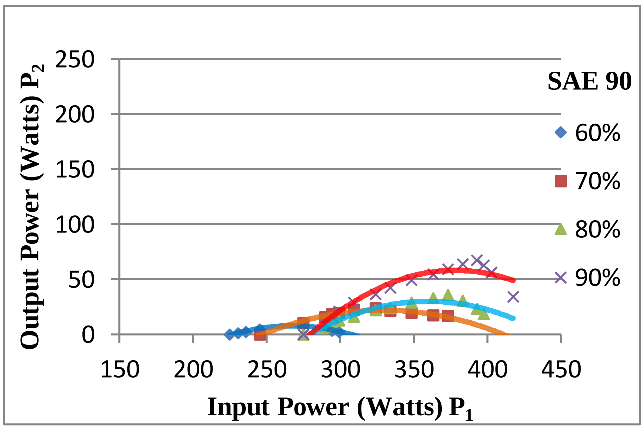

**Graph 4.a:** Two Shaft Fluid Coupling



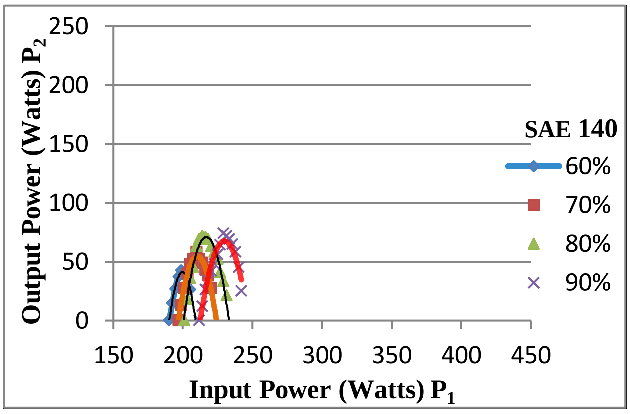

**Graph 4.b:** Single Shaft Fluid Coupling



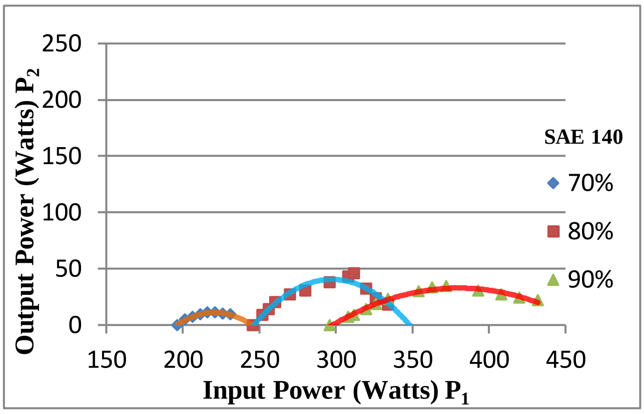

**Graph 5.a:** Two Shaft Fluid Coupling




**Graph 5.b:** Single Shaft Fluid Coupling




**Graph 6.a:** Two Shaft Fluid Coupling




**Graph 6.b:** Single Shaft Fluid Coupling

## IV. Results and Conclusion:

On the basis of the above test results of the experimental investigations on Hybrid Fluid Coupling with different fluids, the following conclusions are made.

1. With reference to Table 1.a and Table 1.b, the effect of source of power on speed ratio is determined and it is observed that the speed ratio is more in case of Two Input shaft Fluid Coupling compare with Single Input shaft Fluid Coupling.
2. With reference to Table 1.a and Table 1.b, it is observed that the output shaft of Two Input shaft Fluid Coupling starts rotating when the fluid coupling is filled upto 40% capacity only
3. With reference to Graphs 2.a to 6.b, the output power is more in Two Input shaft Fluid Coupling compare with Single Input shaft Fluid Coupling.
4. It is observed that the power is increasing with increase in fluid filling in both Single Input and Two shaft Input couplings.
5. It can be observed that Low viscous fluids transfer higher power in both Single Input and Two shaft Input couplings.

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