

Technical Service Bulletin

Date: July 10, 2008

Product Description: All AMSOIL four-stroke power sports engine oils

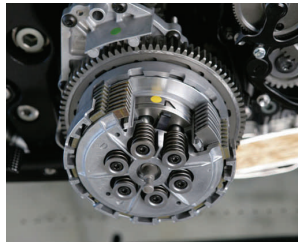
Subject: Wet-clutch operation and lubrication requirements

OBJECTIVE:

1. Provide information to understand the function of oil-immersed clutches commonly found in power sports applications.
2. Review the role played by lubricants in wet clutch applications and the key properties affecting operation.
3. Highlight common problems associated with oil-immersed clutch operation.

OVERVIEW:

By definition, a clutch is a coupling used to connect and disconnect the powered and driven parts of a mechanism. In this case, the clutch connects and disconnects the engine (driver) and the transmission (driven). The advantages a clutch provides are clear because without the clutch, there would be no way to stop the movement of the vehicle without also stopping the engine. Severing the connection between the engine and transmission removes the load from the transmission, making it physically easier to change gears. Removing the load also minimizes stress on gears and shifting mechanisms, thereby extending their life expectancy.



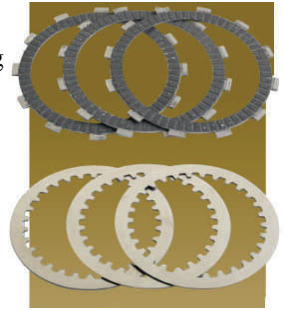
TYPICAL CLUTCH COMPONENTS AND FUNCTIONS:

Manual clutches used in power sports applications are comprised of a number of components. Though their design will vary from one application to another, similar key elements are common: the clutch basket, clutch pack (plates), inner hub, pressure plate, tension spring(s) and actuator.

Spur gears, common in metric bikes and ATVs, transfer rotational power from the engine to the clutch basket (A.). In Harley-Davidson applications, however, a chain and sprocket set or belt and pulley combination are more commonly used for the same purpose. The inner hub (C.) sits inside the clutch basket and is connected to the input shaft of the transmission. There is no direct connection between the inner hub and basket, so if the engine is running, the basket rotates freely around the inner hub. The clutch pack (B1. & B2.) is located between the hub and basket. The clutch pack consists of an alternating series of two types of plates: steel and frictional. Steel plates (B2.) attach to the inner hub via tabs on the inner diameter. The next plate is a

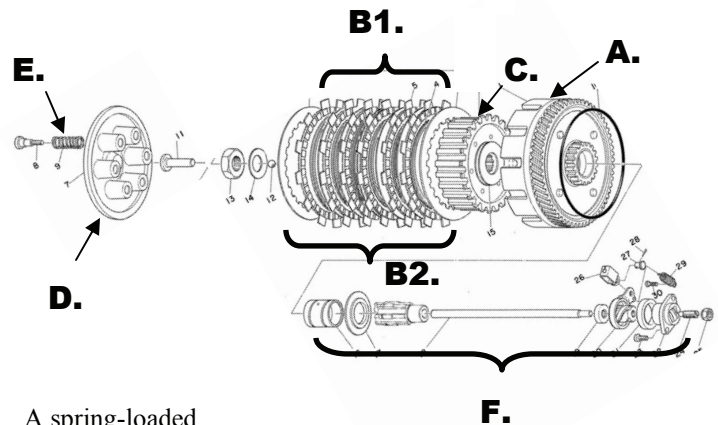
frictional or fiber plate (B1.) with a fibrous surface coating. The frictional plates attach to the basket via tabs on their outer diameter. Plates within the clutch pack alternate until a desired pack height is reached. The total number of plates in a clutch can vary depending on model. The more plates a pack contains, the greater the surface area and generally the greater its horsepower and torque-carrying ability.

Frictional Plates (B1.)



Steel Plates (B2.)

A. Basket B. Clutch Pack (B1.) Frictional Plates (B2.) Steel Plates C. Inner Hub D. Pressure Plate E. Tension Spring(s) F. Actuator



A spring-loaded pressure plate (D.) atop the clutch pack

Typical Clutch Design

applies constant force to the clutch pack. This pressure is obtained either through the use of a single diaphragm-style spring (*Harley-Davidson*) or a series of compression-style springs (E.) typically ranging in numbers from four to eight. The final key element is a mechanical device that engages and disengages the clutch assembly. Though the design varies, the device is normally actuated by depressing a lever. The lever movement is then transferred to the actuator (F.) via a cable.

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ENGAGED POSITION: The clutch is normally in the engaged position. When engaged, the clutch spring(s) applies a constant load on the pressure plate, forcing the clutch pack (plates) together. The load creates a high level of static friction between the plates in the pack, causing them to rotate together. In this position, rotational movement from the engine is transferred to the clutch basket, to the frictional plates, through the steel plates, into the inner hub and finally to the transmission input shaft.

Compression Springs



DISENGAGED POSITION: In power sports applications such as most motorcycles and manual ATVs, disengagement of the clutch is initiated by depressing a lever on the left-hand side of the handle bars. This action pulls a cable that is attached to an actuator within or adjacent to the clutch. Though actuator designs vary, its purpose is to remove the load being applied to the clutch pack via the clutch spring. The most common way to accomplish this is to compress the spring by pushing the pressure plate away from the clutch pack. This allows the clutch plates to separate, creating a loss of rotational transfer between the plates. At that time the clutch basket can rotate freely with engine speeds while the inner hub and transmission either remain stationary or rotate at a different speed.



Diaphragm Spring

ENGAGEMENT: When the clutch lever is released, pressure is once again applied to the clutch pack, squeezing the plates together. This increases friction between the plates, transferring torque (*the force to produce rotation*) from the rotating frictional plates to the stationary steel plates connected to the inner hub and transmission. The steel plates begin to rotate and increase in speed until they match that of the frictional plates. When speed is equalized, the clutch is considered to be fully engaged.

OIL-IMMERSED CLUTCH (Wet-Clutch):

There are two general categories of clutches in power sports applications. One operates partially immersed in oil (wet-clutch) while the other has no contact with a fluid at all (dry-clutch). A dry-clutch configuration is common on older Harley-Davidson bikes as well as some models of BMW and Ducati. The wet-clutch configuration is by far the most widely-used and is common on Japanese motorcycles and manually shifted ATVs. In a wet-clutch design, the oil acts as a heat transfer medium, reducing the overall operating temperature of the clutch

assembly. By reducing operating temperatures, the formation of varnish and lacquer on the clutch plates is minimized. When varnish and lacquer deposits form, it changes the frictional characteristics of the plates, promoting slippage and increased heat. This effect can result in more rapid deposit formation and the potential for plate distortion. The fluid in a wet-clutch acts like the water used with wet sandpaper, minimizing the build-up of wear debris on the frictional plates. The oil also provides lubricity to components and wear areas within the clutch, such as bearings and the points of contact between the outer tabs of the frictional plates and the clutch basket. Wet-clutches generally last longer and provide more consistent operational performance because they operate at a more consistent temperature.

Wet-clutches can be found in three different configurations. The first is where there is a separate fluid reservoir for the clutch keeping it isolated from the engine and transmission. An example of this configuration is the primary-drive chain case found on recent models of Harley-Davidson motorcycles (*exceptions include Sportsters and V-Rods*). The second configuration is a shared transmission and clutch fluid reservoir. Examples of this configuration can be found on Harley Sportsters and V-Rods, as well as a few metric bikes like the Honda CRF-250R. The third is a common engine, transmission and clutch reservoir. This is the most common configuration and is found in the majority of metric and European motorcycles as well as ATVs.

The three different configurations place unique demands on lubricants. In the first example, oil must be capable of handling lubrication and frictional demands of the clutch and potentially a roller chain or single gear set. In the second configuration, the oil provides for clutch lubrication in addition to the transmission. In the final configuration, the clutch, transmission and engine all need to be lubricated with the same fluid, requiring a multi-faceted fluid capable of meeting a variety of needs.

OIL IMMERSION AND FRICTIONAL REQUIREMENTS:

Clutches balance the requirements to lock-up in the drive position and minimize friction and wear during the transition. This balance raises questions on surface compatibility. Not every lubricant is suitable for use in motorcycle or ATV wet-clutch applications and some specifically recommended for use provide varying levels of performance.

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Good wet-clutch performance is extremely important to ensure satisfactory drivability. Frictional properties, cleanliness, clutch material/oil compatibility, anti-foaming properties, shear stability, and high-temperature stability are all important in maintaining the integrity and performance of a wet-clutch system.

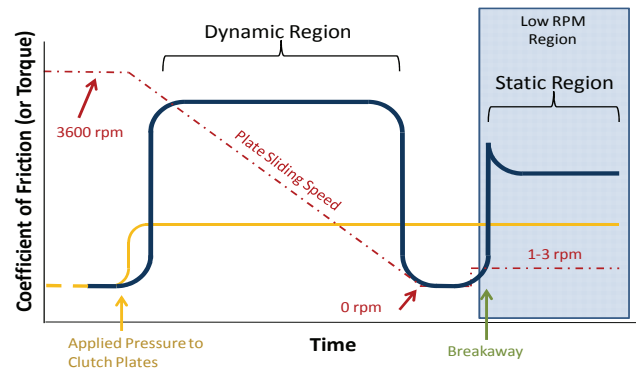
Frictional resistance, is separated into two types: static and dynamic friction. The force required to begin movement of a box across the floor is an example of static friction. Once the box is in motion, the force required to keep it in motion is called dynamic friction. It takes less effort to keep the box moving than it does to break it loose. The reason is that it requires less force to overcome dynamic friction than static friction. In power sports clutches, static friction is the force that keeps the frictional plates and steel plates locked together and prevents them from slipping when the clutch is in the engaged position. Dynamic friction comes into play as the clutch is engaged and the plates begin to contact each other. Dynamic friction begins the rotation of the steel plates. When there is enough contact and the forces of static friction are overcome, the steel plates rotate at the same speed as the clutch and become locked together.

The surface condition of the plates affects the amount of friction generated during lock up. Referring back to the box example, it is easier to push the box over a smooth surface than a rough surface. Remember, in a clutch there are significantly different surfaces: the rough frictional plate and the smooth steel plate. The resulting force required for the two different plates to grab and lock-up is called the coefficient of friction. A rough plate will lock-up quicker than a smooth plate.

The subsequent graph displays a typical friction profile. As the clutch is engaged, spring-pressure forces the rotating frictional plates up against the non-rotating steel plates. Dynamic friction between the two plate-types increases rapidly, causing the steel plates to begin rotating. The level of dynamic friction remains relatively constant until both plate-types are rotating at the same speed. Once rotation speed has been equalized, undesirable slippage between the two plate-types is minimized by the resistance provided by static friction. The ability to minimize slippage when the clutch is engaged and locked is depicted on the right-hand side of the graph. Note that static friction is highest just prior to the plates breaking away or slipping. Once slipping, the resistance force is reduced as dynamic friction has taken over.

From the standpoint of operator feel, dynamic friction should have a high and relatively flat trace. This provides a shorter time

FRICITION PROFILE DURING A SHIFT



between clutch engagement and lock-up, resulting in faster shifting. It is also desirable for the level of dynamic friction to decrease slightly as the plate rotation speeds equalize. This provides a smooth shift feel. If there is too much dynamic friction, the feeling is abrupt and harsh. If there is not enough, the shift is elongated and the potential for excessive plate slippage occurs. High static friction is also desirable as it provides good clutch holding power and the ability to transfer the maximum design capacity through the clutch.

Within the power sports industry, engine oil is the most commonly used fluid in wet-clutch applications. There are other products suitable for wet-clutch applications, but regardless, the introduction of any fluid will affect the frictional characteristics within the clutch. Therefore, it is important to remember the contribution of the base oil and additives in the final product.

Though it is commonly thought that the use of synthetic oils results in excessive clutch slippage, extensive field and laboratory testing have disproven that theory. Properly selected synthetic based oils perform very well and do not alter the frictional characteristics of a wet-clutch and can actually improve their performance and longevity. The type of base oil used has the least impact on wet clutch performance.

The additive chemistry used in formulating the oil has a far greater impact. Friction modifiers can decrease the coefficient of friction within the clutch pack and result in excessive plate slippage. Some additives like solid graphite or teflon can also create similar slippage. Extreme-pressure additive containing fluids commonly used in gear lubricants should never be used because they can cause excessive clutch slippage and related damage.

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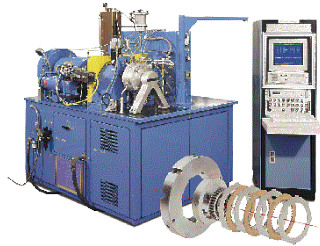
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CATEGORIZING AN OIL'S FRICTIONAL PROPERTIES:

The power sports industry relies on two standards for the review of frictional properties of oil as they relate to wet-clutch applications. The first is the Japanese Automotive Standards Organization (JASO) standard T903:2006 subsection T904. The second is very similar to JASO standard called International Organization for Standardization (ISO) standard 24254:2007. In both cases, an SAE No.2 Friction Test Machine is used for the analysis. During the test, a conventional clutch pack is immersed in the test oil and run through 1,000 engage and disengage cycles. The data is recorded at cycles 500 and 1,000. Data points recorded include static and dynamic coefficients of friction, as well as the time between initial plate contact and the point at which plate rotation speed equalizes (stop time). The results are then compared to two reference oils and an index number is generated. The index number is then compared against four performance categories set forth in the JASO and ISO standards. For JASO T903:2006 the categories are MB, MA, MA1 and MA2. For ISO 24254:2007 the categories are L-EMB, L-EMA, L-EMA1 AND L-EMA2.



JASO MA2 and ISO L-EMA2 oils generally provide the greatest coefficient of friction, offering the best clutch-holding capacity and the least tendency for excessive slippage.

Consumers must rely on the oil manufacturer to indicate compatibility and performance. Oil companies normally list the JASO or ISO category on the packaging label. Consumers can select the best oil identifying the JASO or ISO category printed on the label and the recommended equipment. If no JASO or ISO category is listed for the oil, it is likely that compatibility in a wet-clutch application has not been reviewed. To avoid potential performance and longevity issues, these products should not be used.

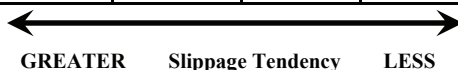
WET-CLUTCH COMPATIBILITY OF AMSOIL PRODUCTS:

When formulating engine oils for power sports applications, wet-clutch compatibility is a major concern. The friction characteristics of all AMSOIL power sports engine oils have been fully reviewed using the test methodology set forth in both the JASO standard T903:2006 sub-standard T904 and ISO standard 24254:2007.

The engine oils AMSOIL recommends for use in power sports applications and the corresponding frictional categories are listed below. Wet clutch performance is an important property along with reducing the formation of varnish and lacquer, and reducing wear and running temperatures. The oil must also maintain plate cleanliness, provide good anti-foaming properties and superior shear stability.

JASO and ISO Frictional Categories

JASO	MB	MA	MA1	MA2
ISO	ISO-L-EMB	ISO-L-EMA	ISO-L-EMA1	ISO-L-EMA2
DFI <i>Dynamic Friction Index</i>	≥ .50 x < 1.45	≥ 1.45 x < 2.50	≥ 1.45 x < 1.80	≥ 1.80 x < 2.50
SFI <i>Static Friction Index</i>	≥ .50 x < 1.15	≥ 1.15 x < 2.50	≥ 1.15 x < 1.70	≥ 1.70 x < 2.50
STI <i>Stop Time Index</i>	≥ .50 x < 1.55	≥ 1.55 x < 2.50	≥ 1.55 x < 1.90	≥ 1.90 x < 2.50



JASO MB and ISO L-EMB oils exhibit the lowest frictional properties of the four categories and generally offer the least clutch-holding capacity and the greatest potential for slippage.

Wet-clutch frictional categories meet by AMSOIL motor oils	JASO Frictional Category	ISO Frictional Category
AMSOIL ADVANCED SYNTHETIC MOTORCYCLE OIL SAE 20W-50 MCV	MA2	ISO-L-EMA2
AMSOIL ADVANCED SYNTHETIC MOTORCYCLE OIL SAE 10W-40 MCF	MA2	ISO-L-EMA2
AMSOIL ADVANCED SYNTHETIC MOTORCYCLE OIL SAE 10W-30 MCT	MA2	ISO-L-EMA2
AMSOIL SYNTHETIC HEAVY WEIGHT RACING OIL SAE 60 AHR	MA	ISO-L-EMA
AMSOIL FORMULA 4-STROKE, SCOOTER OIL SAE 10W-40 ASO	MA2	ISO-L-EMA2
AMSOIL FORMULA 4-STROKE, POWER SPORTS OIL SAE 0W-40 AFF	MA2	ISO-L-EMA2

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COMMON CAUSES FOR WET-CLUTCH PERFORMANCE ISSUES:

The following list outlines some common performance issues in wet-clutch applications. Many of the solutions listed can be easily implemented by the equipment owners. Some should be completed only by a qualified mechanic.

1. **Worn frictional plates:** Much like brakes on a car, motorcycle and ATV clutches require friction in order to function. With friction, however, comes wear, and wear generally is the limiting factor when it comes to how long a clutch will function. As the friction plate thickness decreases, it allows the clutch spring to extend, minimizing the pressure applied to hold the frictional and steel clutch plates together. The most common way to correct this issue is to replace the worn frictional and steel plates.
2. **Glazed frictional plates:** Glaze build-up on frictional or steel clutch plates minimizes the degree of friction generated, causing the plates to slip more readily. Excessive build-up of these deposits can occur for a number of reasons including clutch slippage due to improper rider operation or the use of poor-quality lubricants. Initially, clutch slippage will create elevated plate temperature. This higher temperature will cause a more rapid breakdown of the lubricant in the clutch, forming deposits. As the deposits build, they insulate the plates, reducing heat transfer and causing the plates to operate at an increasingly higher temperature. This further accelerates the formation of additional deposits resulting in additional clutch plate slippage and spirals into clutch failure. Glazed plates can sometimes be cleaned but most often have to be replaced. In either case, the use of a thermally stable oil along with proper operating techniques and adjustment will minimize the potential for glazing to occur.
3. **Stretched clutch cable:** In virtually all motorcycles and many ATVs, the clutch is actuated by a lever on the handle bars. This lever is attached to the clutch via a cable, which can stretch as a result of frequent use. A stretched cable can minimize or eliminate the ability of the clutch to disengage. This results in difficult shifting and a tendency for the bike to attempt to move forward, even when the clutch lever is fully depressed. Generally the remedy is as simple as a few turns of the cable housing adjuster located near the clutch lever itself. If severe stretching has occurred, the cable will have to be replaced.
4. **Worn or improperly-adjusted engagement components:** Located between the clutch cable and the clutch itself is a device commonly referred to as the clutch actuator or release mechanism. Wear can occur through normal use that could require either component replacement or adjustment. This wear may cause the clutch to not fully disengage resulting in vehicle creep and hard shifting. Improper adjustment can cause the same, but it also result in a pre-load of the clutch, damaging the release mechanism as well as the clutch pack.
5. **Distortion of clutch plates:** Distortion of the clutch plates generally occurs as a result of exposure to elevated operating temperatures. As the plates distort, surface contact is reduced, making the clutch assembly even more prone to slippage. The common remedy is to replace any distorted plates and resolve any temperature-related issues. Again, another reason to utilize a lubricant that is thermally stable and can minimize operating temperature.
6. **Loss of clutch spring tension:** Over time, clutch springs can lose tension, reducing the pressure they apply to plates. This increases the potential for slippage and in applications where multiple compression springs are used, it is not uncommon for a single spring to lose tension. The uneven load distribution resulting from this scenario promotes slippage. Compression-style clutch springs should be inspected for damage and using uncompressed height as a reference. The height of all springs should fall within the limits outlined by the equipment manufacturer. Diaphragm-style springs should be inspected for signs of damage and cracks, and they should appear convex, not flat.
7. **Improper clutch pack height:** Anytime frictional or metal clutch plates are replaced, the height of the clutch pack (total height of all plates) must be matched to the equipment. If the clutch pack is too tall, there will be insufficient room within the clutch basket for the plates to separate and release. If the pack height is too short, the clutch springs may not have sufficient additional length to provide adequate load to the plates. It is not uncommon for equipment manufacturers to offer steel plates of different thickness allowing for adjustment of the pack height.

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8. **Worn clutch basket:** As the clutch is engaged and disengaged, the frictional plates move inside the clutch basket. Over time, this movement results in wear on the contact surfaces of the plate tabs and the basket itself. When attempting to disengage the clutch, the tabs can hang-up on the basket, preventing the plates from separating completely. When contact between the two types of plates remains, a clean disconnect does not occur, making the transmission hard to shift or the engine difficult to start. A common remedy is to remove the clutch basket and resurface the tab contact areas. In severe cases the basket and clutch plates may require replacement.
9. **Engine modifications:** A major consideration in the design of any clutch is the amount of horsepower and torque applied by the engine. Motorcycle manufacturers generally incorporate a design capable of handling stock engine output while still providing satisfactory life. If the output of the engine is increased through modification, the performance and life of the original clutch may no longer be adequate, and modifications to the stock clutch may then be required. Modification examples would be the installation of stiffer springs, use of higher performance clutch plates, or the installation of a higher capacity clutch assembly. Clutch issues relating to engine modifications are more likely to appear on an older bike as clutch performance gradually deteriorates with age and use. This further reduces the ability of the clutch to handle any additional horsepower.
10. **Improper driver operation:** Motorcycle and manual ATV clutch operation requires human control which can impact performance and life of the clutch. Excess slippage as a result of continually riding the clutch or improper engagement can lead to excessive wear and reduced frictional plate life. It can also promote plate glazing resulting in even more slippage.
11. **Use of an incorrect fluid:** As mentioned previously, not all lubricants are suitable for use in wet-clutch applications. Those containing materials such as friction modifiers or extreme-pressure additives can promote clutch slippage, eventually shortening the life of the clutch. Lubricants formulated specifically for wet-clutch applications provide varied performance. Using an oil that is more viscous (thicker) than recommended, for example, can result in higher operating temperatures and sluggish (sticking) plate release.

SUMMARY:

Performance issues in wet-clutch applications can arise for a variety of reasons. Though most are mechanical in nature, driver operation and the type of lubricant used can also have a dramatic impact. Lubrication-related wet-clutch issues stem more from additive chemistry than the base oil used in the lubricant. Therefore, general statements suggesting synthetic oils somehow offer less compatibility are generalizations based on a flawed hypothesis.

Keys to selecting the correct oil for use in wet-clutch applications include:

1. Ensuring the oil meets the JASO and ISO frictional requirements set forth by the equipment manufacturer.
2. Making sure the oil can provide high-temperature and oxidation stability.
3. Checking that the oil offers shear stability and controls foaming.
4. Using the oil with the correct viscosity (grade) recommended by the equipment manufacturer.

Use of the proper oil will ensure maximum clutch life and improved operation and performance. AMSOIL power sports products are designed for wet-clutch operation and they provide all of the qualities required for superior wet clutch operation.

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