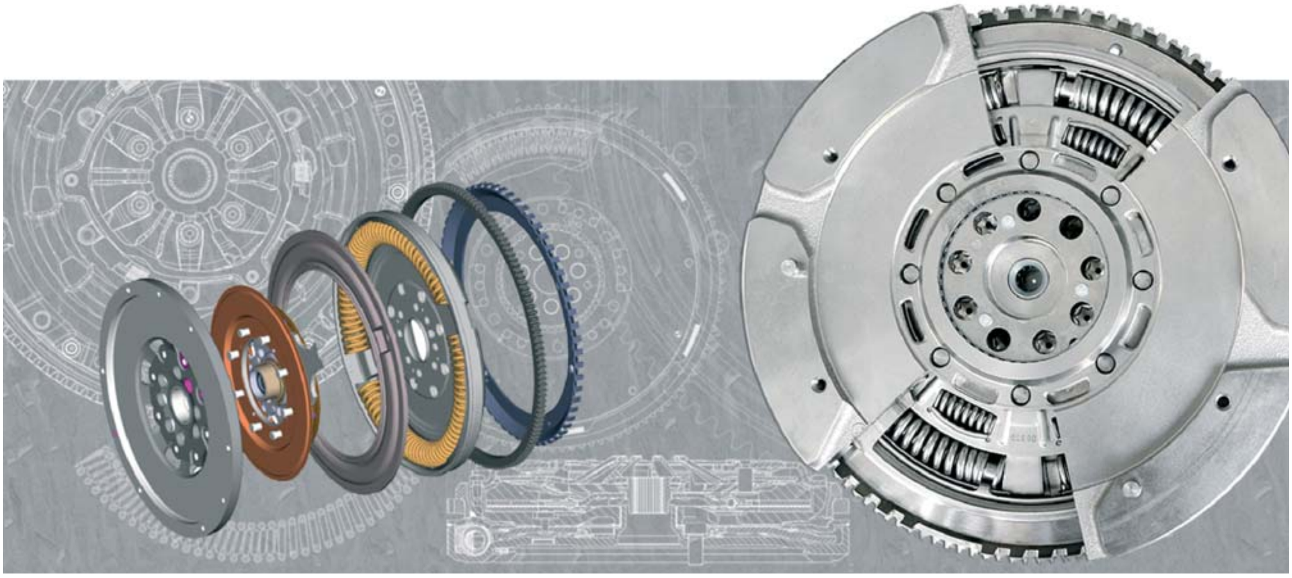
Dual Mass Flywheel

Technology

Failure Diagnosis

Content

From conventional torsion damping to Dual Mass Flywheel



The rapid development of vehicle technology over the last few decades has brought ever higher performance engines paralleled by an increased demand for driver comfort. Weight-saving vehicle concepts and wind tunnel-optimised bodies now allow other sources of noise to be perceptible to the driver. In addition, lean concepts, extremely low-speed engines and new generation gearboxes using light oils contribute to this.

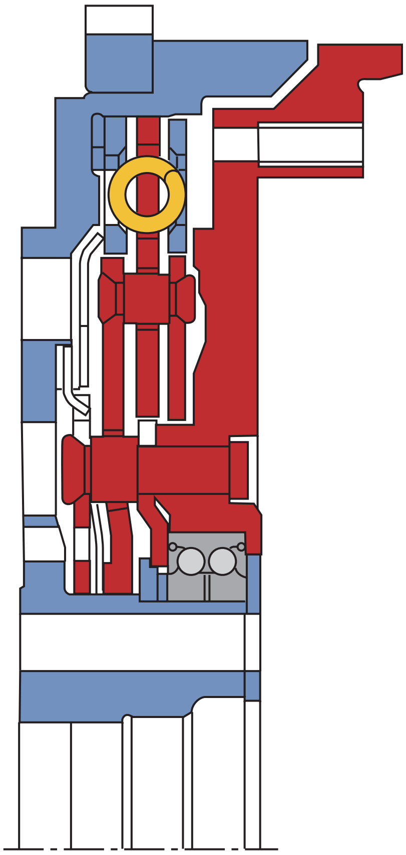
Since the middle of the 1980s, this advancement has pushed the classic torsion damper as an integral part of the clutch driven plate to its limits. With the same or even less installation space available, the classic torsion damper has proved inadequate to outbalance constantly increasing engine torques.

Extensive development by LuK resulted in a simple, but very effective solution – the Dual Mass Flywheel (DMF) – a new torsion damper concept for the drive train.

The configuration of the springs in the 1st generation DMF were identical to conventional torsion dampers, where the pressure springs are mounted in a radial direction close to the centre and can therefore provide only limited spring capacity. This design was sufficient to isolate vibration in 6-cylinder engines as these excite low resonance speeds.

In contrast, 4-cylinder engines induce higher irregularities and consequently higher resonance speeds. Re-positioning of the springs towards the outer edge and the use of large pressure spring diameters increased the damper capacity 5 fold without requiring more space.

DMF function diagram



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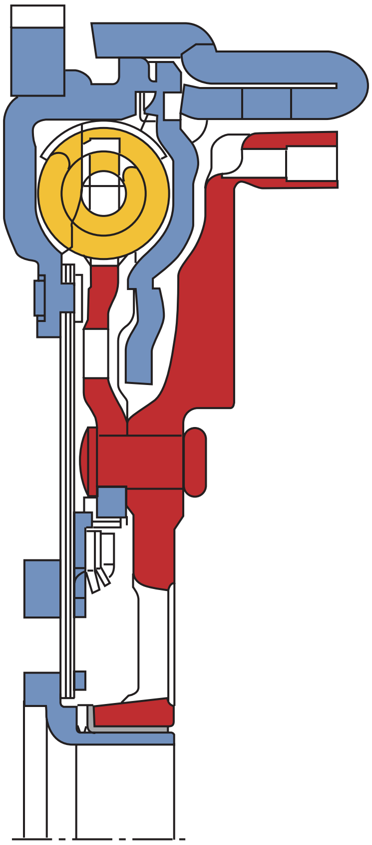
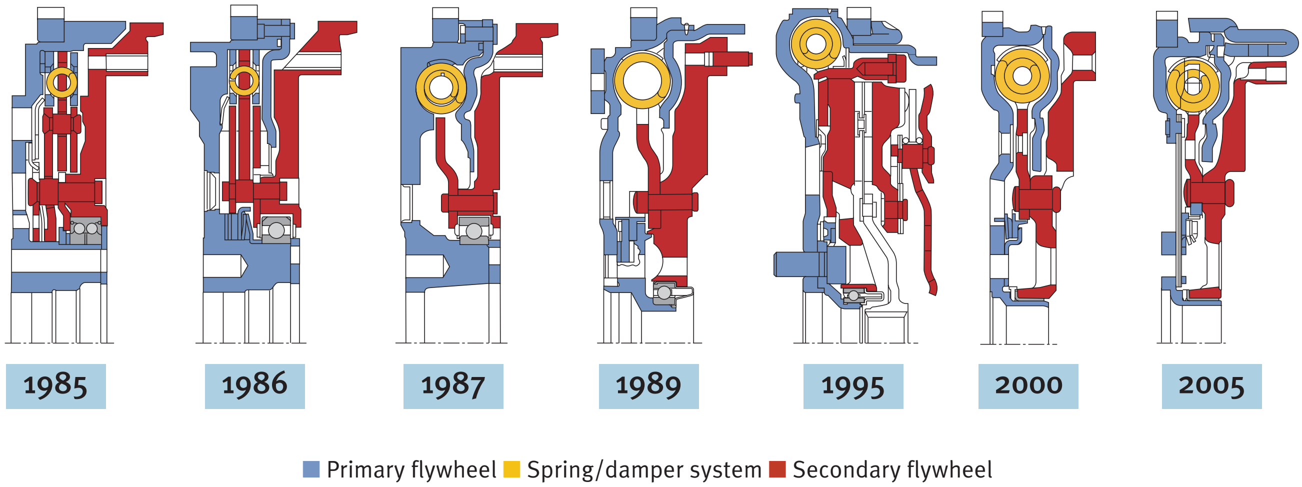


2005

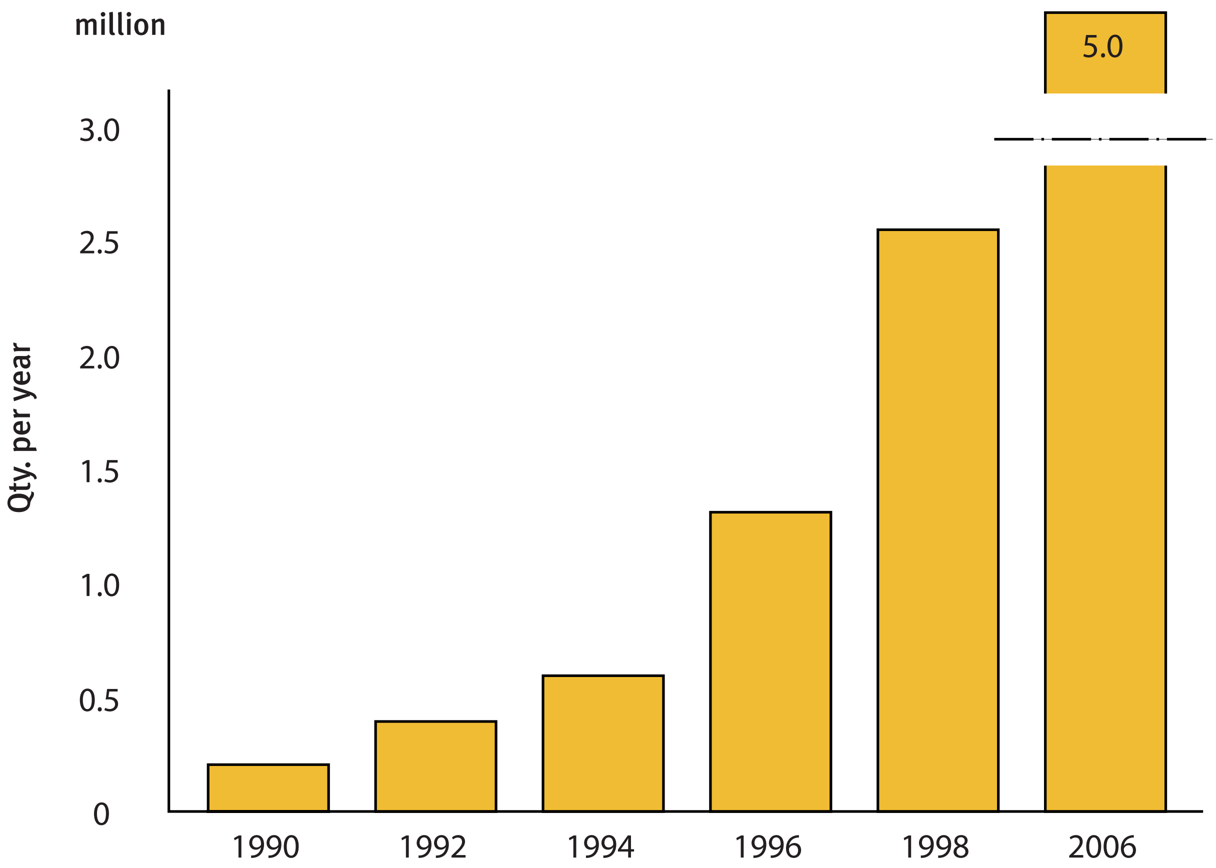
Primary flywheel ■ Spring/damper system ■ Secondary flywheel

DMF – milestones in technology



Sales volumes 1990-2006

Today, LuK's annual DMF production volume exceeds 5,000,000 pieces



2. Dual Mass Flywheel – DMF

2.1 Why DMF?

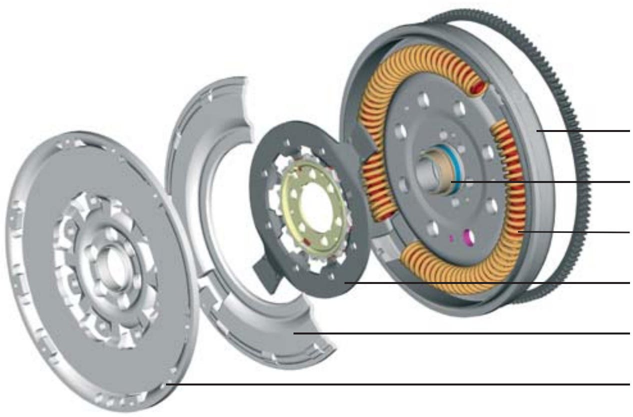
The periodic combustion cycles of a 4-stroke engine produce torque fluctuations which excite torsional vibration to be passed down the drive train. The resulting noise and vibration, such as gear rattle, body boom and load change vibration, result in poor noise behaviour and driving comfort.

The objective when developing the Dual Mass Flywheel was therefore to isolate as much of the drive train as possible from the torsional vibration caused by the engine's rotating mass.
Owing to its integral spring/damper system, the Dual Mass Flywheel almost entirely absorbs this torsional vibration. The result: Very good vibration damping.

2.2 Design

A standard Dual Mass Flywheel consists of the primary flywheel (1) and the secondary flywheel (6).

The two decoupled masses are connected via a spring/damper system and supported by a deep groove ball bearing or plain bearing (2) so they can rotate against each other.



Standard-Dual Mass Flywheel

1. Primary flywheel
2. Plain bearing
3. Arc springs
4. Flange
5. Primary cover (cross section)
6. Secondary flywheel

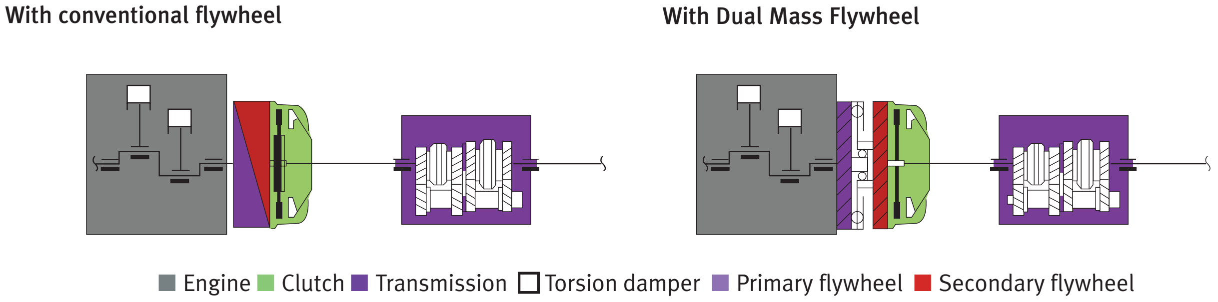
The primary mass with starter ring gear is driven by the engine and tightly bolted to the crankshaft. It encloses, together with the primary cover (5) a cavity which forms the arc spring channel.

At the heart of the spring/damper system are the arc springs (3). They sit in guides in the arc spring channels and cost effectivley fulfil the requirements of an "ideal" torsion damper. The guides ensure correct guidance of the springs during operation and the grease around the springs reduces wear between the guides, channels and the springs.

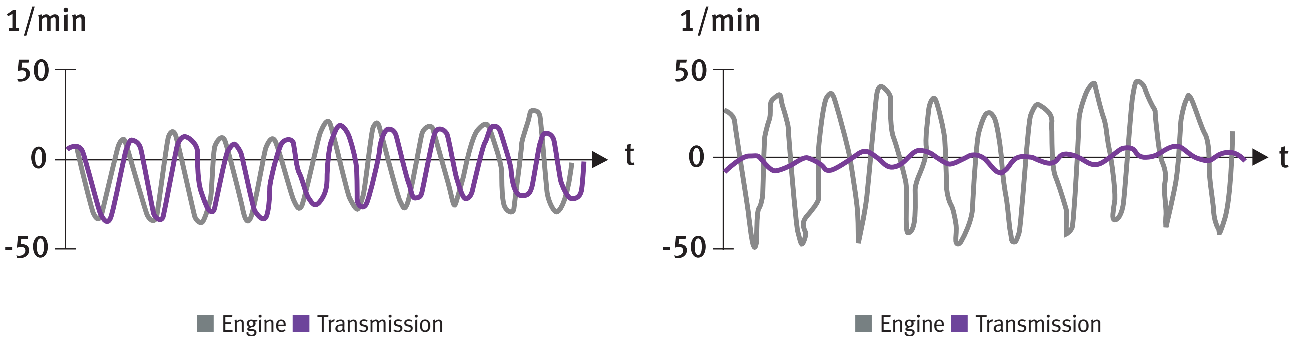
Torque is transferred via the flange (4). The flange is bolted to the secondary flywheel with its wings sitting between the arc springs.
The secondary flywheel helps to increase the mass moment of inertia on the gearbox side. Vents ensure better heat dissipation. As the DMF has an integral spring/damper system, a rigid clutch disc without torsion damper is normally used.

2.3 Function

The functioning principle of a DMF is simple, yet efficient. Owing to the additional mass on the transmission input shaft, the vibration torque range, which is normally between 1,200 rpm and 2,400 rpm with original torsion dampers, is moved to a lower resonance speed range. This ensures excellent damping of engine vibration even at idle speeds



Transfer of torsional vibration

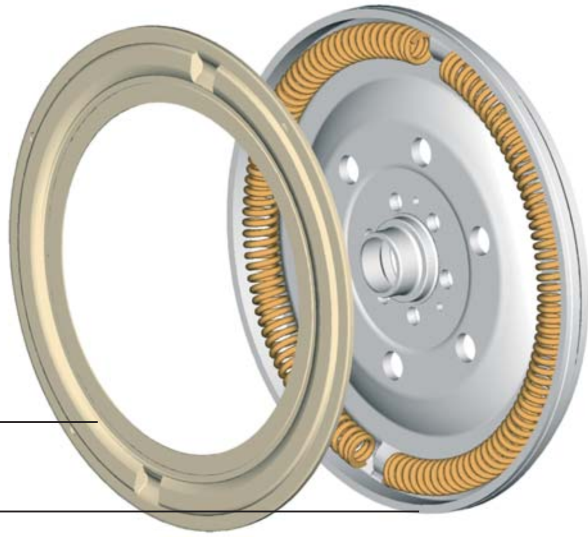


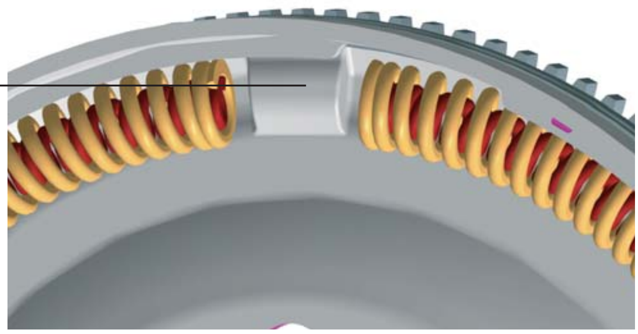
With conventional flywheel: In the design that was previously common, with a conventional flywheel and torsion-damped clutch disc, the torsional vibrations in the idling range are transferred practically unfiltered to the gearbox and cause the gear teeth edges to knock together (gearbox rattle).

With Dual Mass Flywheel: In contrast, the spring/damper system of the DMF filters out torsional vibration caused by the engine. This prevents gearbox components knocking against each other – rattling does not occur and the drivers demands for higher comfort are fully met.

3.1 Primary flywheel

The primary flywheel is connected to the crankshaft of the engine. The inertia of the primary flywheel combines with crankshaft's to form one whole. Compared to a conventional flywheel, the primary mass of the DMF is significantly more flexible, which helps to relieve the crankshaft load. In addition, the primary mass - together with the primary cover - forms the arc spring channel which is typically divided into two sections, separated by the arc spring stops.



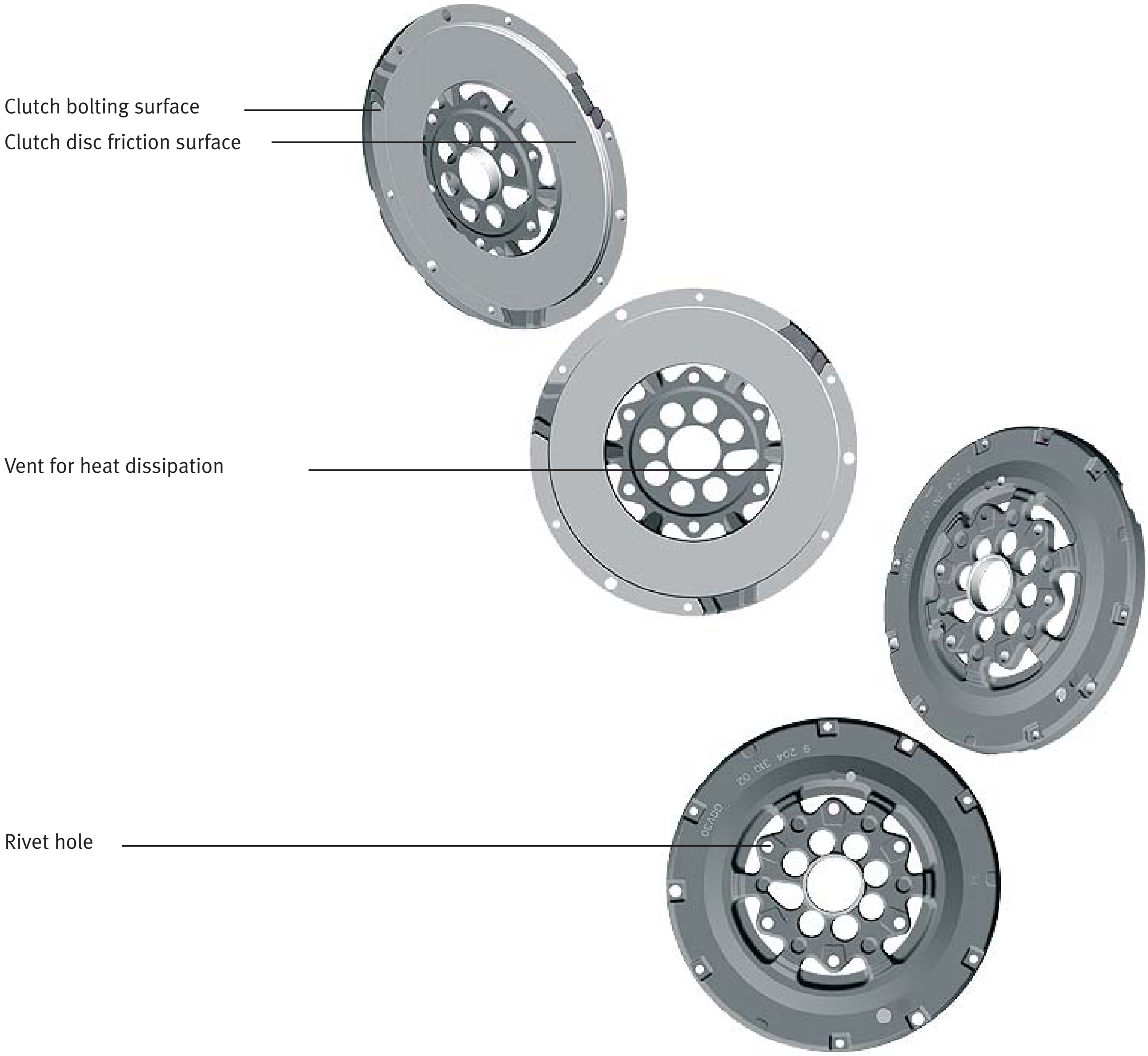


For engine starting, the starter ring gear is positioned on the primary flywheel. Depending on the type of DMF, it is either welded or shrunk on.

3.2 Secondary flywheel

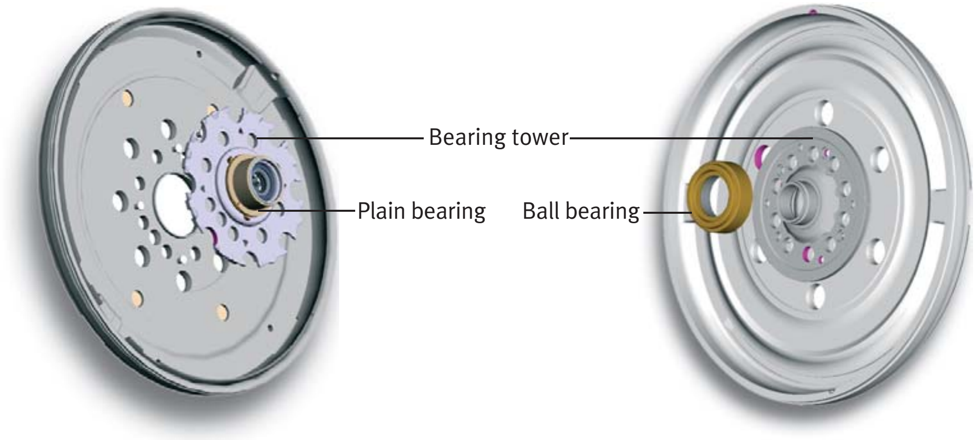
Via the secondary flywheel the DMF connects to the drive train on the gearbox side. Interacting with the clutch, the secondary mass transfers the modulated torque away from the DMF. The clutch cover is bolted to its outer edge.

After the clutch has been engaged, the integral clutch spring mechanism presses the driven plate against the friction surface of the secondary mass. Torque is transferred by means of frictional engagement. The secondary flywheel mass mainly consists of the secondary mass and the flange. Torque is transferred via the wings of the flange sitting between the arc springs (refer to 3.4).



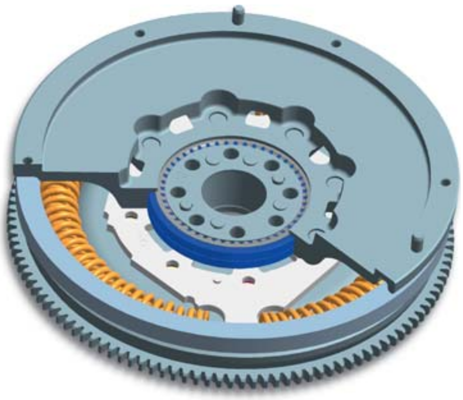
3.3 Bearing

Bearing position
The bearing is positioned in the primary flywheel. The primary and the secondary flywheels are connected via a pivoting bearing. It supports the weight forces applied by the secondary flywheel and the clutch pressure plate. At the same time, it bears the release force applied on the DMF during clutch disengagement. The pivoting bearing allows not only both flywheels to rotate against each other, but also a gentle tilting movement (wobbling).



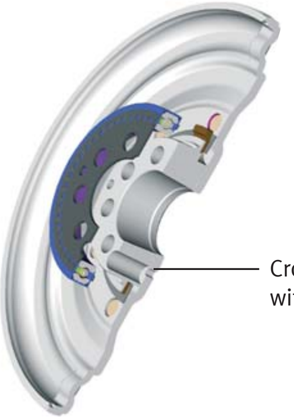
Two different types of bearings can be used on a DMF

From early on, ball bearings have been used and continuous further improvement helped to ensure excellent durability



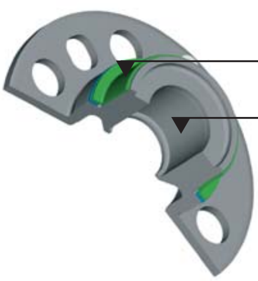
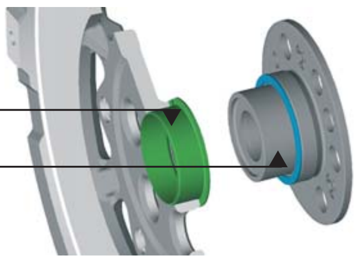
Further technical improvement introduced the small-size ball bearing, then the plain bearing, which is now the common standard for DMF designs.

Large-size ball bearing
The primary flywheel is fitted with a turned hub on which the large-size ball bearing is fitted.



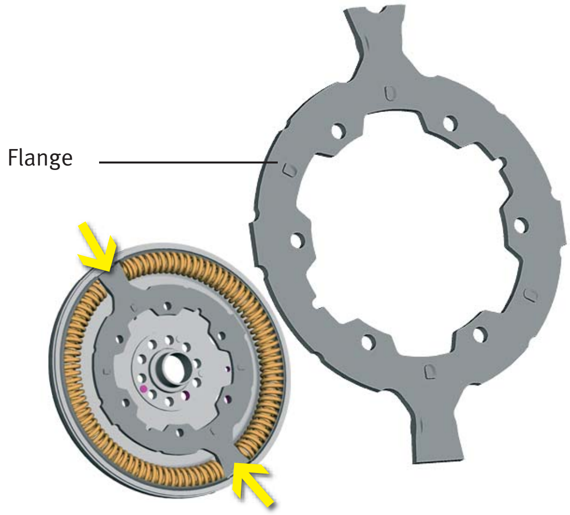
Small-size ball bearing
A hub flange with the bearing seat (turned or drawn) is mounted onto the primary flywheel made of metal sheet. The bearing seat can be adjusted to mount a small ball bearing –as shown here – or a plain bearing

Plain bearing
Further development on the ball bearing has lead to the plain bearing.

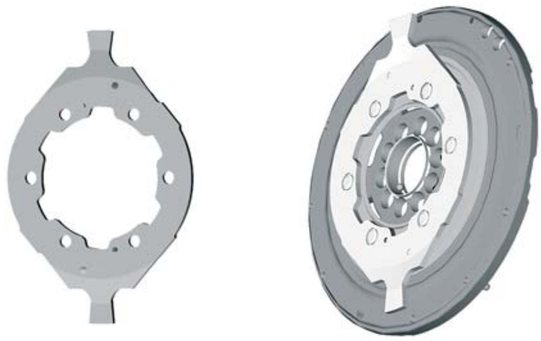
3.4 Flange

The task of the flange is to transfer torque from the primary flywheel via the arc springs to the secondary flywheel; in other words, from the engine to the clutch. The flange is tightly riveted to the secondary flywheel with its wings (arrows) sitting between the arc spring channel of the primary mass. The gap between the arc spring stops in the arc spring channel is big enough to enable the flange to rotate.

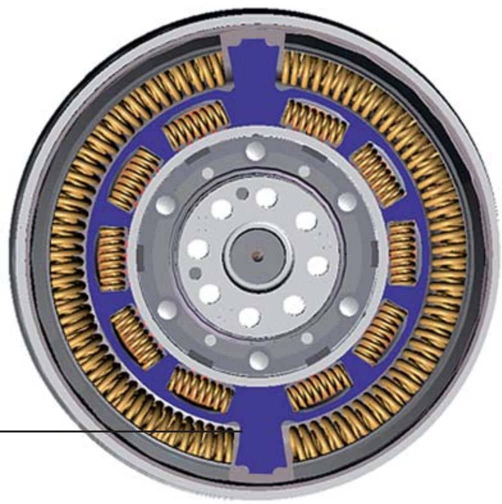


Flange designs

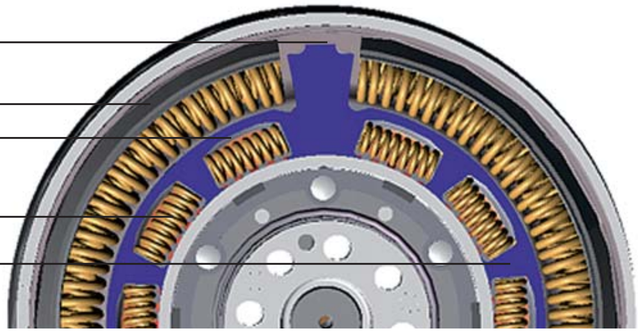
Rigid flange
On the rigid version, the flange is riveted to the secondary fly-wheel. To improve vibration damping, the flange wings are designed with different symmetries. The simplest form is the symmetrical flange, where pull and push sides are identical. Thus, load is applied on the arc springs via both outer and inner areas of the end coil



Flange with internal damper
The key function of the DMF is to isolate the transmission from the vibration generated by the engine. In order to com-pensate for the constantly increasing engine torques while the installation space remains the same, the wind-up curves of the arc springs must rise more steeply. Consequently, their vibration damping capacity deteriorates. Using friction-free internal dampers helped to improve vibration elimination during acceleration. Both the flange and the side panels are designed with spring apertures which house straight pressure springs. The excellent vibration damping characteristics of the DMF with internal damper are guaranteed even in the highest torque ranges.

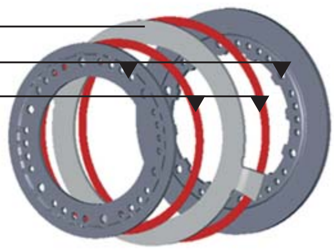


At high engine speeds, the resulting centrifugal forces press the arc springs to the outside against the guides and the coils are disabled. Consequently, the arc spring stiffens and spring action is partly lost. In order to maintain sufficient spring action, straight pressure springs are mounted in the flange. Owing to their lower mass and mounting position on a smaller radius, these springs are subject to a lower centrifugal force. Additionally, the convex shape of the upper edge of the spring windows helps to minimise friction. This ensures that neither friction nor the effective spring rate will increase as engine speeds go up.



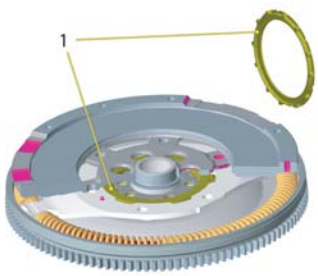
Flange with friction clutch

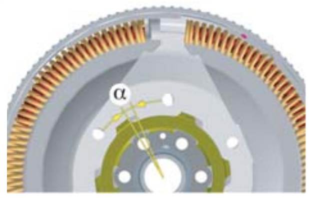
Unlike the rigid flange, this third type of flange is not riveted to the secondary flywheel. The flange is designed as a diaphragm spring. The diaphragm spring is held in position by two retaining panels at the edge. This way, a fork-type fixture is formed as shown in the cross-sectional view. The resulting friction torque between the fixture and the diaphragm spring ensures a reliable transmission of the engine torque. At the same time, the slip clutch prevents the DMF from overheating.



3.5 Friction control disc

In some models of Dual Mass Flywheels, there is an additional friction device – the friction control disc (1). The friction control disc has a clearance angle (α), which means that the additional friction only occurs with larger torsional angles. This provides extra damping during operation, e.g. on starting or change of load.

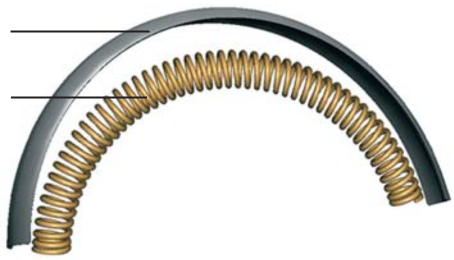




3.6 Arc springs

DMF systems help to improve the noise behaviour of the vehicle by using special torsion damper designs. As a direct result, less noise is generated and fuel consumption reduced.

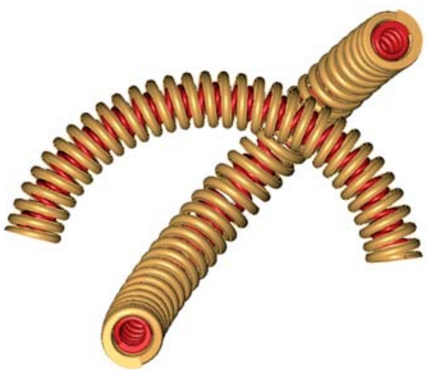
In order to make ideal use of the available space, a coil spring with a large number of coils is fitted in semicircular position. The so called arc spring lies in the spring channel of the DMF and is supported by a guide. Under operation, the coils of the arc spring slide along the guide and generate friction and thereby damping. To prevent the arc springs from wear, the sliding contact areas are lubricated. The optimised shape of the spring guides helps to reduce friction significantly. Besides improved vibration damping, arc springs help to reduce wear.



Benefits of the arc spring:
- high friction at large torsional angles (start) and low friction at small torsional angles (acceleration)
- low spring rate owing to good and flexible use of available space
- impact damping possible (damping spring)

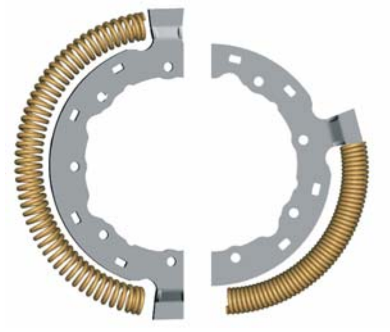
Thanks to the diversity of arc spring designs, a DMF system can be manufactured to precisely match the individual load characteristics of each vehicle type. Arc springs of various designs and characteristics are used. The most frequent types are:

- **Single-stage springs**
- **Two-stage springs**
  in either **parallel arrangement** with different layouts or **in-line arrangement**
- **Damping springs**

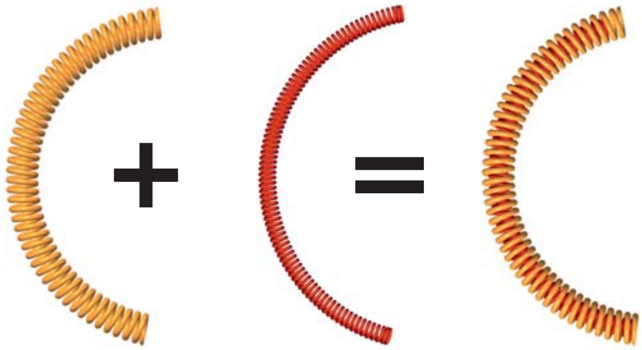


In practice, the spring types are applied in different combinations

Single spring
The simplest form of an arc spring is the standard single spring.

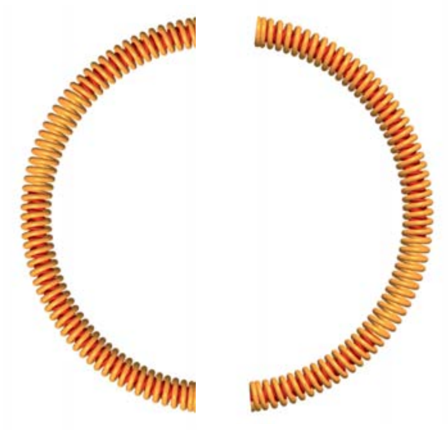


Single-step parallel spring
Today, the single-step parallel spring is the standard arc spring design. It consists of an external and internal spring, both with nearly the same length. Both springs are arranged in parallel. The individual characteristics add up to the spring set curve.



Two-stage parallel spring
Also in two-stage parallel springs, two arc springs are arranged one inside the other. The internal spring, however, is shorter, thus engaged later. The wind-up curve of the external spring is matched to the requirements at engine start. Here, load is applied only on the softer external spring, enabling the system to pass the critical resonance speed range faster. In the higher and maximum torque ranges, load is exerted on the internal spring aswell. Both external and internal springs work together in the second stage. The interplay of both springs provides good damping at all engine speeds.

Three-stage arc spring
This type of arc spring consists of one external spring and two internal springs of different length arranged in-line. This design combines the benefits of the parallel and in-line arrangements and therefore allows for optimum torsion damping at each engine torque.



3.7 DMF special versions

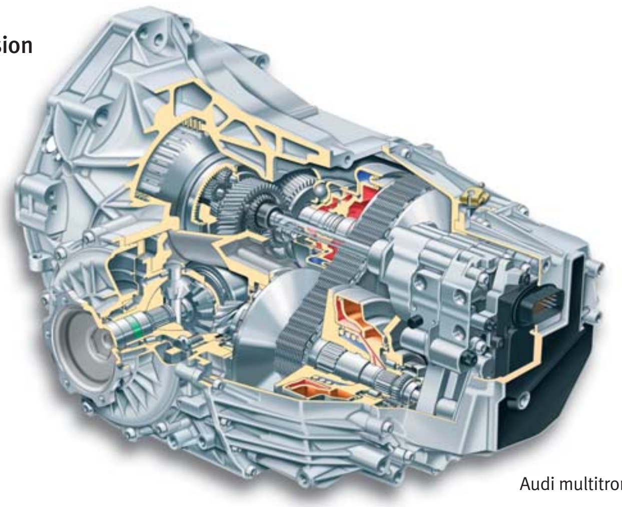
Compact DMF (DFC)
DFC = Damped Flywheel Clutch
This special version of a Dual Mass Flywheel is a pre-assembled modular unit consisting of a DMF, a clutch disc and a clutch pressure plate, which are perfectly synchronized to each other.

Clutch assembly comprising clutch pressure and driven plates

Secondary flywheel with flange

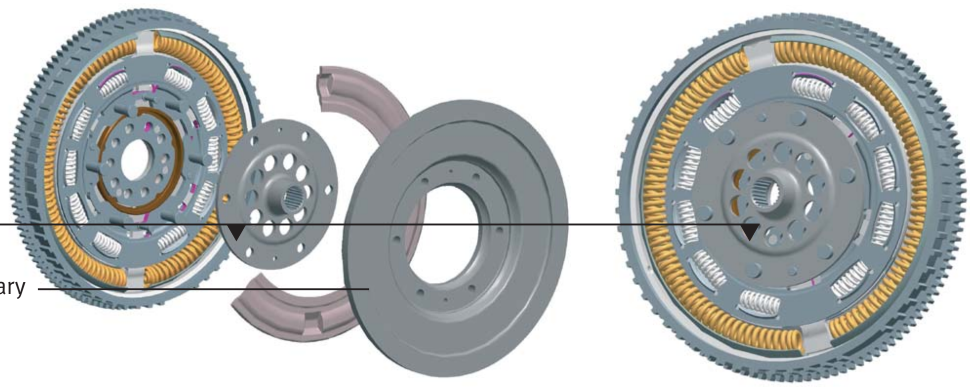
Primary flywheel

DMF for CVT
CVT = Continuously Variable Transmission



Audi multitronic®

This version of a DMF is used for continuously variable transmissions and direct shift gearboxes. Here, power is transferred not via frictional engagement between secondary flywheel and clutch driven plate, but directly from the hub to the gearbox input shaft by means of positive engagement. This allows for a variety of gearbox types to be connected.



4.1 General advice

Always check the DMF when replacing the clutch. A worn and defective DMF can damage the newly installed clutch

Important note!

Many vehicle manufacturers choose to equip new models with a Dual Mass Flywheel – and the trend is growing. The reasons for this are the technical benefits provided by the DMF as well as the need for increasing noise comfort while reducing emissions of state-of-the-art engines. The DMF characteristics are precisely attuned to each vehicle and its engine. The market offers alternative repair solutions to substitute the DMF. These kits typically include:

- a conventional, rigid flywheel,
- a clutch pressure plate,
- a clutch driven plate and
- a release bearing

Caution!

These alternative repair solutions do not comply with the vehicle manufacturer's specifications! The clutch driven plate used on these applications is not able to provide full damping of the torsional vibration generated by the engine due to its lower torsional angle in comparison with a DMF. As a result, noise emissions and vibration induced damage to the power train can occur.

Ask your customer.

In the event of a customer complaint, targeted questions can help to identify the fault.

- Which component is not working, what is the customer's complaint?
- When did this problem first occur?
- When does the problem manifest itself?
  ⇢ From time to time, often, always?
- Under which operating conditions does the problem occur?
  ⇢ e.g. while driving-off, accelerating, shifting up/down, when the vehicle is cold or at operating temperatures?
- Is the engine difficult to start?
- Total and annual mileage of the car?
- Extraordinary load conditions under which the vehicle operates?
  ⇢ e.g. towing a trailer, overloading, Taxi, fleet vehicle, driving school, chip tuned?
- Driving habits?
  ⇢ City traffic, short/long distance driving, Motorway driving?
- Have the clutch and transmission required an earlier repair?
  ⇢ If yes, at what mileage and for which reason?

General vehicle inspection:

- Control unit fault codes (engine, transmission)
- Battery power
- Condition and function of the starter motor
- Tuned engine (chip tuning)?

Important!

- A DMF that has been dropped must not be installed.
  ⇢ Damaged ball or plain bearing, distorted sensor ring, increased imbalance
- Remachining of the friction surface is not permissible!
  ⇢ The weakening of the friction surface results in insufficient burst speed characteristics.
- Do not apply high axial load on the secondary flywheel of a DMF with plain bearing!
  ⇢ This can damage the inner membrane of the DMF.

What should be considered when installing a DMF?

⇢ Observe the specifications of the vehicle manufacturer!

- Check the shaft sealing rings (engine and transmission side) for oil leaks and replace if necessary.
- Check starter ring gear for damage and make sure it is secure.
- Always use new fixing bolts.
- Verify that the distance between the speed sensors and the DMF sensing pins/sensor ring is correct.
  ⇢ Varies depending on the vehicle make.
- Check the dowel pins are fitted correctly
  ⇢ Dowel pins must not be forced into or pushed out of the Dual Mass Flywheel.
  ⇢ Dowel pins forced further into the DMF will score the primary mass (noise).
- Use a cloth dampened with solvent to clean the contact surface of the DMF.

⇢ No solvent must penetrate the interior!

- Make sure you use bolts of the required length.

⇢ Bolts which are too long score the primary flywheel (noise) and can even lock it.
⇢ Bolts which are too long damage the ball bearing or extract it from its seat.

The following is not permissible

- Cleaning in a parts washing machine
- Cleaning with high pressure cleaners, steam cleaners, compressed air or any cleaning sprays

The following is permissible on some vehicle makes and models and has no effect on the operation of the clutch components:

- Small trails of grease on the DMF back side (engine side) leading from the bores towards the flywheel edge.
- The secondary flywheel can be rotated by several centimetres against the primary flywheel and does not automatically return to its original position.
  ⇢ On a DMF with friction control disc a hard knock can be felt and heard.
- Depending on the design, axial play between the primary and secondary masses can be up to 2mm.
  ⇢ On some models with plain bearing axial play can be up to 6mm..
- The secondary flywheel of each DMF has a tilting clearance
  ⇢ Up to 1.6mm for a ball bearing, and up to 3.0mm for a plain bearing.
  ⇢ Primary and secondary flywheel must never knock against each other!

4.2 Noise

When diagnosing a DMF while it is installed, it is always important to determine, whether noise is emitted from adjacent components such as exhaust system, heat shields, engine mountings, accessories etc. Additionally, it is important to isolate any noise caused by front end accessories such as belt tensioning units or A/C compressors. To determine the source of the noise a stethoscope can be used.

Ideally, compare the affected vehicle to a car with identical or similar equipment.

Clicking noise when engaging or shifting gears, and during load changes can originate in the power train caused by excessive gear clearance in the transmission, play in the prop./driveshafts or in the differential. The DMF is not at fault.

When removed, the secondary flywheel can be rotated against the primary flywheel. Here, too, noise can be perceptible caused either by the flange hitting against the arc springs or the secondary flywheel knocking against the friction control disc. Here, too, the DMF is not defective.

There are various causes of humming noise, for example resonance in the power train or imbalance of the DMF exceeding admissible limits. A DMF can be severely imbalanced, if e.g. the balance weights on the back side are missing, or the plain bearing is defective. Whether imbalance is the root cause of humming noise can be determined quite simply. While stationary increase the speed of the engine. If vibration increases as engine speeds go up, the DMF is defective. Here, too, it is helpful to compare the vehicle to another car with an identical or similar engine version.

4.3 Chip Tuning

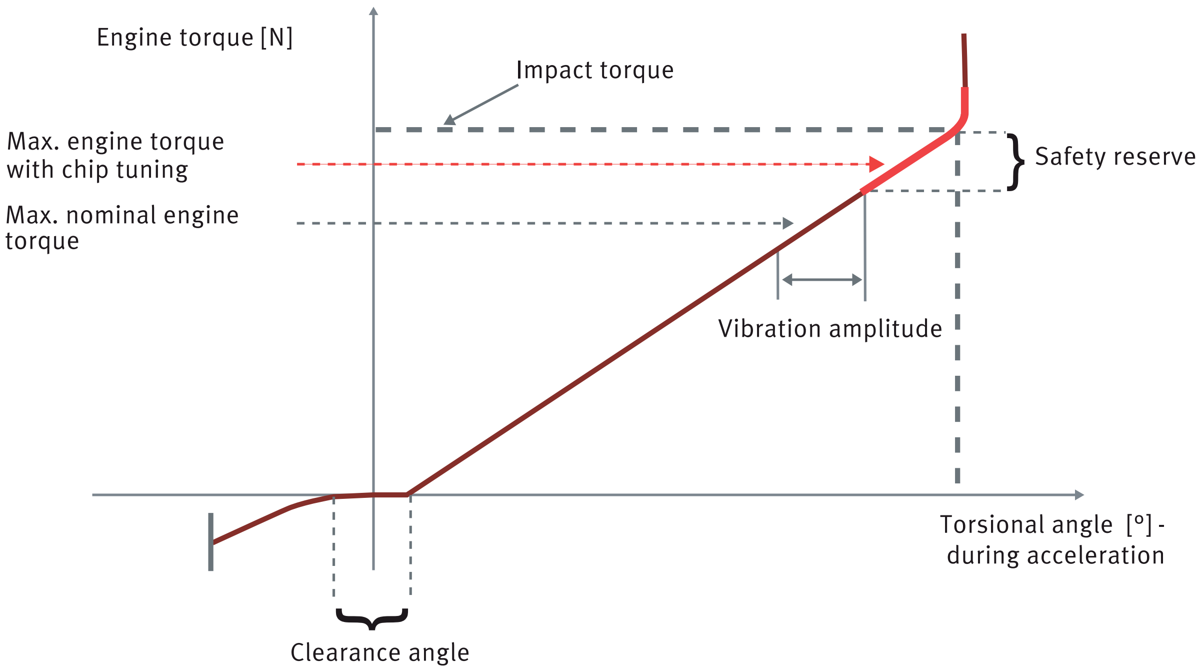
Chip tuning is a quick, easy and rather inexpensive way of increasing engine power output. For a relatively small amount of money you can easily increase the power of an engine by up to 30%. Facts not normally considered are whether the engine is durable enough to withstand the higher outputs, e.g. thermal overloading, and also if the rest of the drive train can withstand the increase in torque/performance.

Usually the torsion damper system of a Dual Mass Flywheel, just like the remaining parts of the drive train, is designed for the respective engine. In many cases the safety reserve of the Dual Mass Flywheel is used up or exceeded by a torque increase by sometimes more than 30%. As a consequence, the arc springs can already be completely compressed during normal driving, which deteriorates noise insulation and can cause the vehicle to jolt. As this is the case at half of the firing frequency, quickly, very high loads are produced and transferred not only to the Dual Mass Flywheel, but also to the transmission, which could result in damage to drive shafts and the differential. Damage stretches from increased wear to a catastrophic failure which results in a huge repair bill.

The operating point of the Dual Mass Flywheel is shifted toward its security reserve by the increase in power of the engine. During driving, the Dual Mass Flywheel is permanently overloaded by the higher engine torques. This causes the damper springs in the Dual Mass Flywheel to operate “fully loaded” more often than they are designed to. The consequence: the Dual Mass Flywheel can be destroyed!

It is true that many tuners give a warranty on the vehicle when increasing power output. But what about when the warranty period is over? The increase in output can damage other components in the drive train slowly but continuously. Sometimes these components will fail at a later time (after expiration of any warranty given!) which means the repair costs have to be paid by the customer

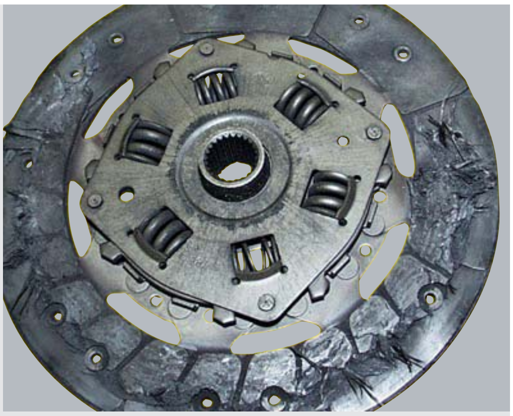
Arc spring curve – during acceleration (example)



Important!
Chip tuning and the resulting performance enhancement lead to the loss of approval to operate the vehicle.

4.4 Visual inspection / damage patterns

Clutch driven plate



Description
Clutch disc burnt

Cause
Thermal overload of the clutch driven plate
⇢ occurring e.g. when the wear limits were exceeded

Effect
Thermal load applied on the DMF

Remedy
Perform a visual inspection for signs of thermal discolouration on the DMF
⇢ For damage assessment refer to:

- Low thermal load » page 24
- Mean thermal load » page 24
- High thermal load » page 24
- Very high thermal load » page 25

In-between primary and secondary flywheel

Description
Burnt residues of abraded clutch facing at the DMF's outer edge or in the ventilations holes.

Cause
Thermal overload of the clutch driven plate

Effect
Residues of the abraded friction material can penetrate into the arc spring channel and cause malfunction

Remedy
Replace DMF

Friction surface

Description
Scoring

Cause
Worn out clutch
⇢ Clutch lining rivets score on friction surface

Effect
Limited power transmission capability
⇢ The clutch is unable to generate the required torque
⇢ Damage to the DMF friction surface

Remedy
Replace DMF

Friction surface

Description
Localised, dark hot spots
⇢ sometimes many

Effect
None

Remedy
No remedial measures required

Friction surface

Description
Cracks

Cause
Thermal overload

Effect
Loss of the DMF’s operational reliability

Remedy
Replace DMF

Ball bearing

Description
- Grease egress
- Bearing seized
- Sealing cap missing or discoloured brown due to overload

Cause
Thermal overload or mechanical damage/overload

Effect
Insufficient bearing lubrication
⇢ DMF fails

Remedy
Replace DMF

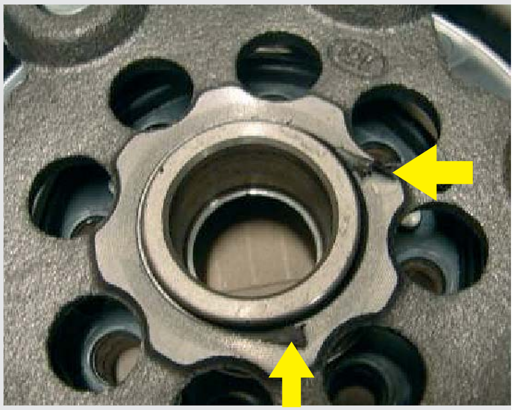
Ball bearing

Description
Damaged or destroyed

Cause
Wear and/or mechanical impact

Effect
DMF is defective

Remedy
Replace DMF



Ball bearing

Description
Worn out
⇢ In relation to the diameter, the maximum radial bearing clearance for a new part is 0.04mm with an admissible increase throughout its service life up to 0.17mm.

Cause
Wear and tear

Effect
- $\leq$ 0.17mm: None
- $>$ 0.17mm: Increased tilting of the secondry flywheel

Remedy
Replace DMF if bearing clearance $>$ 0.17 mm

Low thermal load

Description
Friction surface slightly discoloured (gold/yellow)
⇢ No tarnish at the outer edges of the DMF or in the rivet area.

Cause
Thermal load

Effect
None

Remedy
No remedial measures required

Low thermal load

Description
Friction surface discoloured blue due to temporary thermal load (220 °C)
⇢ No discolouration in the rivet area

Cause
Discolouration of the friction surface is a normal occurrence during operation

Effect
None

Remedy
No remedial measures required

Low thermal load

Description
Tarnish in rivet area and/or at the outer diameter.
No tarnish on the friction surface
⇢ The DMF was in continued operation after high thermal had occurred

Cause
High thermal load (280°C)

Effect
Depending on the duration of the thermal load applied, the DMF is defective.

Remedy
Replace DMF

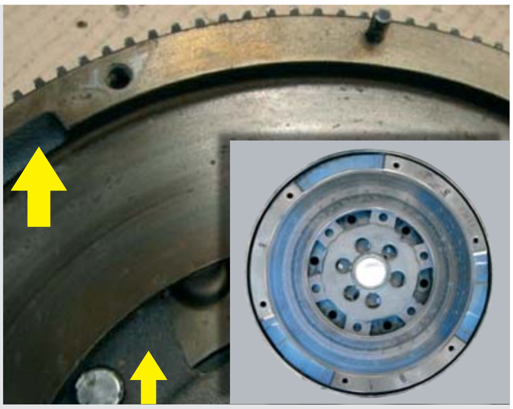
Very high thermal load

Description
DMF discoloured blue/purple at the lateral or back side and/or is visibly damaged, e.g. cracks

Cause
Very high thermal load

Effect
DMF is defective

Remedy
Replace DMF



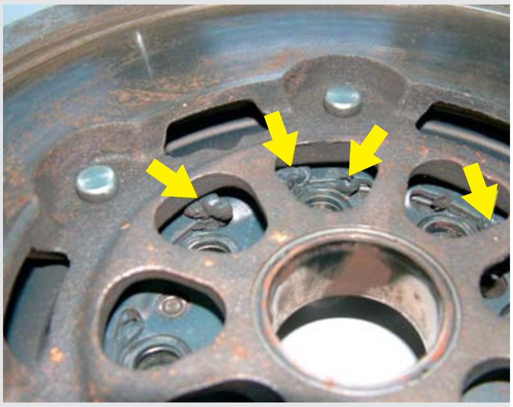
Friction control disc

Description
Friction control disc melted

Cause
High thermal load inside the DMF

Effect
Limited operational reliability of the DMF

Remedy
Replace DMF



Primary flywheel

Description
Secondary flywheel scores the primary flywheel

Cause
Friction ring of the plain bearing worn out

Effect
Noise emission or starter motor operation impaired

Remedy
Replace DMF

Starter ring gear

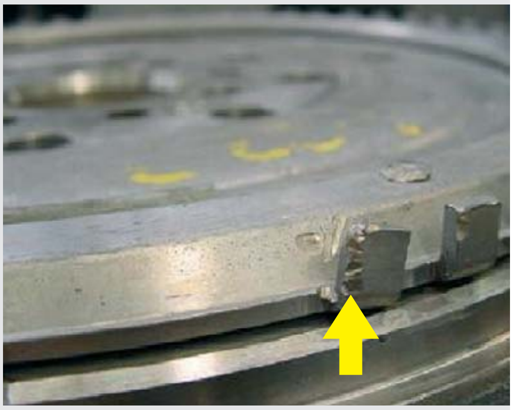
Description
Starter ring gear heavily worn

Cause
Defective starter

Effect
Noise occurring during engine start

Remedy
- Replace DMF
- Perform starter function test

Sensor ring

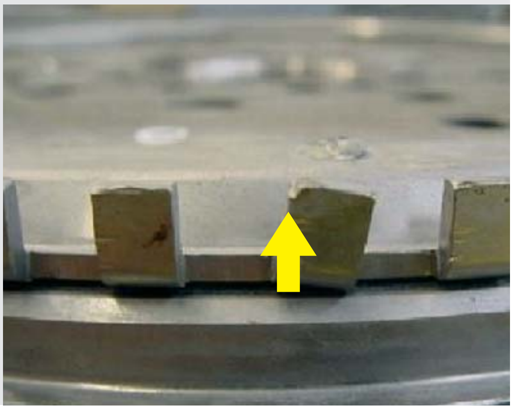


Description
Sensor ring teeth distorted

Cause
Mechanical damage

Effect
Engine runs uneven

Remedy
Replace DMF

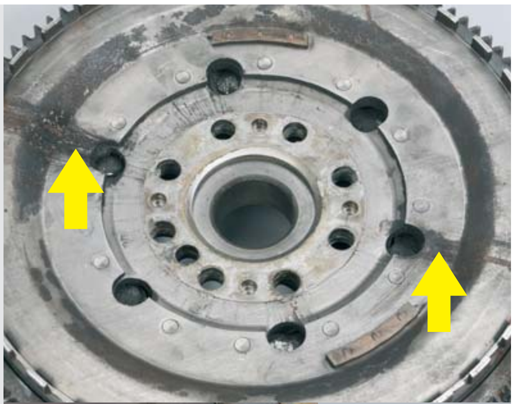


Minor grease egress

Description
Slight trails of grease leaking from the openings or seal caps.

Effect
None

Remedy
No remedial measures required

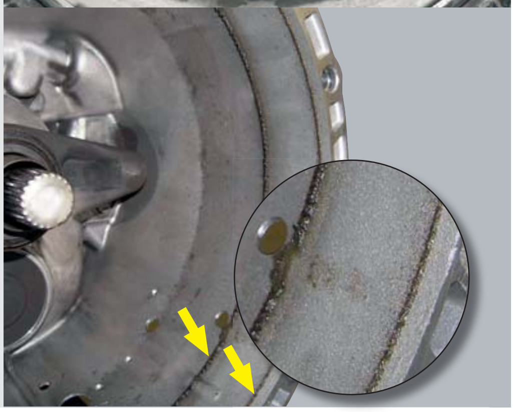


Heavy grease leakage

Description
Grease egress > 20g
⇢ Housing covered with grease

Effect
Incorrect lubrication of the arc springs

Remedy
Replace DMF

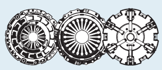
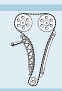
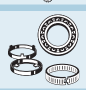
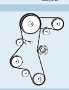
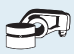
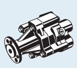
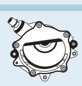
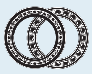


Balance weights

Description
Loose or missing
⇢ Indicated by clearly visible welding spots

Effect
DMF out of balance
⇢ Loud humming

Remedy
Replace DMF

					
	✓	✓	✓	✓	✓
	✓	✓			
	✓	✓	✓	✓	
	✓	✓	✓	✓	
	✓	✓			
	✓	✓	✓	✓	
	✓	✓			
	✓	✓	✓	✓	

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