TPA (The Precision Alliance)
4215 Pleasant Rd.
Fort Mill, SC 29708

803-396-5544 Phone
803-396-7810 Fax
www.tpa-us.com

Proper Application of Miniature Shaft Couplings

Authored by *Masahide Satoh*
Tatsuya Taniguchi

NBK
Nabeya Bi-tech Kaisha

What are couplings?

There are many types of couplings, and even now, those types are broken into many subdivisions. These couplings are mechanical elements that connect two shafts, transmitting torque constantly from the driving shaft to the driven shaft. However, there is no single coupling that can satisfy all the various demands. Thus, to meet these demands, we see many kinds of couplings offered in the marketplace today.

Along with this increase in variety and quality, we see the role of couplings becoming increasingly important as well. Thus designers cannot help but be careful about their selection, especially because making a mistake invites incorrect operation and breakdown. However, with all the various types of couplings being marketed, it takes much effort to choose the most suitable coupling while taking price into account.

Couplings are divided into rigid couplings and flexible couplings. Rigid couplings are used when misalignment is not an issue, e.g., to extend a shaft or to fix a rotating body to a free-end shaft. Flexible couplings are for use with misalignment. Though blueprints show shafts in alignment—and should be designed that way—unanticipated misalignment is a given, whether it be from installation, swing of the shaft itself, or heat deformation during operation. Thus, it is the flexible coupling that usually worries designers.

Flexible Couplings: Selection Checklist

Before selecting a flexible coupling, designers must first get a handle of the following fixed set of data:

1. **Drive power and rotation speed**
    a. Rated torque
    b. Maximum torque
    c. Vibration torque size and vibration frequency
    d. Moment of inertia and mass of driven shafts
2. **Operational information**
    a. Operation cycle (continuous, intermittent, alternating, etc.)
    b. Demanded life expectancy
    c. Maintenance period
3. **Environmental conditions**
    a. Shock and vibration quantity
    b. Temperature and humidity values
    c. Other (oil, salt, dust)
4. **Shaft misalignment**
    a. Parallel misalignment
    b. Angular misalignment
    c. End-play
5. **Allowable operational misalignment**
6. **Other demanded characteristics**

While it is not that every single one of these is necessarily important, we think that the more data designers collect in advance, the more suitable their coupling will be.

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As explained so far, flexible couplings are mechanical elements that allow misalignment and transmit torque. However, there are cases when torque transmission is not necessarily the primary purpose. For example, with miniature couplings used in measuring devices, the purpose is to transmit rotation displacement (angle); torque transmission should be thought of as the result.

Flexible couplings are generally classified by their structure. Understanding the structure of a flexible coupling (i.e., whether it allows misalignment through elasticity or structural slipping) is an important part of knowing its performance. However, designers could know everything and still not move forward, for they must also consider price. Performance and cost are generally inversely proportion.

Designers must examine what usage range a particular flexible coupling is suitable for (i.e. how does the price compare with couplings with different structures), or what usage range is the most economical. For example, let's compare a rubber coupling versus a metal coupling. If the allowable misalignment and torque transmission levels are the same, metal couplings become more advantageous as the torque increases, for rubber is weaker than metal and must distort more to make up for it. But because torque is not the only demand, designers may need vibration and shock-absorbent or high response couplings; a simple comparison is difficult.

This worry is highest in applications with less than one horsepower. In other words, torque transmission is usually the primary purpose in applications over one horsepower. So, to a certain degree, choosing a coupling is based simply on the torque value. However, in applications under one horsepower, torque transmission is often ***not*** the primary purpose. Consequently, using a coupling marketed for transmitting torque would be very expensive. With the comparatively large range of prices in the less-than-one horsepower field, choosing the wrong one could mean using a coupling excessive in quality and price.

Therefore, for applications under one horsepower, NBK offers a series of couplings and bushings called the Couplicon-Mini Series. Within this series are flexible couplings with two different types of structures. They are designed to meet either designer's needs, all while realizing a low price. The following is an introduction of the products in the Couplicon-Mini Series along with our thoughts about design.

Flexible Couplings

MSF Flexible Couplings

The MSF flexible couplings in Photo1has an elastic serrated sleeve, having the same design as our "Sure-flex." The structure consists simply of two internally serrated casings and one sleeve. The casings are a zinc die cast (size MSF-32 uses a sintered alloy casing), and the sleeve is urethane. The specifications are in Table 1. The main characteristics are outlined below.

Photo 1

Superior Flexibility - The reason for the MSF's flexibility is in the sleeve's serrated structure. When there is parallel or angular misalignment, torque-induced friction on the serrated teeth between casings and the sleeve distorts the sleeve and prevents it from slipping. In the same way, the sleeve twists shape and transmits torque while absorbing the vibration.

Torque-limiting Function - The MSF has a torque-limiting function when the torque is great enough to break the device. With typical rubber couplings, even if the rubber does tear under excessive torque, the metal pins or jaws compressing the rubber can make contact and transfer torque. Consequently, either the coupling or the device breaks when overloaded. However, with the two casings of the MSF, there is no interference even if the elastic sleeve breaks, thus interrupting torque transmission.

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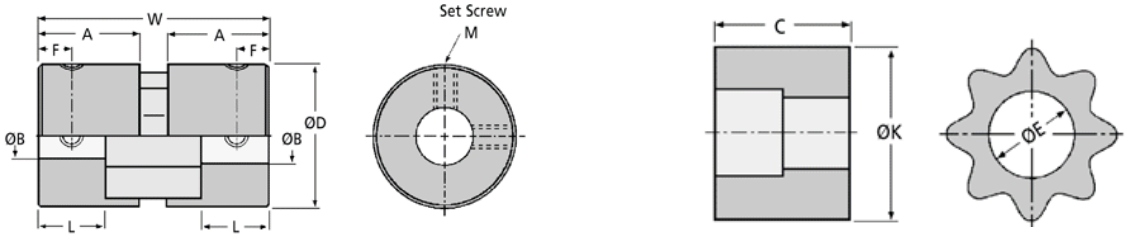
Table 1

Catalog Number	A	B	L	W	M	Sleeve C	Sleeve K	Sleeve D	Rated Torque	Max. Rot. Frequency	Mass	Moment of Inertia	Static Tors. Stiffness	Errors of Ecc.	Errors of Ang.
	(mm)								(N•m)	(mm^{-1})	(g)	($kg•m^2$)	(N•m/rad)	(mm)	(deg)
MSF-16	16	12	8	27	M3	11	14	6/6	0.5	24000	22	9.0×10^{-7}	4.4	0.2	2
MSF-20	20	15	10	34	M3	14	18	8/8	1	19000	42	2.7×10^{-6}	9.5		
MSF-25	25	18	12	41	M4	17	22	10/10	1.5	15000	81	8.1×10^{-6}	20		
MSF-32	32	21	14	48	M4	20	29	12/14	3	12000	150	2.5×10^{-5}	52		



Electrically Insulating - The casings of the MSF connect with the sleeve. These casings are non-conductive and would continue to insulate if the sleeve were to break down under excessive torque. There are four standard outer diameters ranging from Ø16 to Ø32, and the casings have fastening set screw bores in two places. The sleeve can accommodate any bore size, only casings need be exchanged. There are 49 combinations.

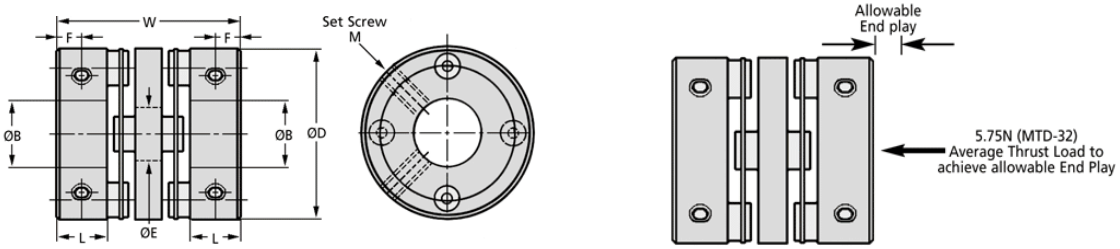
MTD Flexible Couplings

Photo 2

The MTD in Photo 2 is a disc type flexible coupling that derives its elasticity from its metal springs. With two hubs, one spacer, two discs, as well as the pins that connect them, the structure is a complicated one. However, it frees up the users hands with its single-body assembly. The hubs and spacer are high-strength aluminum; the rest is stainless steel. The specifications are in Table 2. Both disks have four pins, two attached to the hub and two attached to the spacer. One disc allows for only angular misalignment. Parallel misalignment is allowed because both disks allow for angular misalignment in opposite directions.

Table 2

Catalog Number	A	L	W	M	Rated Torque	Max. Rot. Frequency	Mass	Moment of Inertia	Static Tors. Stiffness	Errors of Ecc.	Errors of Ang.	End-Play
	(mm)				(N•m)	(mm^{-1})	(g)	($kg•m^2$)	(N•m/rad)	(mm)	(deg)	(mm)
MTD - 20	20	7.5	27	M3	0.5	19000	21	1.2×10^{-6}	600	0.10	1	±0.4
MTD - 25	25		27	M3	1	15000	27	2.6×10^{-6}	1000	0.15	1.5	±0.5
MSF - 32	32		28	M4	1.5	12000	43	6.7×10^{-6}	1700	0.15	2	±0.6



Here is an outline of the MTD's main features.

Zero Backlash - There is no backlash with the single-body construction. Therefore, there is almost no change in quality when starting, stopping, or alternating rotation.

High Torsional Stiffness and Response - Torque is transferred from hub to disc to spacer to disc to hub. Regardless of the material, the MTD has the same level of stiffness as the shaft itself, so long as the misalignment is small. Because the twisting angle when torque is transmitted is so very small, it can be thought of as a flexible shaft. Also, the hubs and spacer are lightweight aluminum, making the moment of inertia is small. Even with a sudden increase/decrease in revolutions, the MTD nimbly transmits the rotation change and torque.

Maintenance-free - The MTD has superior water and chemical resistance. With its zero-backlash structure there are no rubbing components, making it maintenance-free. If it is used with small misalignments, it's lifetime is extremely long. Three outer diameters with a total of 35 bore combinations are standard.

With the MSF and MTD outlined above, the difference in performance is from the difference in construction. The MSF has low torsional stiffness, but absorbs vibration and shock; the MTD has torsional stiffness as high as the shaft, but does not absorb vibration and shock for the most part. The former is for devices in which torque transmission is the primary purpose, like small fan pumps. The latter is suitable for devices in which exact rotation angle transmission is the primary purpose, like measuring and control devices. Most any application will be satisfied by one of these two couplings.

Rigid Couplings

Rigid Coupling Usage - Now in applications under one horsepower, there are a surprising number of cases in which rigid couplings are used in place of flexible couplings. The reason can be thought of as follows. As the device gets smaller, so does the misalignment. While misalignment is never perfectly zero, it is often possible to use a rigid coupling. Even if there is a parallel or angular misalignment-induced reaction force, it is small enough to be accommodated by the flexibility of the entire device. Also, with the actual construction, there are many cases in which the rigid coupling fixes the surrounding after being installed. Another reason is that rigid couplings are less expensive. The rigid couplings from the Couplicon-Mini Series are introduced below.

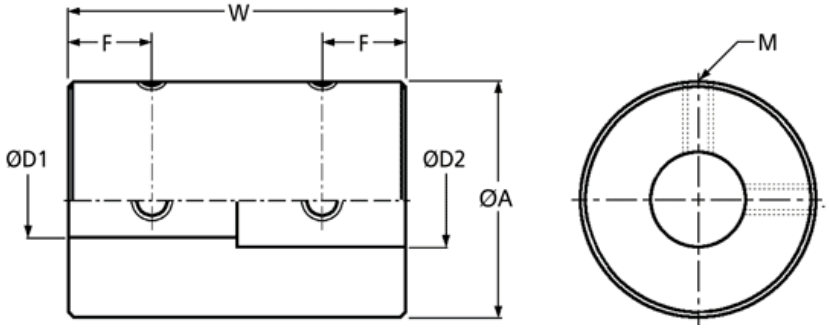
MRG Rigid Coupling

It has an economically simple cylindrical structure made of lightweight aluminum. The coupling can be attached to different shaft sizes, every bore size is standardized. There are 30 different combinations. The specifications are shown in Table 3.

Photo 3

Table 3

Catalog Number	A	W	M	Max. Rot. Frequency	Mass	Moment Of Inertia
	(mm)			(rpm)	(g)	($kg \cdot m^{2)}$
MRG – 16	16	24	M3	24000	11	4.4×10^{-7}
MRG – 20	20	30	M3	19000	20	1.3×10^{-6}
MRG – 25	25	36	M4	15000	39	3.9×10^{-6}
MRG – 32	32	41	M4	12000	71	1.2×10^{-5}



The MRG is often connected to the shaft by setting screws. However, the screw tips dig into and mar the shaft, often so much that the coupling is difficult to remove even after loosening the screws. To avoid marring the shaft, there are clamping and bushing methods, for small and large torque loads. At NBK, the bushing system within the Couplicon-Mini Series is standardized too. The following is a brief introduction.

Conclusion

Previously, JIS (Jaw-In-Shear) type coupling have been the most widely used for connect shafts. However, with the increasing variety of designers' demands, the types of couplings outside the JIS line have increased and tend to become more specialized. When designers choose couplings, they should understand what characteristics are necessary. Then they should decide on a coupling that has the necessary characteristics, while considering the price. If the price is too high, changing the device specifications must be considered. Finally, the most important thing is to assemble the device with as little misalignment as possible. Couplings allow for some misalignment, but no manufacturer recommends it. It is not too much to say that the life of a coupling depends on the amount of misalignment. By increasing the precision of assembly, maintenance costs are reduced significantly.

Above, we have explained about couplings while focusing on the Couplicon-Mini Series for applications under one horsepower. We would like to address applications over one horsepower in the future.