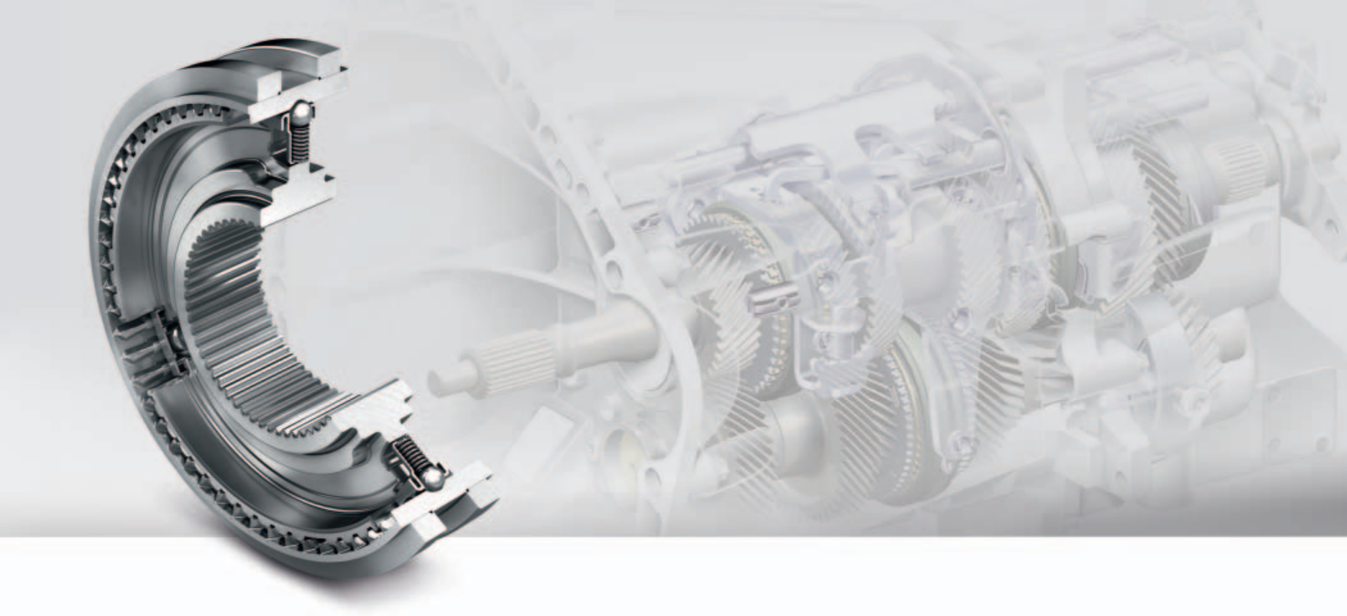

Selector Hub Assemblies

SCHAEFFLER

Foreword

As a development partner to the automotive industry, Schaeffler Group Automotive develops and manufactures components and systems that take account of requirements for increased performance density and the reduction of factors such as mounting work and overall costs.

Higher performance engines, increased torque loads on transmissions and the demand for reduced design envelope are just a few of the defining conditions.

Selector hub assemblies from Schaeffler are compact, ready-to-fit units for synchronization, comprising a selector hub, selector sleeve and detent struts. They facilitate gearshift in manual and dual clutch transmissions and transmit the torque from the transmission shaft to the engaged gear. The Schaeffler product range of synchronization components offers a large number of variants and facilitates flexible possibilities for solutions, even in the case of new requirements.

This TPI contains, in addition to a description of the product characteristics of selector hub assemblies, a presentation of the development tools used for design, simulation and testing.
A checklist is provided in order to support you as a customer in compiling the technical data that are required in order to process your enquiry in an effective manner. First, the chapter Synchronization explains the underlying principles and presents the necessary components.

Further information

Comprehensive description of the detent struts fitted in selector hub assemblies:

- TPI 178, Detent Struts ARRES – Synchronization of manual transmissions.

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Synchronization

Synchronization systems
Components
Single cone synchronizers
Multiple cone synchronizers

Synchronization

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Synchronization systems

Synchronization is derived from the Greek **syn** (together) and **chronos** (time) and is defined as “ensuring the occurrence in unison of two events or processes”.

Function

Synchronization systems in manual transmissions match the different speeds of the gear wheel to be engaged and the transmission shaft to each other.

Following synchronization, a form fit connection is created between the gear wheel and transmission shaft by engaging the clutch. In order to ensure that synchronization occurs before clutching, a finely tuned blocking function is necessary.

Requirements

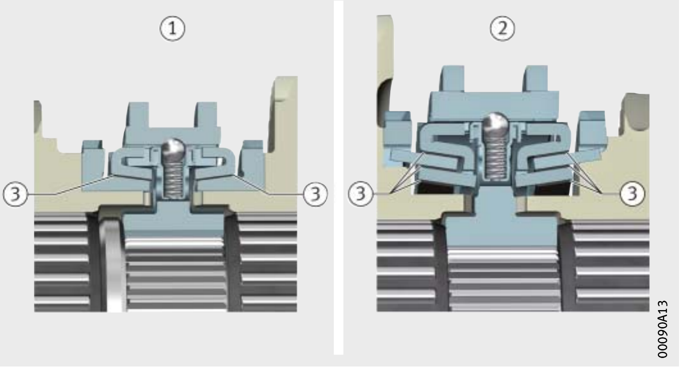
The continuing increase in the performance capacity of engines and clutches is leading to significant increases in transmission torques and mass moments of inertia. This places ever-increasing demands on automotive manual transmissions and their components. As a result, it is generally no longer sufficient to optimize individual transmission components purely at the component level. What is required instead is solutions that are comprehensively oriented to the overall concept of the vehicle.

For synchronization of a manual transmission, there is thus a need for products with characteristics such as compact design, optimized mass and smooth running with the highest functional reliability. In addition, gearshift force should be minimized and gearshift comfort improved.

Systems

The state of the art in mechanical automotive manual transmissions comprizes synchronization systems based on a cone friction clutch, in the form of a blocking synchromesh.

The distinction in blocking synchromeshes is between single cone synchronizers and multiple cone synchronizers, *Figure 1*.



① Single cone synchronizer
② Multiple cone synchronizer
③ Friction surfaces

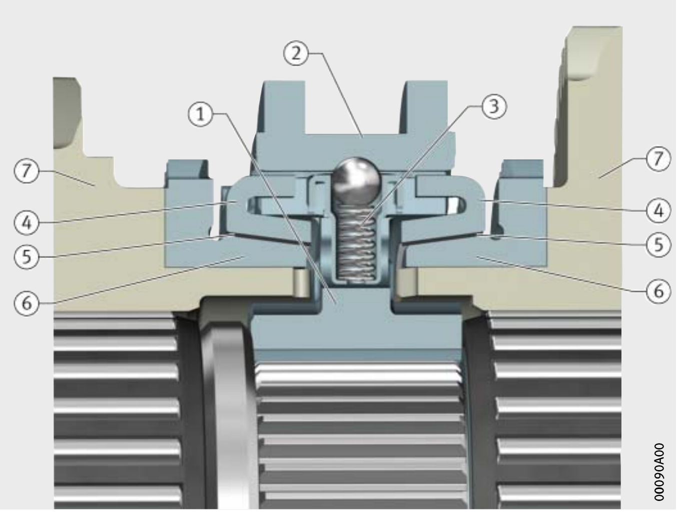
Figure 1
Single cone and multiple cone synchronizers

Structure of a synchronization system

A synchronization system comprizes the following components:

- 1 selector hub
- 1 selector sleeve
- 3 or more detent struts for presynchronization
- 2 or more synchro rings, with friction linings
- 2 gear cone bodies
- 2 gear wheels.

The structure of a synchronization system can be shown using the example of a single cone synchronizer, *Figure 1*.



① Selector hub
② Selector sleeve
③ Detent strut
④ Synchro outer ring
⑤ Friction lining
⑥ Gear cone body
⑦ Gear wheel

Figure 1
Single cone synchronizer

Selector hub

The selector hub has a form fit connection with the transmission shaft. Its external teeth guide the selector sleeve. When engaged, the external teeth transmit torque between the selector hub and the selector sleeve.

The outside diameter of the selector hub has recesses which carry the detent struts for presynchronization. It gives form fit indexing of the detent struts and synchro outer rings.
As a result, these components are brought into their direction of rotation by the selector hub. Depending on the design, synchro inner rings in multiple cone synchronizers system are also indexed.

Components

Selector sleeve

The selector sleeve transmits the axial gearshift force to the detent struts and synchro rings. This facilitates the blocking function. In the presynchronization process, force/travel definition is carried out using three presynchronization slots distributed around the circumference of the inside diameter. The slots form the mating surface for the detent struts.

When the gear is engaged, the selector sleeve transmits the torque from the selector hub via the gear cone body to the gear wheel.

The circumferential slot on the outside diameter of the selector sleeve forms the contact for the gearshift fork. The gearshift fork displaces the selector sleeve axially during gearshift.

Detent struts

For presynchronization, axially movable detent struts are generally used. The detent struts are arranged on the circumference of the selector hub and are preloaded against a slot in the selector sleeve teeth by means of springs.

Detent struts exist in both multi-piece and single-piece designs. The multi-piece design is being increasingly replaced by the single-piece design.

These multi-piece detent struts comprize at least two individual parts. During mounting, the detent elements must in this case be fitted under spring tension. This mounting work is not required when using the detent struts ARRES developed by Schaeffler, see page 17.

Synchro rings

Synchro rings from Schaeffler are manufactured, without the generation of swarf, from thin-walled, through-hardenable steel strip. The outside diameter of synchro outer rings incorporates the blocking teeth with the roof angles aligned to the selector sleeve.

In order to achieve problem-free synchronization, the friction cones must have both a low adhesive friction coefficient and a sufficiently high sliding friction coefficient. This is achieved by means of friction linings on the cone surfaces of the synchro rings. For the requirements stated, Schaeffler specially developed the friction linings STC300 and STC600, *Figure 2*.

Synchro outer rings are used in the single cone synchronizer. For multiple cone synchronization systems, Schaeffler offers not only synchro outer rings but also synchro intermediate rings and synchro inner rings. The synchro rings are manufactured at Schaeffler by forming technology without the generation of swarf.

Friction linings:
① STC300
② STC600

Figure 2
Synchro rings with friction linings

Further information

- API 06, Intermediate Rings for Multiple Cone Synchronization.

Gear cone body

The gear cone body is welded to the gear wheel or rigidly linked through a combination of form fit and press fit. It has an outer cone and clutching teeth with roof angles aligned to the synchro ring.

Gear wheel

The gear wheel is rotatably supported on the transmission shaft. The external teeth transmit the torques introduced via the selector sleeve and gear cone body.

Single cone synchronizers

Design

The single cone synchronizer is generally designed as a conventional blocking synchromesh as found in the Borg-Warner or ZF-B system, *Figure 1*.

For presynchronization, detent struts preloaded by means of springs are used. Synchronization is carried out by a cone friction clutch with a single cone between the gear cone body and synchro ring. This supports the entire frictional power.

Figure 1
Conventional blocking synchromesh in accordance with the Borg-Warner or ZF-B system

Function

The synchronization and gearshift process comprizes the following phases:

Presynchronization

When the selector sleeve is displaced, this moves the detent struts and exerts an axial force on the synchro ring. The selector sleeve and synchro ring are then aligned to each other.

Synchronization

Due to the interaction at the roof teeth of the synchro ring and the selector sleeve, frictional torque is built up at the cones and the speeds are matched.

Disengaging

Once the speeds are matched, the teeth can be rotated (disengaged) in order to facilitate throughshifting of the selector sleeve.

Free flight

Free flight describes the phase between disengaging and meshing with the gear cone body.

Meshing

The teeth on the selector sleeve are meshed in the clutch teeth of the gear cone body.

Engaged

After meshing, the frictional torque is transmitted via the teeth on the selector sleeve to the gear cone body. As a result, the transmission shaft is linked via the selector hub, selector sleeve and gear cone body to the gear wheel.

Multiple cone synchronizers

Design and function

A multiple cone synchronizer is essentially of the same design as a single cone synchronizer. However, the single cone sychronizer has only one syncho ring, while the multiple cone synchronizer has several synchro rings, *Figure 1*. This increases the number of friction cones and friction surfaces.

As a result, the multiple cone synchronizer has a higher frictional torque under the same gearshift force, leading to shorter gearshift times.

In addition, the friction surface is larger, which results in smaller specific frictional energy and frictional power. The thermal load on the friction linings is therefore lower.

① Synchro outer ring
② Synchro intermediate ring
③ Synchro inner ring

Figure 1
Multiple cone synchronizer

Areas of application

Multiple cone synchronization systems are used in preference for the lower gears, for example the 1st/2nd gear pair. Due to the wide speed differentials, very high synchronization performance is required in these cases and the gearshift forces are correspondingly higher.

Selector hub assemblies

Selector hub assemblies

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Selector hub assemblies

Features

Selector hub assemblies are used in single cone and multiple cone synchronizers. They facilitate gearshift in manual and dual clutch transmissions and transmit the torque from the transmission shaft to the engaged gear.

Requirements

The requirements placed on modern manual transmissions include not only the transmission of large frictional torques and a long rating life but also reductions in design envelope and mass. As a result, component strength plays a decisive role in design work.

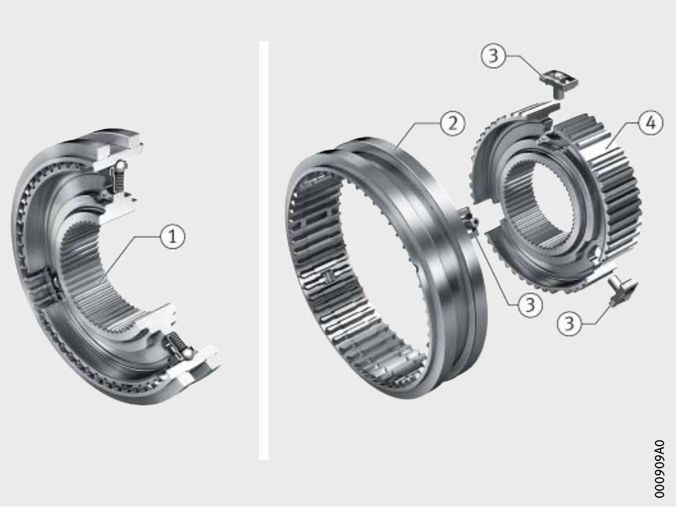
Further important requirements arise from the demands for increased gearshift comfort. Lower gearshift forces and reduced gearshift times are required.

Compact unit

A selector hub assembly comprizes the selector hub, the detent struts ARRES and the selector sleeve, *Figure 1*.

The advantages of the selector hub assembly compared to the supply of individual components include:

- simplified mounting on the transmission shaft
- reduced number of individual parts, giving simpler handling in the manufacturing process
- favorable tolerance chain due to the supply of all components from the same manufacturer
- functionally verified, independent unit.



① Selector hub assembly

Components:
② Selector sleeve
③ Detent struts ARRES
④ Selector hub

Figure 1
Selector hub assembly from Schaeffler

Torque flow

The selector hub is rigidly linked to the transmission shaft and transmits the torque from the transmission shaft to the selector sleeve, *Figure 2*. In the engaged condition, the frictional torque is transmitted from the selector sleeve onward to the gear wheel.

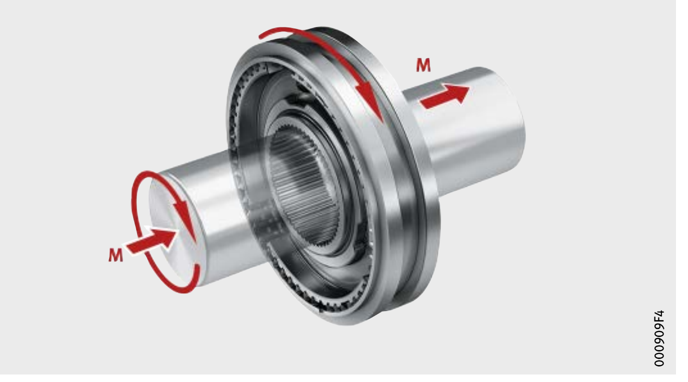


Figure 2
Torque flow through a selector hub assembly

Components

The design and manufacture of the components of a Schaeffler selector hub assembly are matched to the tasks of achieving reliable function and fulfiling all requirements.

Selector hub

Selector hubs are geometrically demanding components that are subject to high loads. For their production, various manufacturing technologies are used in industry:

- powder metallurgy processes
- heavy-section forming followed by machining with the generation of swarf
- sheet metal forming.

The sheet metal forming process used by Schaeffler is a highly economical alternative to heavy-section forming. The component strength values achieved are higher than those achieved in production using powder metallurgy.

Depending on the application and on customer requirements, Schaeffler can also supply selector hub assemblies with selector hubs produced by powder metallurgy or heavy-section forming.

Selector hub assemblies

Selector sleeve

The selector sleeve is subjected to high loads. This is produced by most manufacturers using machining with the generation of swarf. A special feature of selector sleeves from Schaeffler is their manufacture by forming technology, without the generation of swarf.

The advantages of selector sleeve manufacture at Schaeffler include:

- 100% inspection of functionally relevant features
- wide range of designs and variants
- efficient material utilization
- high surface quality
- high reproducibility in the case of off-tool dimensions
- technological concept for high volumes
- continuous grain orientation in areas subjected to stresses.

A selection of variants of selector sleeves is shown in *Figure 3*.

Figure 3
Variants of selector sleeves

Detent struts ARRES

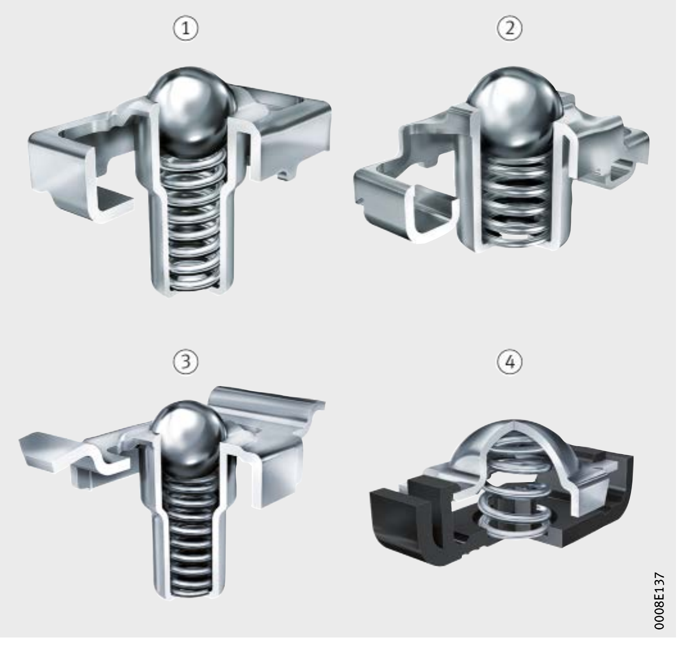
Presynchronization in selector hub assemblies from Schaeffler is carried out by so-called detent struts ARRES.

Detent struts ARRES are specially designed for the specific application. Parameters such as spring force and sliding surface have a decisive influence on the gearshift function as well as gearshift comfort and are therefore matched to each transmission.

The advantages of detent struts ARRES include:

- easier mounting due to single piece design
- a single supplier for the complete component
- assured quality due to 100% process monitoring
- no holes required in the selector hub
- low wear of the guidance surfaces due to optimized surfaces and materials.

Detent struts ARRES are available in various designs, *Figure 4*.



① Standard
② Stepped
③ With wings
④ Flat design

Figure 4
Detent struts ARRES

Further information

- TPI 178, Detent Struts ARRES – Presynchronization of manual transmissions.

Design of the selector sleeve

The design of the selector sleeve is characterized by numerous design details, *Figure 5* and *Figure 6*, page 19.

Design features of each selector sleeve

The following design features are a part of each selector sleeve:

Roof angle

The roof angle is matched to the teeth of the synchro outer ring. It can be designed as symmetrical, asymmetrical and with different angles.

Recess

The recess prevents, for example, the clutching teeth on the selector sleeve separating from the gear cone body in the engaged condition.

Presynchronization slot

The detent struts engage in the presynchronization slot of the selector sleeve. The ramp profiles on both sides ensure that, when the selector sleeve is displaced, the detent struts are moved as well, are pressed axially against the synchro outer ring and thus activate presynchronization.

The profile of the presynchronization slot also influences gearshift comfort.

Gearshift fork slot and thrust washers

The gearshift fork locates in the gearshift fork slot. It presses against the thrust washers and thus displaces the selector sleeve in an axial direction during gearshift.

Clinch/butt joint

Selector sleeves from Schaeffler have, depending on their design, a clinch or a butt joint. This feature can be attributed to the manufacturing process. The resulting gap in the teeth can be used as an aid for mounting the selector sleeve in the correct position.

Additional design features

Depending on the requirements of the customer, other design features can additionally be integrated:

Reduced tooth height

In order to improve the strength of the selector hub, it may be necessary to radially increase the critical cross-section in the area of the pockets for the detent struts. The necessary space is created by reducing the height of the teeth on the selector sleeve.

Guidance gaps

Guidance gaps give optimized guidance of the synchro rings during gearshift.

Different tooth lengths

The relevance of wear or comfort as requirements may necessitate different tooth lengths within a selector sleeve. A distinction is made between synchronization teeth and clutching teeth.

Tooth roof pitch angle

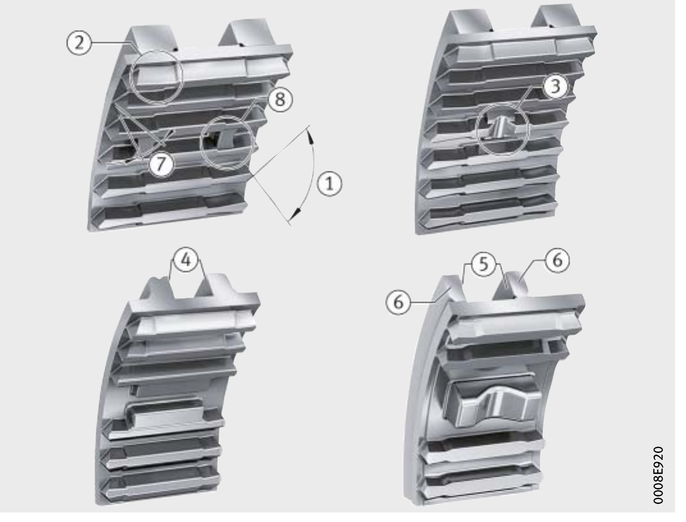
The tooth roof pitch angle describes the pitch of the roof apex, ensures easier meshing of the clutching teeth and thus assists in achieving gearshift comfort.

End position locks

End position locks restrict the travel of detent struts in the engaged condition and prevent their dislocation.

End stop

The end stop restricts the axial travel distance of the selector sleeve.



① Roof angle
② Recess
③ Presynchronization slot
④ Gearshift fork slot, symmetrical to base component
⑤ Gearshift fork slot, asymmetrical to base component
⑥ Thrust washers
⑦ Tooth roof pitch angle
⑧ End stop

Figure 5
Design features of selector sleeves

① Clinch
② Butt joint

Figure 6
Selector sleeves with clinch and butt joint

Design and calculation software

In the development of selector hub assemblies, Schaeffler uses state of the art design and calculation software.

The programs used facilitate:

- comprehensive 3D modeling
- analysis and matching of the tolerance chain
- design of the synchronizer in the context of the transmission system
- optimization of component strength.

Design software

Selector hub assemblies are modeled in a 3D CAD system, *Figure 7*. The geometrical data can therefore be compared at any time with the adjacent construction.

In addition to studies of design envelope, tolerance analyses are also carried out in 3D.

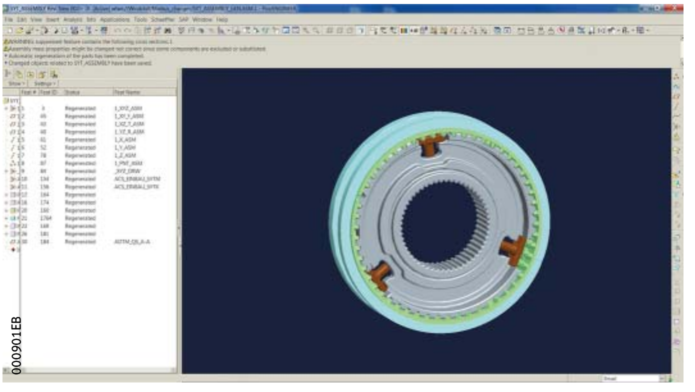


Figure 7
Design software

3D tolerance analysis

The 3D tolerance analysis investigates how the tolerances of the individual components of a synchronization system affect the complete system. The objective is optimum matching of the tolerance chain in relation to the function of the complete system.

In the different synchronization stages (neutral, presynchronization, main synchronization, engaged), measurements relevant to the specific function are carried out.

The software determines the tolerance chain and analyzes the influence of tolerances on a defined closed component (measurement). The results given by the analysis are the arithmetic extreme values (worst case), the standard deviation of the tolerance chain, the sensitivity of the dimensions examined and the influence of the dimensions examined on the total deviation. On the basis of the results, the arithmetic and statistical deviations are determined and compiled in a results list.

In the example, a complete synchronization system was investigated in relation to the effects of individual part tolerances on the complete system, *Figure 8*.

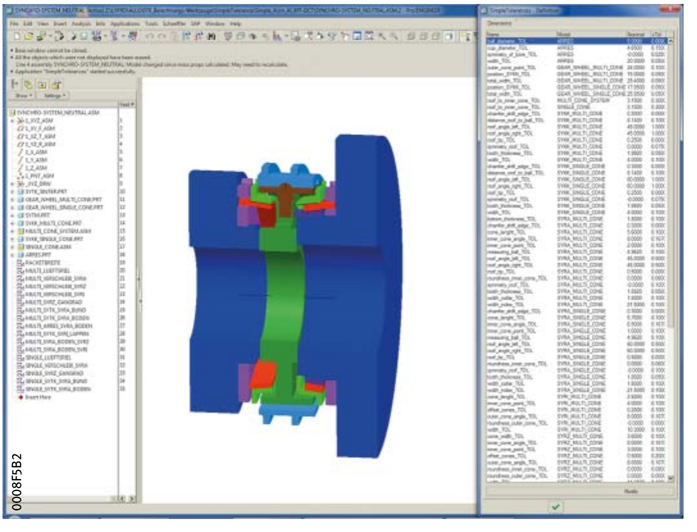


Figure 8
Tolerance analysis

Design using BEARINX

With the development of BEARINX, Schaeffler has created one of the leading programs for the calculation of rolling bearings in shaft systems and of linear guidance systems. The program facilitates the detailed analysis of rolling bearings in a shaft system. The entire calculation is carried out in a comprehensive calculation model, on all levels starting from the complete system down to the individual rolling contact.

A special additional module in BEARINX facilitates the design of synchronizers for manual transmissions, *Figure 9*.

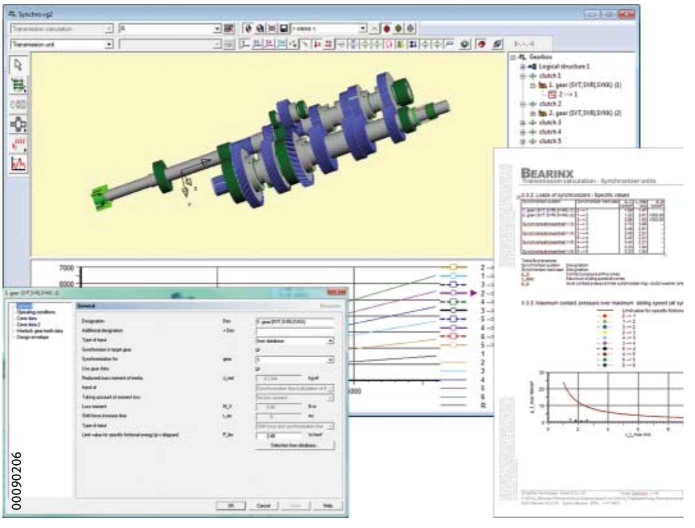


Figure 9
BEARINX

Input data

The input data for the design of a synchronizer in BEARINX are:

- transmission structure and power flow
- mass moments of inertia
- design envelope
- slippage time
- gearshift force
- increase in gearshift force
- torque losses.

Results

The results in the design of a synchronizer in BEARINX are:

- speed differentials
- geometry of the blocking teeth
- geometry of the synchro rings
- selection of the friction system.

Variant calculation

Due to its automated variant calculation function, the program is an important tool in system design.

FEM calculation software

The mechanical stresses on the components of a selector hub assembly or a gear set are calculated, starting from three-dimensional modeling, through the use of the Finite Element method, *Figure 10* and *Figure 11*.

This makes it possible, as early as the development stage, to ensure that selector hub assemblies fulfill the customer requirements for component strength and torque transmission.

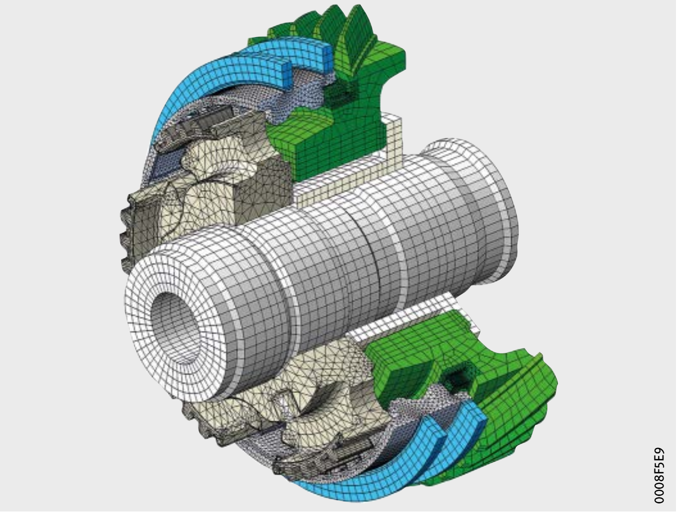
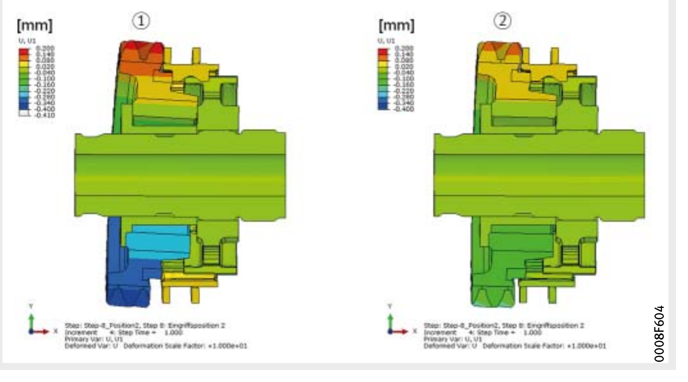


Figure 10
FEM calculation:
networked assembly



① Initial design
② Optimized design

Figure 11
FEM calculation:
stress distribution (dynamic)

Interactive gearshift simulator

The interactive gearshift simulator makes it possible to predict and display the effects of geometrical changes to components of the synchronizer or the gearshift unit on the gearshift sensation.

The simulation is based on a design program that is integrated in the development software and calculates the gearshift forces. The gearshift forces calculated in this way are then transmitted to the simulator gearstick in such a way that they can be experienced as a gearshift feel, *Figure 12*.

Through the simulation of design changes and the comparison of variants, the number of iteration loops in the development process can be reduced.

Figure 12
Interactive gearshift simulator

Test methods for product development

Versatile test devices are available for the development of selector hub assemblies. The test methods described below and the associated test rigs are important examples taken from the extensive testing portfolio.

In addition to values such as fatigue strength and operating life that are clearly defined and quantifiable, other characteristics such as gearshift comfort can also be investigated.

Operating life and functional testing in the transmission

In long term tests, function over the entire operating life of the transmission is studied. The test rigs can also be used, however, for pure functional measurements. For example, gearshift forces can be determined by the use of a gearshift robot.

The advantage of testing of gearshift systems in the complete transmission compared to testing in a subsystem is that the test conditions can be matched particularly closely to the application. A large number of parameters such as torque, gearshift forces, oil flow quantity or oil temperature can be controled in accordance with the test specification or measured as part of the test result.

Various test rigs allow matching to different vehicle types. In the simplest case, the drive and load are simulated by two electric motors. With the use of three electric motors, it is possible to simulate different speeds of the drive wheels and thus travel around a corner or bend, *Figure 13*.

Figure 13
Operating life and functional testing in the transmission

Operating life and functional testing of the synchronization subsystem

In addition to testing in the complete transmission, the operating life and function of synchronization systems are also investigated in so-called synchro test rigs. The object of the test is a unit comprising two gear wheels and the components arranged between them (gear cone body, synchro rings, selector hub, selector sleeve and detent struts). In contrast to testing in the transmission, this specifically tests the gearshift function but not the transmission of torque.

Measurement of gearshift comfort in the transmission

Despite the use of versatile simulation tools in the development process, extensive experimental studies are carried out to assess gearshift comfort. The focus of these studies is on determining the gearshift and selection forces occurring when changing gear. Comparisons can thus be made between simulated and measured forces, *Figure 14*.

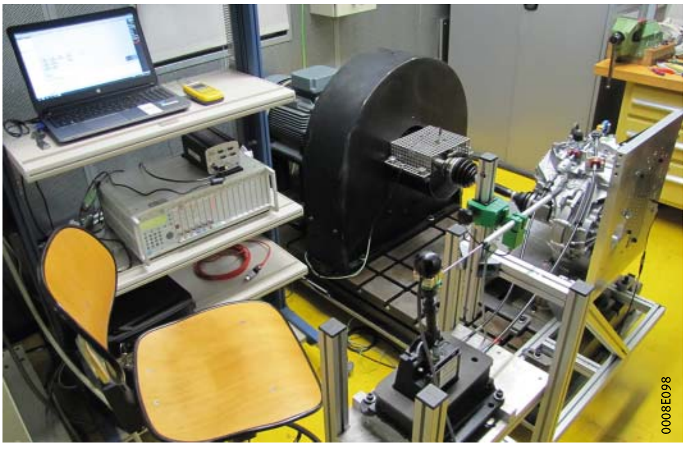


Figure 14
Measurement of gearshift comfort in the transmission

Measurement of gearshift comfort in the vehicle

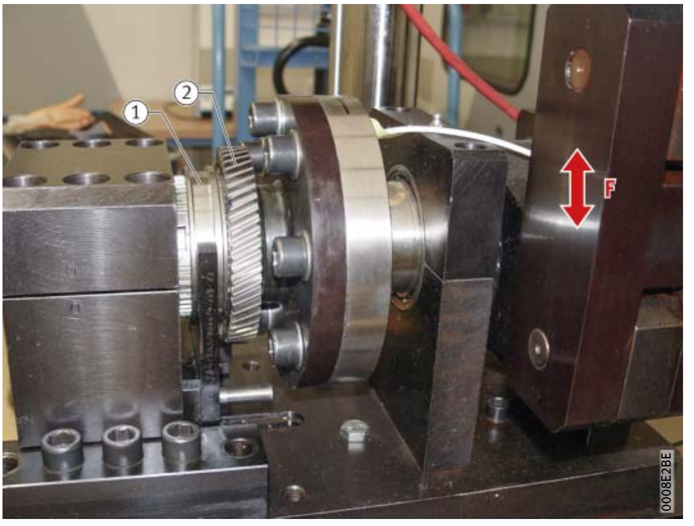
One the test rig tests have been completed successfully, the gearshift components are instaled in vehicles and assessed in relation to gearshift comfort.

The capture of gearshift forces and speeds by measurement technology makes it possible to take account of the individual influence of operators and their different gearshift behavior in the assessment of gearshift comfort. In addition, automated data capture facilitates long term monitoring under actual operating conditions in the vehicle, *Figure 15*.

Figure 15
Measurement of gearshift comfort in the vehicle

Fatigue strength testing

The fatigue strength of a synchronization system is tested on the pulser by means of defined force applications. The test structure facilitates testing under torsion load, *Figure 16*.



① Selector sleeve
② Gear wheel

Figure 16
Fatigue strength testing under torsion load

Test methods for confirmation of manufacturing processes

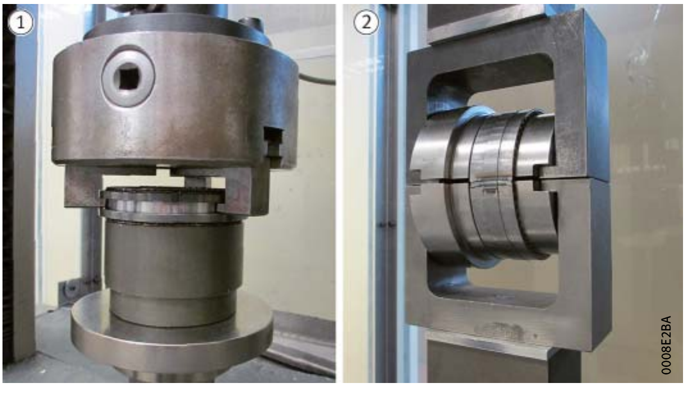
Manufacturing processes are confirmed using both static as well as dynamic test methods.

Static washer separation testing

The objective of this test is to demonstrate the strength of the weld connections between the thrust washers and the sleeve body. The thrust washers are subjected to a defined force in an axial direction, *Figure 17*, ①.

Static tear strength testing

The objective of this test is to demonstrate the strength of the weld seam in the clinch or butt joint area. The weld seam is subjected to a defined force in accordance with the tensile test principle, *Figure 17*, ②.



① Static washer separation testing
② Static tear strength testing

Figure 17
Static tests on selector sleeve

Selector hub assemblies

Dynamic axial loading of selector sleeve

The objective of this test is to demonstrate the fatigue strength of the weld connections between the thrust washers and the sleeve body.

Dynamic radial loading of selector sleeve

The objective of this test is to demonstrate the fatigue strength of the weld seam in the clinch or butt joint area, *Figure 18*.

Source:
Fraunhofer LBF

Figure 18
Dynamic radial loading of selector sleeve

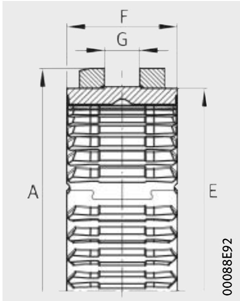
Dynamic gearshift fork testing

The objective of this test is to investigate the wear behavior of the friction combination between the gearshift fork and the selector sleeve. The selector sleeve is rotated at a defined speed.
At the same time, the gearshift fork meshing in the gearshift fork slot on the selector sleeve is subjected to a dynamic axial load.

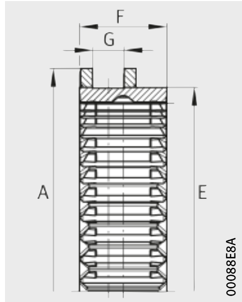
In order to investigate the strength under misuse, the axial force can be increased to 5 kN.

Selector sleeves

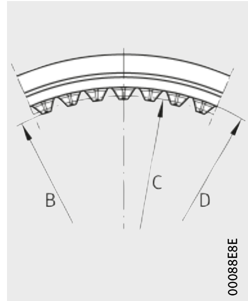
Available designs



Symmetrical



Asymmetrical



Tooth set

Dimension table · Dimensions in mm

Desig-nation	Maximum torque	Dimensions						Tooth set				Position of gearshift fork relative to base body[1]
		A[1]	E	F	G[1]	Roof angle[1) 2)]		B	C	D	Modulus	
	Nm					°						
S1	**1 000**	**102**	**91,5**	19,47	9,85	114	–	84,05	85,32	88,6	**1,58**	Symmetrical
S2	**1 400**	**105,6**	**97**	23,13	9,15	85	80	88,15	90	91,8	**1,5**	Asymmetrical
S3	**1 400**	**91,3**	**86,1**	19,77	10,35	90	120	79,05	81	82,36	**1,5**	Symmetrical
S4	**1 200**	**101**	**92,1**	19,77	7,1	84	–	84,05	85,32	88,6	**1,58**	Asymmetrical
S5	**1 000**	**96,1**	**86,1**	19,77	9	90	120	79,05	81	82,36	**1,5**	Symmetrical
S6	**1 400**	**105,6**	**97**	23,13	9,15	85	80	88,15	90	91,8	**1,5**	Asymmetrical
S7	**1 600**	**104,1**	**95,55**	25,8	8,1	85	92	87,3	86,4	91,65	**1,6**	Symmetrical
S8	**1 600**	**104,1**	**95,55**	25,8	8,1	85	117	87,3	86,4	91,65	**1,6**	Symmetrical
S9	**1 000**	**114,9**	**106,9**	21,3	10,1	115	–	97,5	96	102,3	**2**	Symmetrical
S10	**2 000**	**116,5**	**107,6**	23,8	12,05	115	90	99,4	102	102,95	**1,7**	Symmetrical
S11	**1 200**	**104,9**	**96,9**	21,5	10,05	115	–	87,6	90	92,4	**2**	Symmetrical
S12	**1 200**	**96,5**	**88,4**	19,36	8,75	117	–	80,2	81,6	84,6	**1,7**	Symmetrical
S13	**1 800**	**127**	**114**	23,2	8,28	110	–	104,6	108,3	109,2	**1,9**	Symmetrical
S14	**1 200**	**104**	**91**	21,4	8,28	110	–	81,8	85,5	86,4	**1,9**	Symmetrical
S15	**1 800**	**123**	**114**	22,8	8,28	110	–	104,6	108,3	109,2	**1,9**	Symmetrical
S16	**1 000**	**89,3**	**80,25**	20,65	7,15	90	116	71,75	73,5	76,1	**1,75**	Asymmetrical
S17	**1 000**	**89,3**	**80,25**	20,65	8,05	90	116	71,75	73,5	76,1	**1,75**	Asymmetrical
S18	**1 000**	**89,3**	**80,25**	22,5	8,05	90	116	71,75	73,5	76,1	**1,75**	Asymmetrical
S19	**1 000**	**92,3**	**80,25**	20,2	8,05	116	–	71,75	73,5	76,1	**1,75**	Asymmetrical

1) Dimension can be modified.

2) If two values are given for the roof angle: alternative designs are available.

Checklist for selector hub assembly

Basic information

Device designation: ____________________

Transmission type: ____________________

Number of gears: ____________________

Engine input torque: ____________________

Feature / Gear pair		/		/		/		/	
Conversion ratio									
Gearshift force	N								
Gearshift time	ms								
Maximum speed	min^{-1}								
Differential speed	min^{-1}								

Background

❑ New development

❑ Cost reduction

❑ Optimization

❑ Other: ____________________

Planned implementation

Synchronizer type:

❑ Single cone synchronizer in gear: ____________________

❑ Double cone synchronizer in gear: ____________________

❑ Triple cone synchronizer in gear: ____________________

❑ Other system: ____________________

Presynchronization:

❑ ARRES ____________________

❑ Other system: ____________________

Environmental conditions

Transmission oil:

❑ Contamination conditions (standard): ____________________

❑ Operating temperature range: ____________________

❑ Special features: ____________________

Adjacent construction

Drawings:

❑ Transmission

❑ Selector hub

❑ Gear wheels

❑ Selector sleeve

❑ Synchro ring(s)

❑ Gearshift fork

❑ Presynchronization

❑ Gear cone body

Checklist for selector hub assembly

Information on design envelope (if no appropriate drawing available)

Feature / Gear pair	/	/	/	/
Design envelope of selector hub assembly (largest diameter and width)				

Material of gearshift fork shoe:

Connection of gear cone body to gear

Information on components

Selector sleeve = SYTM/selector hub = SYTK

Material

Feature		/		/		/		/	
Gear pair		SYTM	SYTK	SYTM	SYTK	SYTM	SYTK	SYTM	SYTK
Material									
Density	g/cm^3								
Strength	N/mm^2								
Hardness									
Surface treatment									

Clutching teeth

Feature		/		/		/		/	
Gear pair		SYTM	SYTK	SYTM	SYTK	SYTM	SYTK	SYTM	SYTK
Number of teeth									
Modulus	mm								
Pitch circle diameter	mm								
Mesh angle	°								
Profile displacement	mm								
Tip pitch circle diameter	mm								
Root diameter	mm								
Back angle	°								
Roof angle	°								
Roof pitch	°								
Angle of presynchronization slot	°								
Ball diameter of detent strut	mm								

Checklist for selector hub assembly

Dimensions of gearshift fork slot in selector sleeve

Feature Gear pair	/	/	/	/
Diameter mm				
Width mm				
Position of gearshift fork slot				

Other information on selector sleeve

Feature Gear pair	/	/	/	/
Planned wear travel mm				
Gearshift travel mm				
Gearshift travel limiter (examples: collar, stop)				
Special characteristics (examples: reduced flank, different tooth lengths)				

Shaft/hub connection

Feature Gear pair	/	/	/	/
Tooth data for shaft/hub				
Fit (press fit, clearance)				
Mounting concept				

Test conditions

Planned tests, specifications:

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Mounting and packaging

Method of mounting at customer:

- ❑ Manual
- ❑ Automatic
- ❑ Special packaging required:

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