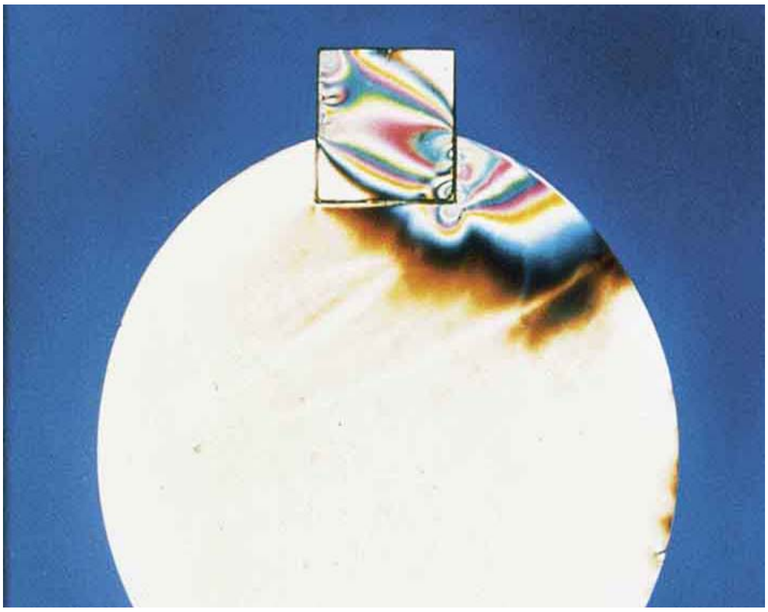
Technical Manual

Keyway joints



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ETP Transmission AB

Keyway joints

Keyways are still the most common of all joints between shaft and hub. Compared to other "form locking joints" as polygon profiles the key and keyway is:

+ cheap to manufacture
+ well standardized

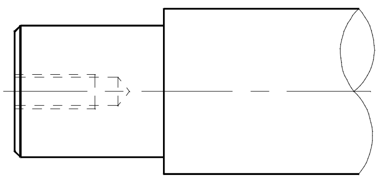
The disadvantages are:

- axially it must be locked by an extra device in order to transmit axial force
- alternating loads give a play and risk for breakage/fatigue
- very difficult to dismantle
- the shaft is weakened by the keyway
  just use part of the shaft for torque transfer
- increased unbalance of the shaft
- difficult to calculate and thereby over dimensioned

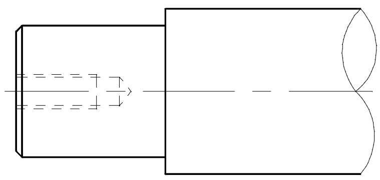
ETP Transmission AB

Disadvantages of keyway joints eliminated through the ETP-Products

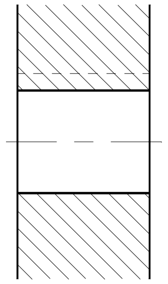
SHOULDER ON SHAFT AND DRILL-
ING - THREADING OF HOLE



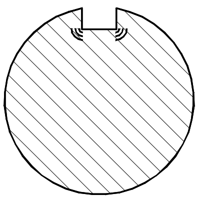
MILL KEYWAY IN SHAFT



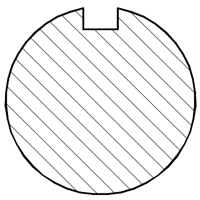
SLOT KEYWAY IN HU



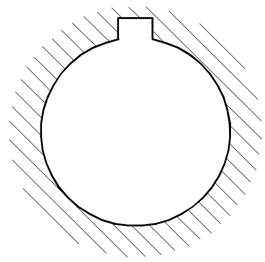
STRESS CONCENTRATIONS MAKE
"OVERDIMENSIONING" NECESSARY



DIMENSIONAL ACCURACY AND
INSPECTION NECESSARY

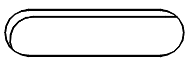


SHAFT

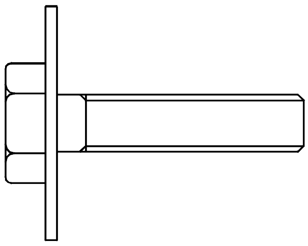


HUB

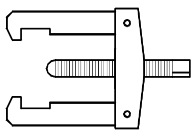
KEY

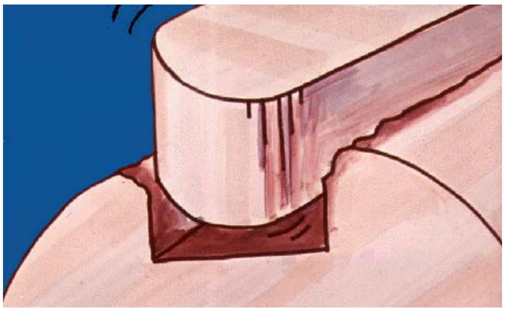


AXIAL SECURING OF HUB

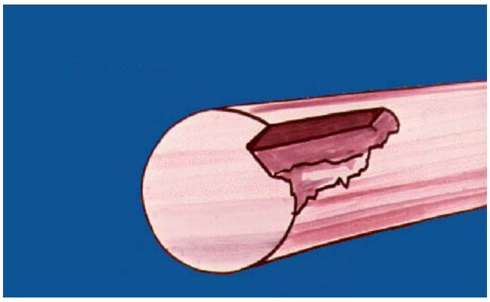


REMOVAL WITH PULLER

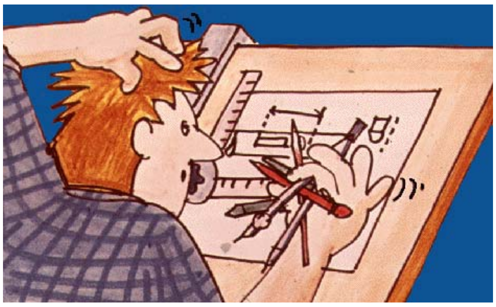




The key very easily works itself loose.



Due to fatigue the shaft often breaks.



The exact location of the keyways needs to be decided.

Due to fatigue and rust dismantling can be difficult.

ETP Transmission AB

Stresses in a keyway joint

There are three ways to calculate and design a keyway:

1. The surface pressure method
2. The safety factor method
3. The notch factor method

1. The surface pressure method

This is the most accurate but also the most complicated method. It has been formulated by a German scientist, Mr Militzer.

The surface pressure varies along the keyway, see picture 3.1. Also in a cut section of a key the stresses varies a lot, see picture 3.2. Militzer has taken care of both the variation of the surface pressure and the stress conditions as well as how the forces are transfered into the key.

2. The safety factor method

Because the stress distribution for keyed connections is not completely understood, a factor of safety of 1,5 should be used when the torque is static. For minor shock loads a factor of safety of 2,5 should be used and one up to 4,5 should be used for high shock loads (especially if the loads are reversible).

It is also stated that a minimum key length should be ≥ 25 % larger than the shaft diameter. A calculation of this type gives a rough value. A comparison between Militzer and this method where the surface pressure is even, gives about 80 % higher value for the method of Militzer.

This will then be compensated by the safety factor which in the end leads to over dimensioned shaft sizes and too big over all dimensions.

3. The notch factor method

The notch factor gives a rough value of how the stress is increased in the keyway. It depends on the form and size of the keyway. To determine the notch factor, the ration r/D is studied, where r is the radius in the keyway and D is the shaft diameter.

The following theory applies:

T_V twisting torque (Nm)

W_V modulus for torsion

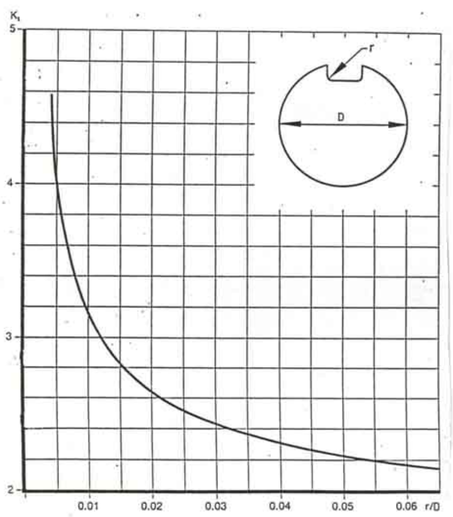
W_V $\frac{\pi * D^3}{16}$ (mm3)

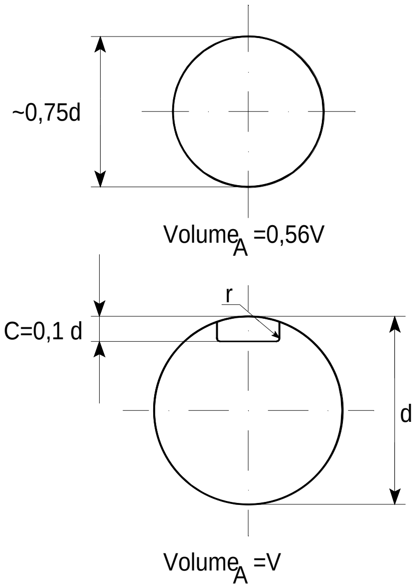
τ shear stress (N/mm2)

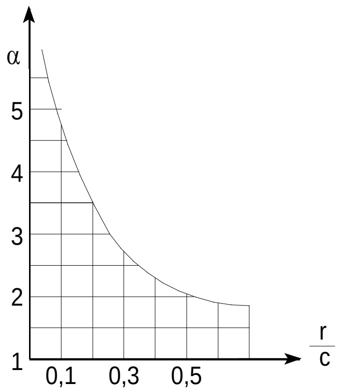
τ $\frac{T_v}{W_v} * K_t$ where K_t is the notch factor

D	r	r/D	K_t, see diagram
Compared 12 – 30	0,16	0,0133 - 0,0053	2,9 - 3,9
(30) – 65	0,25	0,0083 - 0,0038	3,3 - 4,5
(65) – 130	0,40	0,0062 - 0,0031	3,7 - 5,0

With a plain shaft (without keyways) a keyway reduces the strength of the shaft by a factor 3 - 5.

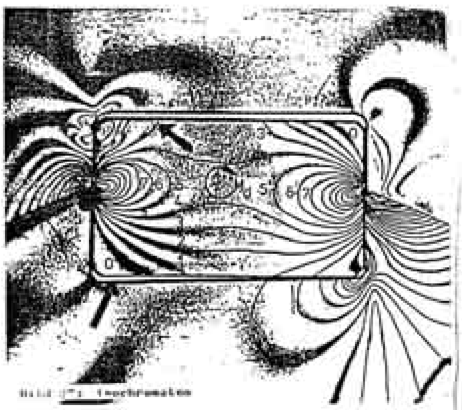


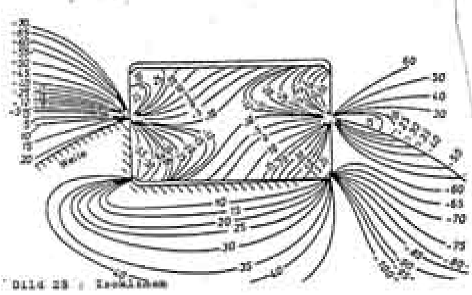




Shear stress

$$\tau_{max} = \alpha * \frac{M_v}{W_v}$$





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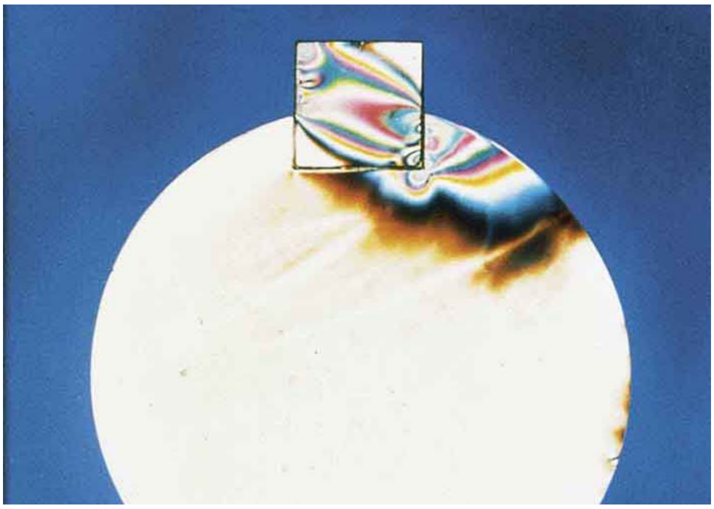

The pictures shows the stress pattern in a shaft with a keyway under pure torque.
The stress concentrations are obvious.
The diagram shows the importance of having a big and smooth radius at the bottom of the keyway, this is in realty seldom the case.

Comparison keyway & ETP-Product

ETP-Product compared with a shaft with keyway at different loads.

	Low even load	High even load	Low alternating load	High alternating load	Occasionally peak loads
ETP-Product	works	works	works	works[2]	slips
Keyway	works	works	backlash[1]	breaks[2]	works[3]

1. Even at low alternating load the key and keyway start to increase the play. The backlash also increases.

2. This depends on how high the load is, too high load will break both the ETP-Product and the keyway.

3. The ETP-Product slips and thereby protects other components. The keyway can stand occasionally peak loads but if too high the shaft breaks.

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Arguments for friction joints

Friction joints compared to the standard keyway joints have the following advantages:

- Easy to mount and dismantle
- Transmit both axial forces and torques
- No play (axial or radial)
- No stress concentration
- Smaller shafts possible
- Better run out accuracy
- Better balance accuracy
- Less fretting corrosion
- Easy to put in position
- More flexibility in the design
- When overloaded it slips (no crack)

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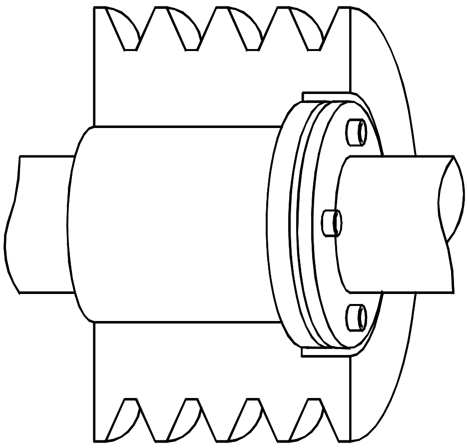
Comparison keyway/ETP-CLASSIC

With an ETP-Product it is possible to reduce the shaft diameter with 25% which means:

- less weight of the total design, by less volume
- less costs

The shaft size often decides the size of many other components in a machine.It is therefore important to reduce the shaft size as much as possible.

ETP-CLASSIC



Keyway joint