Dependable Joining Technology

In Technical Collaboration with

HIRUN INTERNATIONAL

ENGINEERING SOLUTION

THE INNOVATIVE SLIDING MATERIAL, HI - 3

Sliding materials are the most critical components of the spherical bearings.

The sliding material foreseen in EN1337 and by many other standards is PTFE.

The performance characteristics of pure PTFE with mating surface is stainless steel given in EN 1337-2 are the following:

- Characteristic compression strength up to +30°C: 90 MPa
- Characteristic compression strength at +48°C: 57,6 MPa
- Wear resistance: 10.242 m slide path
- Temperature ranges: -35 ÷ +48 °

The performance characteristics of PTFE becomes inadequate in the following cases:

- When the temperature range is exceeded: - That is a common case in many parts of the world like Arabic Peninsula, several regions of India, Thailand and others parts of world.

- When the sliding path foreseen in the useful service life of the bearings is exceeded:- This is a common case in many modern projects of high speed railways and Mass Rapid Transit systems as will by explained in the following.

- In addition, for the specific case of the Bangkok Monorail it was simply impossible to design bearings resisting the specified loads and moments fulfilling the required geometry limitations with a sliding material having a compressive strength of 90 MPa only.

High Speed Railways and Mass Rapid Transit systems are characterized by the following aspects:

- A very high number of train per day: for HSR is normally considered 1 train every 10 minutes for 24 hours a day, so 144 trains per day; for MTR 1 train every 3 minutes for 18 hours per day, so 360 trains per day

- Each train represents a high percentage of the design load:- In the following computation it is considered each train to represent 50% of the design load.

The sliding path in a sliding bearing during its service life can be evaluated through the following assumptions and considerations.

1. The sliding path due to thermal variations represents a minor portion of the total sliding path and will be disregarded

2. The sliding path due to the flexural bending of the beams represents the most important factor

To evaluate the sliding path due to the flexural bending of the beams we consider the deflection limitation of the beams under design load that is normally considered in most of the railway projects worldwide:

$$F \leq L/3000$$

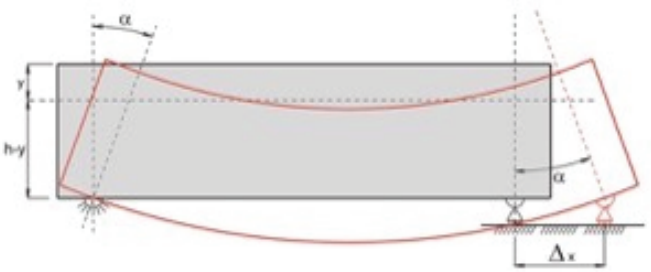
Where F is the deflection and L is the span.

Assuming a parabolic deformation of the beam under design load we obtain the following angle of rotation at the supports for a simply supported beam:

$$\alpha = \frac{2F}{L/2} = \frac{4F}{L} = \frac{4}{3000} = 1{,}33 \text{ mrad}$$

The correspondent sliding path at the sliding bearing is:

$$s = 2\Delta x = 4\,\alpha(h\text{-}y)$$



Flexural bending of a simply supported beam and consequent travel path of the sliding bearing

In the case of Bangkok Monorail h-y is 2300 mm approximately and therefore we get the travel path for every train transit, considering every train to be 50% of the full design load:

$$s = 0.5 \text{ X } 4 \text{ X } 1{,}33 \text{ X } 10^{-3} \text{ X } 2300 = 6{,}1 \text{ mm}$$

With 360 trains per day the wear resistance of the PTFE according to EN 1337.2 is reached after a number of years:

$$Y = \frac{10242000}{6{,}1 \text{ X } 360 \text{ X } 365} = 12{,}8$$

The above computation does not pretend to be 100% precise, however puts in evidence that the wear of the sliding material is a very critical aspect and that PTFE according to EN1337.2 is inadequate to grant a reasonable service life of the bearings without major maintenance.

For this job therefore a much more performing material has been developed and tested granting the following performances:

- Higher compressive strength
- Higher wearing resistance
- Higher resistance to high temperature.

The material utilized for the bearings of Bangkok Monorail is based on a modified PTFE and we applied to it the commercial name HI-3.

The basic performances of HI-3 are summarized in the following table and put in comparison with the performances of PTFE according to EN 1337.2 and with an alternative material UHMWPE

Tab. 2. Sliding materials performance comparison

PROPERTY	HI-3	PTFE	UHMWPE
Compressive strength	180 MPa	90 MPa	180 MPa
Heat resistance(long term)	90°C	48°C	48°C
Heat resistance(short term)	120°C	48°C	80°C
Wear resistance	50,000 m	10,000 m	50,000 m
Static friction	$\leq$ 3%	$\leq$ 3%	$\leq$ 3%

The performance characteristics of the sliding material HI-3 has been tested by a cold-flow test.

The cold-flow test at high temperature is the most severe test to verify the performance of the sliding material in service conditions with long term sliding path.

The conditions for the test are the following:

- Sample diameter ϕ 75 mm; Sample thickness 5 mm; Sample protrusion 2 mm
- Compression applied during the test to generate uniform pressure ≥ 40 MPa
- Preload 1 h with sample already conditioned at the test temperature
- Test temperature ≥ 60°C continuously applied during the test
- Mating surface in stainless steel type X5CrNiMo17-12-2 with mirror finish
- Continuous sliding motion for 100 hours to perform ≥ 36000 cycles
- Sliding path ≥ 1800 m
- Average sliding speed 5 mm/s

After the test the sample shall be visually inspected to verify absence of cracks or breaks, the sample's cold flow shall be measured, the maximum cold flow acceptance value is ≤ 3.2 mm measured on the sample's diameter.

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