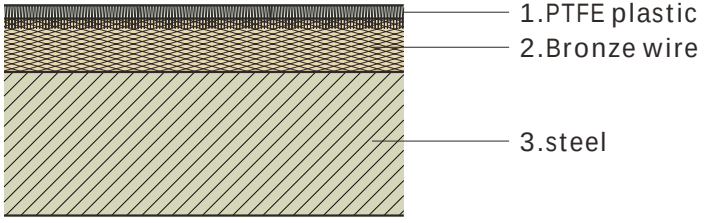
The structure and properties of EMP pads

The EMP pad consists of three layers, noticing the following sketch please. Surface layer is made of PTFE, interlayer is agglomerated bronze wire and bottom-layer is made of steel. PTFE of surface layer is combined with agglomerated bronze wire firmly by special techniques. The aggregation is called as elastic metal-plastic complex material, when it is welded with the steel by special techniques, EMP pads has been formed.

The properties of EMP pads mostly rest with the elastic metal-plastic complex material over the steel. Because of the surface layer of the it is PTFE, and the main property of PTFE is with no-polarity and slippery outline of its molecule. From the property of slippery molecule outline, EMP pads got the characteristic of quite low friction factor. Furthermore, it can form the shifting film in the process of opposite sliding no to the surface of the opposite area and it can also protect the opposing part. However, when the start-up, stopping or any other emerge from on the machine unit and as a result, the liquid lubricating film could not be formed or the liquid lubricating film was destroyed, the bearing would be in a status of boundary friction, at that time the traditional babbit bearing liner would be worn out of even damaged. The Elastic metal-plastic Pad under above mentioned work condition would make the machine unit be in a normal running status.

From the structure sketch of EMP pad, we can learn that agglomerated bronze wire work as a connecting link between the preceding and the following. But in aspect of mechanical and physical properties, it provides strength, elasticity, and dimension stability. How appropriate is agglomerated bronze wire combined with PTFE decide the property of EMP pads.



Shart1 . The Structure of Elastic Metal and Plastic pads

Mechanical & physical properties of EMP pads

Items	Value
Modulus of elasticity (MPa)	2.0×10^{3}
Flexibility (μm/Mpa)	4.5～6.0
Surface hardness HB (kgf/mm^{3})	4.56
Thermal conductivity (W/mk)	0.24
Thermal expansion (cm · ℃/cm)	10.5×10^{-5}

Outstanding properties of EMP pads

1. Physical and chemical stability; chemical reaction does not take place between pads and lubricants, and no-pollution for lubricants.
2. Characteristic of good self-lubricating; friction coefficient just 0.04～0.08. No animal grease needed in assembling, just need few turbine oil. It simplifies the formalities of wheeling and the wheeling is very easy, and good result can be brought out.
3. No scraping and no grinding pads before installation. Relief of workload and working strength, and shortening time limit for a project to examine and repair.
4. High load capacity,safe reliability; normal working in any case such as load change or overload, and the pads still keep steady-going for low temperature; Increased power and efficiency of station; Created the prerequisite for enlarging capacity.
5. High limited temperature. In the occasions that fluiddynamical pressure oil film is destroyed, and the pads is in the condition of boundary lubricating or dry friction, high temperature come into being, but no fusion for EMP pads. And this can protect Runner thrust plate too.
6. Cold start & hot start whenever necessary without high pressure oil supporting. Increased flexibility of power station's work greatly.
7. Excellent integrate performance under many especial conditions such as be out of joint, unloading, 15% over rated speed, stopping running after exceeding low speed limit, stopping supplying water for some time, and so on.
8. When power station stop running, rotate speed can be turned down to 10% of rated speed. Therefore the problems, wear and tear of braking ring & block as well as the pollution & jamming by the powder of asbestos, can be solved effectively.
9. In case that one EMP pad is wore-out seriously in some reason, others will run normally without influence, and no-damage for fluoro-plastic layer.
10. By the effect of pressure field and temperature field, profile surface will be self-adjusted. This can not only stabilize the convergent oil film between the surface of fluoro-plastic layer and EMP layer but also ensure small difference of oil film pressure among points everywhere on pads, and keep the power station running in security.

Design Parameters for EMP pads and enclosures

	Items	Value
1.	Allowable pressure per unit	≤7.0Mpa
2.	Allowable average line speed	3～40m/s
3.	Hoop eccentricity in rigging	6～9%
4.	Inner water cooling system	Non-essential
5.	Temperature of thrust groove	≤55℃
6.	Temperature of thrust pads body	≤65℃
7.	Roughness of Runner thrust plate	≤Ra0.4
8.	Hardness of Runner thrust plate	≥HB200
9.	High pressure oil supporting	Non-essential
10.	Dielectric to avoid axis electric current	Non-essential
11.	Lube shop sign	L-TSA32 or L-TSA46

EMP pads can keep running in security under the scope of standard DL/T 622-1997-4.1.

Operating rules for installation and running of EMP pads

1. Cleaning out rust preventing oil and paint clearly from the EMP pads with gasoline or alcohol dipped by mull, avoiding scoring the surface.
2. No any kinds of scrapping and grinding allowed, scoring of pads surface is strictly prohibited in process of assembling.
3. You can refer to the standard GB8564-88 about thrust bearing to assemble EMP pads and follow the technical manual of it.
4. The pads should swing easily not obstructively after be felt in.
5. The load equality demands of thrust surface between pads: the load equality between pads of rigid support thrust bearing is less-than-or-equal-to 20%. Static compress measure deviation of elastic oil reservoir is less-than-or-equal-to 0.3mm.
6. Being machined after cleaning lubricant being besmeared on, and less than ten times every machining.
7. Starting power station without high-pressure oil supporting directly within 30 days after stopping running is allowed.
8. Starting power station with the groove oil temperature above 5℃ and hot starting shortly after stopping running are allowed.
9. Stopping running can go with 10% of rated rotate speed at most, and times of inertia stopping is 5 maximum every year.
10. Groove cooling system leave the water should be less-than-or-equal-to 4 hours, and stopping supplying water for less-than-or-equal-to 0.5 hour.
11. Condition of being out of joint continues less-than-or-equal-to 5 minutes; axial overload no more than 110%.

Quality standard of EMP pads

1. Thickness of elastic layer of EMP pads is 9～10mm including surface PTFE and interlayer agglomerated bronze wire.
2. Surface layer (PTFE) must be massive, and the thickness is 1.5～2.5mm with surface roughness Ra 0.8.
3. No dirt inclusion, delamination, crack and obvious blowhole allowed on the surface of plastic. And no ends of agglomerated bronze wire allowed to appearance.
4. Three layers of EMP pads must be combined firmly; delamination, welding crack and shelling must be prohibited.
5. Confirming the drawing should carry out according to both sides' condition and technical data. Generally speaking, installation size should not be changed when replace the EMP from intrinsic bearing. New designed bearing must satisfy the demanded properties of running.
6. Special demands of customer can go on under the negation between both sides.

The testing and installing operation of Elastic Metal-Polymer (EMP) pads scaffolding

In July of 1992, EMP pads test in 10MN plane thrust bearing teststand of Dongfang electrical machine factory, thistest imitated thrust bearing of working condition DaHuas generating unit. A year later, a high parameter testing with higher velocity and higher pressure was held.

The main parameters of scaffolding testing for the EMP:

Unit area	853cm^2	Rated speed	149～266 rpm
length / width	0.624	average speed	12.38～22.02 m/s
Hoop eccentricity	$\overline{X}$=0.570	trend thrust	295.2～7155.6KN
Radial eccentricity	$\overline{R}$=0.518	average specific pressure	1.0～10.5Mpa
Pads quantity	8	Temperature of the lubricant added into	32.5℃～42.1℃
Pads angle	16.8 °	Shrink the size of the pads	
The brands of the lubricant	N46 steam turbine lubricantthe	The diameter of the pallets should be shrunk accordingly	

The testing was held under the condition of V=12.38m/s and loaded step by step before the specific pressure=4.5Mpa the operation is without water, it lasts for 4 hours. Then to increase the pressure and turn on the cold water to adjust the oil temperature. See the following table.

Average specific pressure (MPa)	4.5	5.0	5.6	6.5	7.0	7.5	8.0	8.5	9.0	8.0*	10.5*
Average velocity (m/s)	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	22.02	18.11
PV Value (Mpa · m/s)	55.71	61.90	69.33	80.47	86.66	92.85	99.04	99.04	111.42	176.16	190.15
Inlet oil Tem (°C)	34.65	35.35	35.10	35.33	36.10	35.30	34.98	34.98	35.90	42.10	39.40
Average pads Tem (°C)	37.10	37.79	37.87	38.12	38.87	38.65	38.33	38.33	39.03	46.10	44.20
Oil film Tem (°C)	56.70	58.50	59.70	62.00	64.40	67.40	67.90	67.90	71.50	90.00	89.00

Annotation: The temperature of oil film is the highest temperature of pads surface.
* Test data of August in 1993, another test data of 1992.

In March of 1993, the thrust bearing of elastic Metal-plastic pads installed and ran in No.2 of DaHua electrical factory, it get past performance examine and throw in running-in. Basic parameter of thrust bearing of DaHua's generating unit.

Unit area	2814 cm^2	Pads quantity	18
Internal diameter of pads	2395 mm	External diameter of pads	3736 mm
Average length of pads	420 mm	Pads angle	16. 8 °
Capacity of stand generating set	100 MW	Rated speed	76.9 rpm
Thrust load	30 MN	Average specific pressure	5.81 Mpa
Pv value	72 Mpa · m/s	Supporting way (fashion)	Tray supporting

Developed by Shanghai Research Institute of Materials, the EMP pads plane bearings are assembled on the 2# and 4# of Guangxi Dahua Hydraulic Power Plant. The stand capacity is 100MW and axial load is 30MN. The following is the contrast of two kinds of EMP pads under different working conditions.

■ Compare with temperature of pad under designed head of water and fully loaded

Kind of pads	OPERATION				THE TEMPERATURE OF THE BEARINGS (°C)			
	H(m)	α%	ψ%	P(MW)	Average	Max.	Min.	Oil
RUSSIAN	21.33	95%	18	100	43.6	44.1	43.1	34.7
SRIM	21.33	100%	18	100	39.5	40.5	38.4	33.9

Adopt the generating unit on load above 1 hour

■ Compare with temperature of pad under higher head of water and fully loaded

Kind of pads	OPERATION				THE TEMPERATURE OF THE BEARINGS (°C)			
	H(m)	α%	ψ%	P(MW)	Average	Max.	Min.	Oil
RUSSIAN	21.85	67%	9	95	44.5	44.9	44.1	35.4
SRIM	27.85	70%	10	100	39.5	40.9	38.8	34.1

Adopt the generating unit on load above 1 hour

■ Compare with the temperature of pad und high head of water and shake

Kind of pads	OPERATION				THE TEMPERATURE OF THE BEARINGS (°C)			
	H(m)	α%	ψ%	P(MW)	Average	Max.	Min.	Oil
RUSSIAN	33.53	42 %	-9	42	45.1	45.6	44.7	35.6
SRIM	33.53	38 %	-9	40	40.3	41.2	39.2	34.4

Adopt the generating unit on load above 1 hour

Compare with temperature of pad und flood season

Kind of pads	OPERATION				THE TEMPERATURE OF THE BEARINGS (°C)			
	H(m)	α%	ψ%	P(MW)	Average	Max.	Min.	Oil
RUSSIAN	7	99%	-3	8	43.1	43.4	43	36
SRIM	7	100%	-1	8	38.6	39.4	37.1	34.3

Adopt the generating unit on load above 1 hour

INSTALLATION INSTRUCTION OF ELASTIC METAL PLASTIC BEARING

1. AFTER OPENING THE BOX WHICH CONTAINS THE ELASTIC METAL PLASTIC BEARING AND THEN CAREFULLY LIFT IT UP OR MOVE IT OUT IN ORDER TO PREVENT THE BEARING PLASTIC SURFACE WITH PTFE FROM DAMAGING.
2. USING CLEAN SOFT CLOTH WITH ALCOHOL (OR GASOLINE, ACETONE) TO WASH BEARING SURFACE AND BODY IN ORDER TO PREVENT THE PLASTIC BEARING SURFACE FROM SCRATCHING BY HARD SUBSTANCE (LIKE GRIT, SCRAP IRON), TO MOVE ANTI-RUST OIL OR ANTI-RUST PAINT AWAY FROM METAL BEARING BASE COMPLETELY IF THERE ARE.
3. THE PLASTIC BEARING SURFACE AND BASE IS NOT PERMITTED TO BE REPAIRED LIKE BABBITT METAL BEARING, NOT EVEN TO BE REPRODUCED. USUALLY THE REMAINING BURRS WITH HIGH POINT AND SCREW HOLE, WORKMANSHIP HOLE, TEMPERATURE MEASURING HOLE ARE TO BE CLEANED, IT CAN BE READY FOR INSTALLATION IF IT IS ACCORDING TO DESIGN REQUIREMENT AFTER CHECKING.
4. REFERRING TO GB 8564-88 PART OF THRUST BEARING, IT IS PROHIBITED TO SCRATCH OR DAMAGE BEARING SURFACE DURING THE PROCESS OF ELASTIC METAL AND PLASTIC BEARING INSTALLATION.
5. THE PADS SHOULD SWING EASILY NOT OBSTRUCTIVIELY AFTER INSTALLATION. WHEN THE ROTOR FALL, THE PADS SHOULD BE IN ORIGINAL STATE. IT IS POSSIBLE THAT THE PAD WILL BE ABSORBED BY JOURNAL BOARD WHEN THE ROTOR JACK UP, BUT THE KEY AND NON SLIPPING SHOULD NOT BE BALLED.
6. THE ADJUSTMENT OF LOADING PRESSURE OF ENGINE BEARING SHOULD BE ACCORDING TO THE FOLLOWING REQUIREMENT WHEN INSTALLATION.
   (A) THE BEARING SUPPORTED BY RIGIDITY, THE LOADING CAPACITY BETWEEN EACH ENGINE BEARING IS WITHIN 20%.
   (B) THE BEARING SUPPORTED BY HYDRAULIC PRESSURE, THE MAX ERROR IS NO BIGGER THAN 0.3MM OF STATIC COMPRESSING VOLUME WHEN MEASURING THE OUTSIDE DIAMETER OF MULTI-WAVE ELASTIC OIL TANK.
   (C) THE LOADING CAPACITY IS NOT ALLOWED TO SURPASS 10 MPA (UNIT PRESSURE) WHEN INITIALLY ADJUSTING THE BEARING.
7. CIRCLING AFTER PUTTING CLEAN LUBRICANT (MODEL OF OIL IS THE SAME AS THAT OF PLANE BEARING) ON THE SURFACE OF PLASTIC BEARING, BUT CIRCLING SHOULD BE NO MORE THAN TEN LAPS AT A TIME. WHEN CIRCLING MOMENT OF FORCE IS INCREASED A LOT OBVIOUSLY, ROTOR SHOULD BE JACKING ONCE MORE IN ORDER TO PUT OIL LUBRICANT. HOWEVER, IT IS NOT ALLOWED TO CIRCLING BY FLUSHING WATER.
8. BEFORE SEALING OIL GROOVE, THE ALL PARTS WHICH OIL CAN TOUCH OF PLANE BEARING, OIL CONDENSE, OUTSIDE CIRCULATING TUBE, FILTER ETC BE CLEANED COMPLETELY TO MAKE SURE SUBTLE SUBSTANCE WHICH CAN DAMAGE BEARING SURFACE LIKE GRIT, COPPER THREAD HEAD, SCRAP IRON, PAINT, COTTON YARN HEAD ETC), DOES NOT EXIST, THEN OIL CAN BE PUT AFTER SEALING COVER.
9. THE LUBRICANT OIL CAN BE FILLED IN PLANE BEARING GROOVE, WHEN IT IS ACCORDING TO RELATIVE STANDARDS AFTER FILTERING.