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"Applications of Bearings In Heavy Movable Structures"

by

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Applications of Bearings in Heavy Movable Structures

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Introduction

This paper is written as complimentary paper to "Selecting Spherical Roller Bearings for Heavy Movable Structures" [1], presented by William "Gill" Detweiler at the HMS Symposium in 1996. This paper addresses the practical details that should be considered after either a rolling element or plain bearing has been selected for an HMS application to optimize bearing service life.

Preliminary Considerations

When the bearing and housing are specified and purchased, several important issues should be taken into consideration. Specifying bearing and housing related details at this early stage will eliminate numerous problems later in the project and during the life of the structure.

Once the bearing size has been selected, the method of mounting the bearing on the shaft should be determined. In the USA, bridge bearing applications commonly use tapered journal mounting with a clamping plate affixed to the end of the shaft. Hydraulic mounting features on the shaft reduce the time and effort required to mount the bearing on the tapered journal. Alternatively, a cylindrical journal arrangement with the inner race of the bearing secured between a shoulder and the clamping plate is commonly used in Europe. This design allows for a clearance fit between the shaft and bearing, greatly simplifying the mounting procedure. One disadvantage of the cylindrical journal configuration is the added design features needed to compensate for the stress concentration effects created by the shaft shoulder radius. The fillet radius at the shoulder and the shaft diameter should be carefully analyzed to avoid excessive stress concentration.

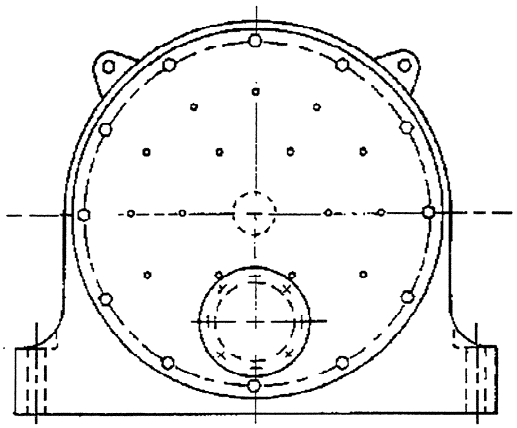

Figure 1. One piece housing [4]

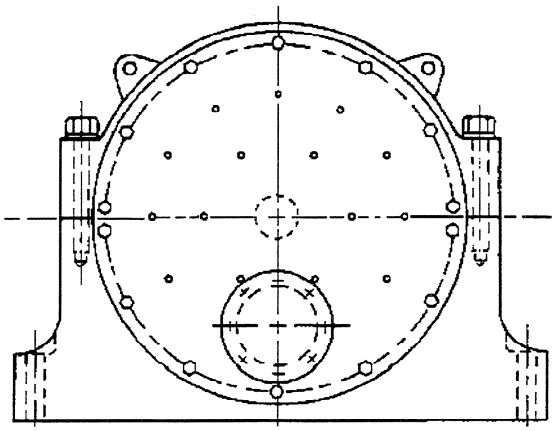

Figure 2. Two piece housing [4]

The housing design should also be decided upon at this time. Two major styles of housings are available: one piece and two piece configurations as shown in Figures 1 and 2. One piece designs can be more compact, hold tighter tolerances on the bore and have no cap bolts to torque. Two piece housings are easier to disassemble since the base can remain bolted to the pedestal. If the bearings are to be aligned by either wire or laser centerline alignment, a small port should be specified on the end covers and clamping plate, as both of these methods require a hollow path through the center line of the shafts across the entire width of the leaf. It is generally recommended that only one bearing be fixed on each structure and that all other bearings be free to float axially to accommodate thermal expansion and contraction. The minimum amount of float needed in each housing should be specified by the bridge designer and clearly marked on the bearing housing drawing. Other housing considerations include: type and quantity of lubricant to be used, provisions for lubrication, suitable lifting attachments, base mounting hole location, sealing arrangements and permissible misalignment capabilities. All of the components associated with the bearing should be shown on the bearing manufacturer's drawings. This would typically include the shaft, clamping plates, seals, lubricant, and hardware. The supplier of each of these components should be clearly specified on the drawing to define their supply responsibilities. Shaft details in the area of the bearing should be specified, such as: surface finish at seal contact surfaces, fillets, chamfers and mounting details.

Sine Bar Inspection of the Shaft

Plans should be made in advance so that the bearing company representative, or other qualified professional, can inspect the shaft while it is in the lathe at the machining contractor. This allows the sine bar measurements to be compared with the machinist's measurement so that modifications can be made without removing the shaft from the turning set up. Before the visit, the micrometer size should be established and communicated so that it is sure to be on hand for the inspection. In addition to the basic sine bar inspection, which includes measurements for diameter, taper, and contour of the journal, the surface finish at the seal contact points and corner radii as well as the hydraulic features should be checked.

Mounting the Bearings on the Shaft

As with the shaft inspection, an appointment should be made so that a representative from a bearing company can oversee the bearing and housing installation. This visit as well as the shaft inspection should be included in the bearing purchase contract.

Before the bearings are ready to be mounted, all of the necessary components must be on hand. This includes the hydraulic pump and fittings for mounting the bearing, shaft clamping plates, appropriate hardware and hand tools. The bearing company representative is expected to supply the necessary feeler gauges for measurement of internal clearance. If the bearings are to be mounted outdoors, covers and protection from rain should also be available.

The bearings should be stored indoors lying flat in their original shipping containers until they are ready to be mounted. When the bearings are at the mounting site they should be lifted by placing a suitable lifting strap around the outer diameter of the bearing. If the bearings must be lifted with a one point grip, a cross support should always be used.

Before the bearings are driven up the tapered journal, the unmounted clearance must be measured and recorded. This can be done by inserting feeler gauges between the roller and the outer ring at the 6 o'clock position while the bearing is hanging on the journal. It is highly recommended that the bearing company representative be present during the entire bearing installation process to measure both the initial and final internal clearance values. For each bearing size, a certain range of clearance must be taken out during the mounting process, see Figure 3. This will insure proper interference between the inner ring and journal, while leaving enough clearance to prevent preloading the bearing.

Bore diameter d (mm)		Reduction in Radial internal clearance (in.)	
Over	Incl.	Min.	Max.[1]
24	30	0.0006	0.0008
30	40	0.0008	0.0010
40	50	0.0010	0.0012
50	65	0.0012	0.0015
65	80	0.0015	0.0020
80	100	0.0018	0.0025
100	120	0.0020	0.0028
120	140	0.0025	0.0035
140	160	0.0030	0.0040
160	180	0.0030	0.0045
180	200	0.0035	0.0050
200	225	0.0040	0.0055
225	250	0.0045	0.0060
250	280	0.0045	0.0065
280	315	0.0050	0.0075
315	355	0.0060	0.0085
355	400	0.0065	0.0090
400	450	0.0080	0.0105
450	500	0.0085	0.0110
500	560	0.0095	0.0125
560	630	0.0100	0.0135
630	710	0.0120	0.0155
710	800	0.0135	0.0175
800	900	0.0145	0.0195
900	1000	0.0160	0.0215
1000	1120	0.0175	0.0235
1120	1250	0.0190	0.0255

Figure 3. Clearance reduction values for spherical roller bearings [5]

In most bridge applications the bearing is driven up the tapered journal by using a shaft clamping plate in conjunction with oil injection through the shaft. During this process, hydraulic fluid is injected through an oil inlet port on the end of the shaft. Figure 4, on the next page, shows a typical oil injection arrangement. The fluid flows through the shaft to a circumferentially machined groove on the journal where it forms a film between the journal and bearing bore surfaces. This film greatly decreases the amount of force needed to drive the bearing up the tapered journal. By incrementally tightening the bolts running through the clamping plate, the bearing is driven up the shaft until the correct amount of internal clearance is removed. The final clearance in the bearing should be recorded for future reference.

Once the bearings are seated on the journal, the overhang of the bearing inner ring relative to face of the shaft should be recorded. This allows the distance between the trunions to be calculated and will simplify the mounting of the housings to the pedestals.

After the bearing is mounted to the shaft, the housing will be assembled over the bearing. For a two piece housing this is usually accomplished by either hoisting or jacking the lower half of the housing into contact with the bottom of the bearing and then lowering the top half over it. The process is somewhat simplified for a one piece housing, as there is only one piece to hoist into place.

If the housing has the Float Control feature, the housing can be filled with grease at this time. The Float Control feature is a new method used to align and position the bearing within the housing. Other wise, it may be

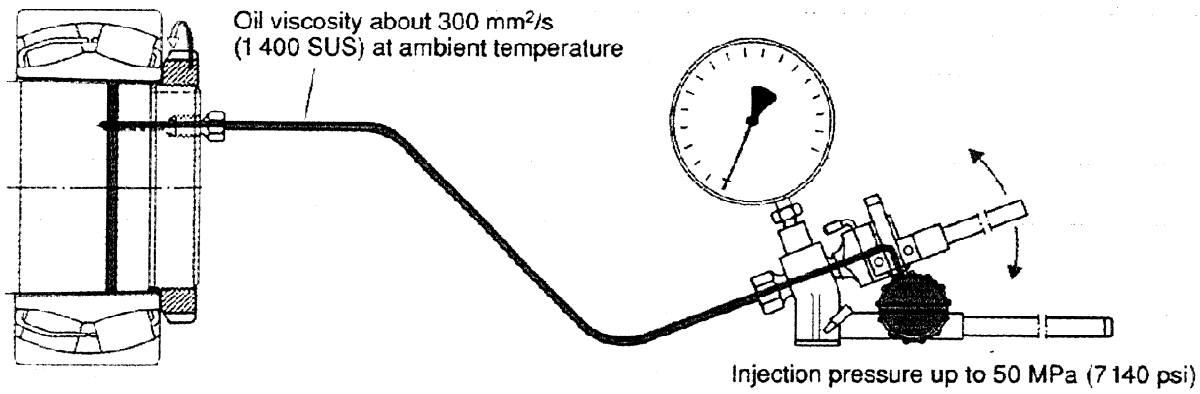

Figure 4. Oil injection [3]

necessary to apply a small quantity of grease to protect the surfaces of the bearing until the housing is placed in its final position on the pedestal. The housing can be completely filled with grease only if a double seal arrangement is used, otherwise grease will leak out. For this reason the double seal is highly recommended. It is desirable to completely fill the housing with lubricant as soon as possible to prevent condensation or a negative pressure within the housing. This pressure differential can occur when a housing is suddenly cooled, for example, by a rainstorm. A negative pressure in the housing can cause moist air to be drawn in to the bearing cavity. Moisture in the housing results in accelerated lubricant and bearing degradation.

Assembling the Housing to the Pedestal

Before the trunion assembly is placed on the pedestal, the pedestal should be inspected for flatness. The pedestal mounting surface should be flat within 0.001 inch per foot (0.025 mm per 300 mm) in all directions. If the pedestal is not sufficiently flat, as the housing is bolted down it will deform to match the pedestal profile. This can pinch the outer race of the bearing and greatly decrease bearing life.

The distance between pedestals should be compared to the distance between trunion housings to insure that they will line up at assembly.

The bearing housing feet should have mounting holes pre drilled by the housing manufacturer. Undersized holes, to be reamed out after positioning, can be used if desired. Once the housings are laid into position, these holes should be used as pilot holes to drill the pedestal. An oversized pedestal will allow flexibility in the final positioning of the housing. This can be used to compensate for any errors in pedestal location, trunion assembly length, overall width variations of the bridge, etc.

In housings where the base holes are not located in line with the cap bolts, blank housing mounting feet are generally not recommended as this leaves too much freedom of location for the mounting holes. The holes could be placed too close to the fillet radius between the pillow block base and side wall or too close to the edge of the foot. Either of these situations could result in a significant strength reduction of the housing.

When the trunion assembly is lowered onto the pedestals, the float within the housing should

be checked and adjusted. By using the Float Control feature, this can be accomplished with the end covers and seal assembly in place. Figure 5 depicts the float allowance as well as a typical double seal arrangement. If the housings are not equipped with the Float Control feature, the end covers must be removed to check the float in the housing.. The bearing needs to be protected from the elements any time the end covers are off. After the housing is secured to the pedestal and the axial float is determined to be adequate, the housing should be packed with grease if it has not been packed already.

Alignment of the trunion arrangement should be checked after the load is applied by measuring the gap between the shaft and housing. As the load is applied to the bearing arrangement, elevation of the pedestals may change appreciably. The designers of the bridge should account for this compression and adjust pedestal height accordingly. It may be necessary to return to the bridge to confirm that the alignment stays within specified limits after full load is applied. The misalignment that can be accommodated is limited by the bearing seal configuration, not the bearing itself. Generally seals can tolerate up to ± 0.5° of misalignment. The sealing effectiveness drops with an increase in misalignment [2], so it is desirable to minimize the misalignment of the trunion assemblies.

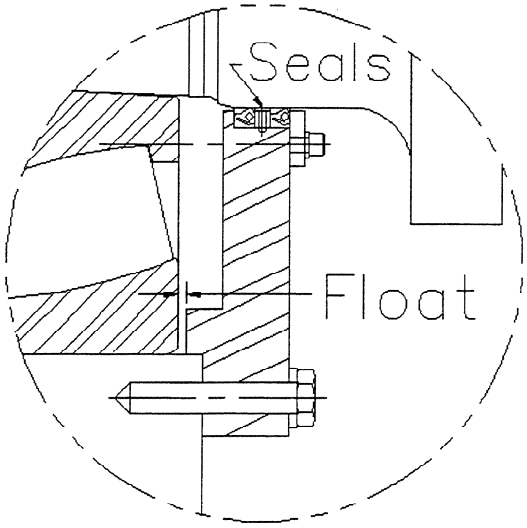

Figure 5. Bearing and shaft in housing

Conclusion

In order to achieve optimum bearing service in an HMS application, many factors need to be taken into account. This paper is intended to describe the procedures to be followed after bearing size selection. Certainly it is not intended to be comprehensive, as many details arise on an individual basis. Application Engineers at most bearing manufacturers are glad to assist with further details as required

This paper is dedicated to the memory of Howard Lichius.

References

[1] Detweiler, William, Selecting Spherical Roller Bearings for Heavy Movable Structures. HMS Symposium, 1996

[2] SKF General Catalog 4000 US, 1997

[3] SKF Bearing Maintenance Handbook 4100 E, 1991

[4] SKF Bearings and Housings for Heavy Machinery 100-930, October, 1996

[5] SKF Recommended Internal Clearance Reduction Values for Tapered Bore Spherical Roller Bearings 310-890, January 1996

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