

PULLEY PRACTICALITIES

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1. INTRODUCTION

The topic of pulleys has been discussed many times and yet there are still grey areas regarding the different types of pulleys available in the market. It may well be that this is due to the lack of product specific exposure which means that it is necessary for the situation to be reviewed.

The purpose of this paper is to provide a broader perspective and understanding of the world of pulleys fitted with internal bearings, with solid recommendations as to the way forward.

2. ASSUMPTIONS

It is assumed that the reader is familiar with the contents of SANS 1669 and pulley terminology in general.

3. DISCUSSION

Driven or drive pulleys are primarily equipped with external bearings and drive units. Suppliers are in the process of introducing self driven pulleys into the local marketplace. This in itself is considered as being a specific application and as such a specialist field. Although some of the points covered can be related to both applications, drive pulleys are not considered to form an integral part of this paper.

Non-driven pulleys can be classed as being fitted with external or internal bearings. The prime application in the South African industry is to make use of pulleys with fixed shafts to the shells and external bearings. This range of pulleys can be broadly grouped into three categories being high tension, medium tension and low tension.

The high tension pulleys will typically be those units constructed along what is referred to as the Tee-bottom design. The medium tension pulleys are of the turbine end disk design with low tension pulleys being the boss type construction. These construction methods are reflected in SANS 1669 part 1.

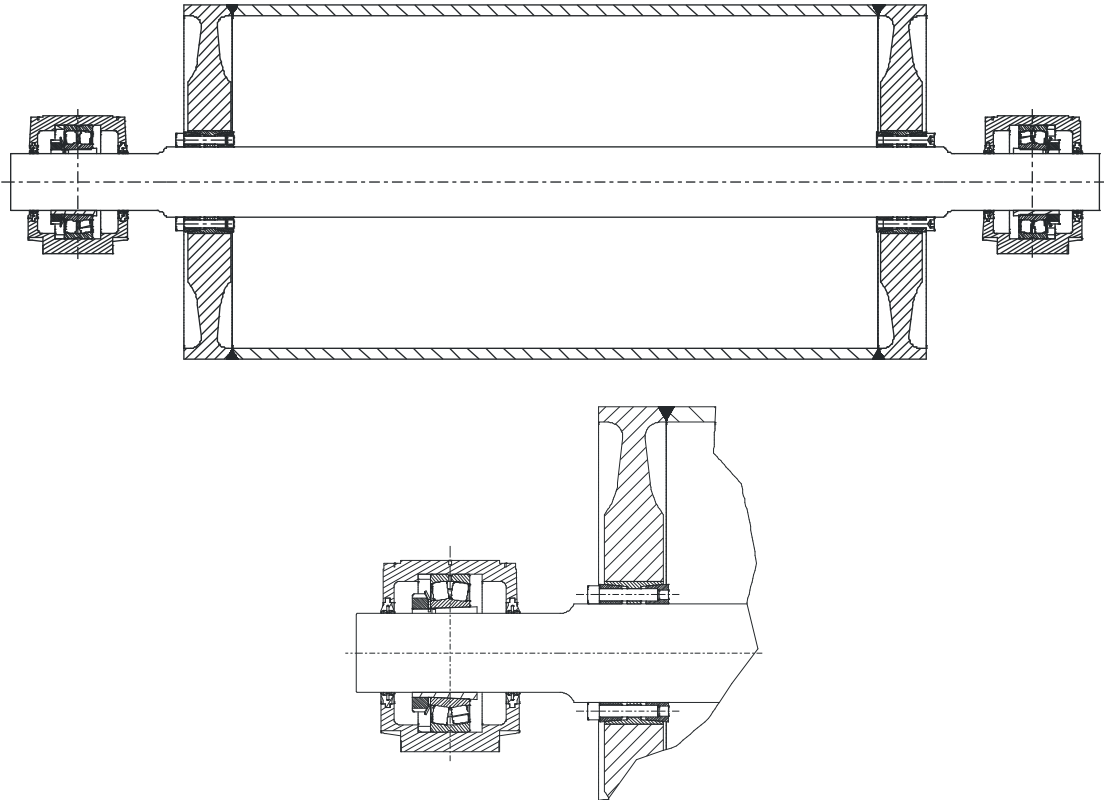


Figure 1. Tee-bottom design.

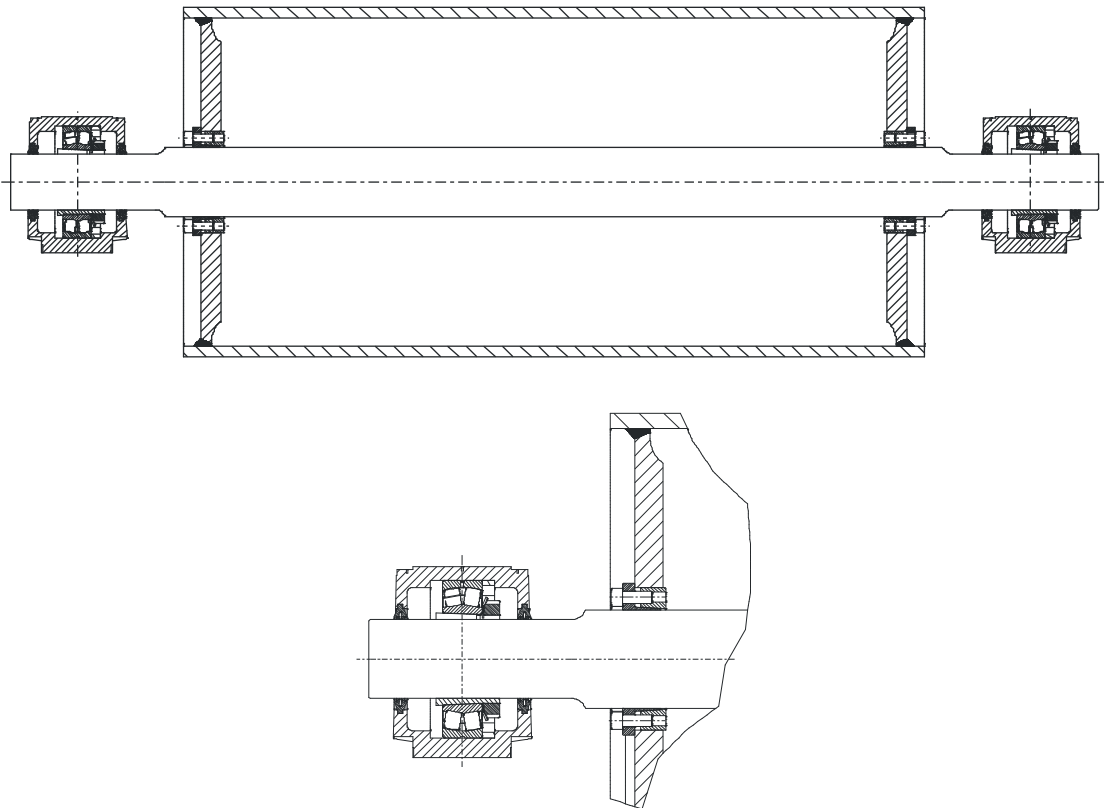


Figure 2. Turbine disk construction

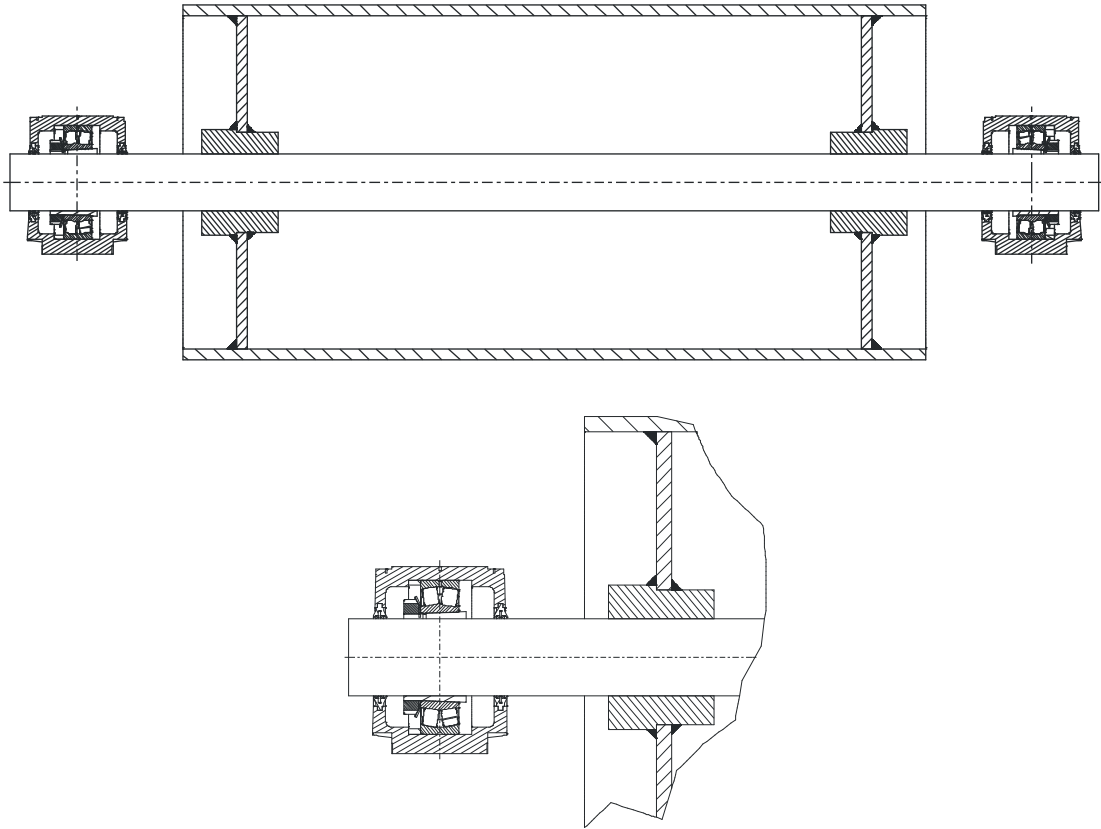


Figure 3. Boss type construction

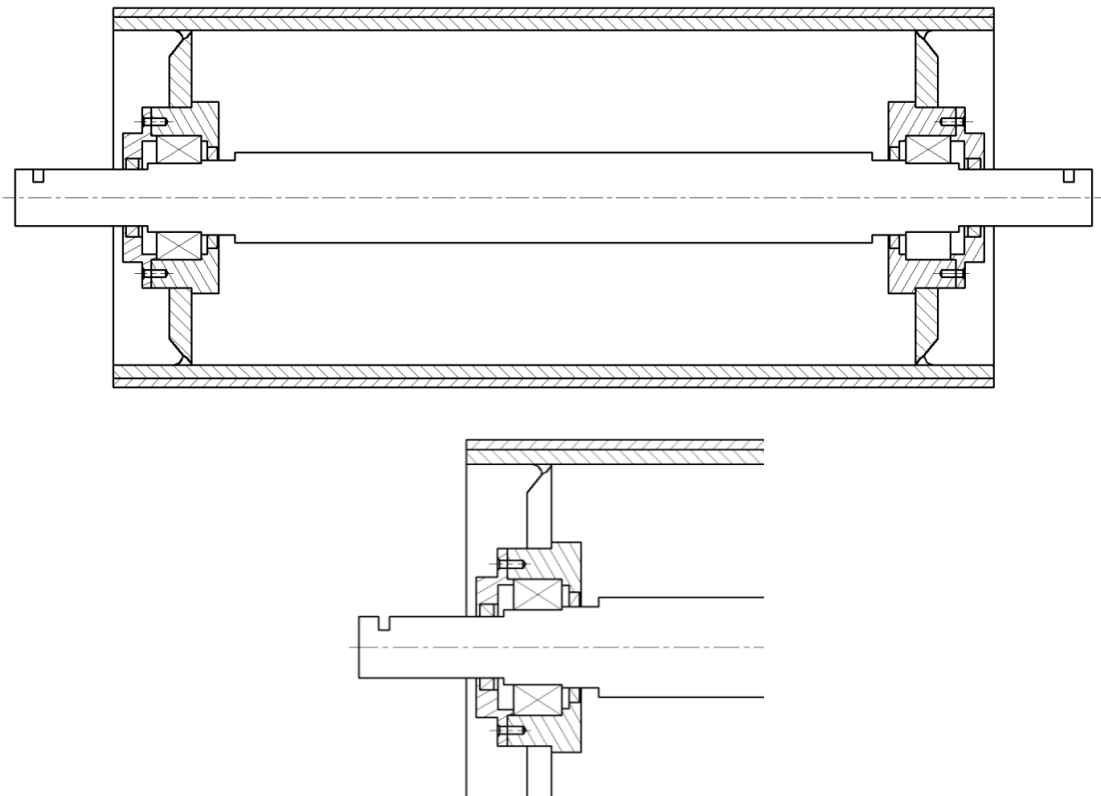


Figure 4. Pulley fitted with inboard bearings

4. PULLEY ALIGNMENT

The procedure for placing any one of these pulley types into service requires specific attention focused on the bearings. The requirement is that the pulley face must be squared to the belt line and levelled. This adjustment is effected locally in the area of the sole plates by means of shims and jacking screws.

In a vertical mounting position, packers are normally placed between the sole plates and the steelwork. A straight edge is placed across the sole plates for the squaring exercise. Once the first objective is achieved, the pulley is inserted and levelled by means of the jacking screws.

In a horizontal mounting arrangement packers are placed between the sole plates and the steelwork for levelling and the pulley then squared to the belt line by means of the jacking screws.

From a general perspective this should then be fine, but is it? One of the most overlooked issues in the industry is that very little attention is paid to squaring the bearing to the shaft. Eyeball engineering is used for roughly squaring the bearing, and then only if it is remembered. The key issue from the maintenance side is that as long as the belt is running, all is fine.

The out-of-square of the bearing is the key reason for bearing failure. Stop and consider this fact for a moment. Bearings are normally designed for 100 000 h basic life rating. This is the equivalent of at least eleven years of operating 24 hours a day, seven days a week. Then why are bearings failing prematurely?

The construction of the pulley bearing is spherical; implying that it can be operated under 'out of square' conditions. While this is true regarding the bearing, the bearing seal cannot operate effectively at all under adversely misaligned conditions. The prime reason then why bearings fail is that under these conditions the bearings are not adequately protected against the ingress of dirt and foreign particles due to misalignment localised at the seals.

What is the way forward? Pulleys are also supplied with internal bearings. For those who are unfamiliar with this concept, picture it as being a huge idler. The shaft is stationary and the shell turns on a bearing mounted on the shaft.

From an application concept, the bearing forms an integral part of the pulley. The bearing used is the same type of bearing that would have been used in any one of the applications described above.

From an assembly perspective, the bearing is installed, and provided normal assembly procedures are followed, the bearing and seal will be assembled square to the shaft. In essence, this type of pulley then removes the possibility of bearings ever becoming misaligned on final assembly. The normal procedure for aligning the pulley horizontally and squaring it up with the belt line is still a requirement, and it is unlikely that this will ever change. As long as the fixtures for securing the shafts to the steelwork are the same, it should not be necessary for any adjustment, as the initial setup should be, and remains adequate from the alignment perspective.

5. PLUMMER BLOCK FIXINGS

Another requirement is that plummer block caps should never be used in tension. This requirement is addressed in the majority of South African specifications at project stage. The reason for this requirement is that the resultant available strength can be applied to the bolts securing the cap plate of the plummer block housing to the base is comparatively smaller than the equivalent bolts used for securing the unit to the steelwork. Typically, on a 100 diameter bearing, the base is secured by means of M24 bolts while the cap plate bolts are only M20.

There is also the matter of stored energy. During maintenance, should the bearing caps be removed off a pulley that has a predominant tension component into the bearing caps when the belt is not running, the pulley may become dislodged and the results could be disastrous.

The methodology for securing shafts fitted with internal bearings is by means of a hole drilled in a flange-type plate. The unit is referred to as a 'dead eye' in the industry. (Figure 5).

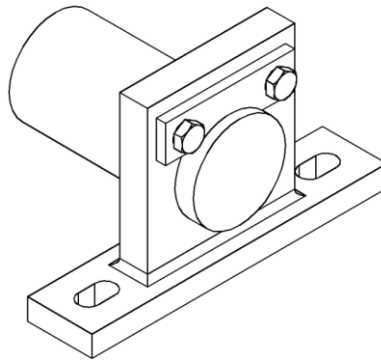


Figure 5. Mounting detail

Examining the fixing requirements for both applications, it is seen that the standard plummer block arrangement is secured by means of bolts. From bearing sizes up to and including 140 mm, two-bolt fixings are used. Bearing sizes above 140 mm are secured by means of four bolts. The two-bolt fixings are normally adequately addressed from an accessibility perspective but the four-bolt units are the problem items.

In the latter case, the mounting face of the bearing is normally a universal column-type section with readily accessible bolts on the outsides but it is difficult to access the bolts on the inside. The fitter needs to be a contortionist of stature to be able to fasten and loosen the bolts on the inside.

The current norm in the industry is to design and use the same fixing arrangement used for the plummer block system for the internal bearing fixture arrangement. The logic is that 'if the client wants to change', he can have one or the other.

The real issue is that the strength of angle-flanged fixings is not governed by cap plates. The four-bolt cap plates require that the corresponding plumbers now become a four-bolt fixing. Moving forward with this idea means that all connections can be made with two-bolts which then nullifies the demand for a contortionist fitter to execute plummer block assemblies.

In developing this approach it becomes necessary for a new standard to be developed. The following drawing and table is proposed:

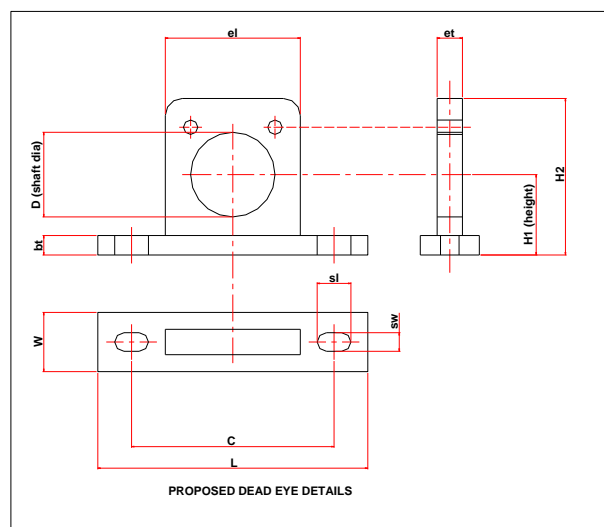


Figure 6. Proposed dead eye mounting details

Proposed dead eye dimension details												
Shaft dia	H1	C	L	W	et	el	H2	bt	Rad	sw	sl	bolt
50	70	170	250	70	30	90	120	23	15	22	40	M20
55	72	175	255	70	30	95	124	23	15	22	40	M20
60	75	180	260	70	30	100	130	23	15	22	40	M20
65	77	185	265	70	30	105	139	23	15	22	40	M20
70	80	190	270	70	30	110	145	23	15	22	40	M20
75	82	195	275	70	30	115	149	23	15	22	40	M20
80	85	200	280	70	30	120	155	23	15	22	40	M20
85	87	205	285	70	30	125	159	23	15	22	40	M20
90	90	210	290	70	30	130	165	23	15	22	40	M20
100	95	220	300	70	30	140	185	23	15	22	40	M20
110	109	254	350	80	40	158	204	28	15	26	48	M24
115	111	259	355	80	40	163	208	28	15	26	48	M24
125	116	269	365	80	40	173	218	28	15	26	48	M24
135	121	279	375	80	40	183	228	28	15	26	48	M24
140	124	284	380	80	40	188	234	28	15	26	48	M24
150	129	294	390	80	40	198	244	28	15	26	48	M24
160	150	340	460	100	50	220	280	38	15	32	60	M30
170	155	350	470	100	50	230	290	38	15	32	60	M30
180	160	360	480	100	50	240	300	38	15	32	60	M30
200	170	380	500	100	50	260	320	38	15	32	60	M30
220	180	400	520	100	50	280	340	38	15	32	60	M30
240	190	420	540	100	50	300	360	38	15	32	60	M30
260	200	440	560	100	50	320	390	38	15	32	60	M30
280	210	460	580	100	50	340	410	38	15	32	60	M30
300	220	480	600	100	50	360	440	38	15	32	60	M30

Table 1. Proposed dead eye mounting details

Note that the design of these dead eyes is for units in direct compression only.

The same configuration requires that keep plates be fitted to prevent the shafts from turning. It is proposed that the details as per DIN 15 058 are used for this application. This DIN only covers the size range up to 250 diameter shafts and the proposed range noted extends to 300 diameter shafts. For this reason an extension was derived from the existing table and accordingly proposed as per the following table.

EXTENSION TO DIN 15 058 FOR SHAFT SIZES OVER 250 UP TO 300												
Range	Shaft diameter	a	b	c1	c2	d1	f	g	h	Thread	Screw	Mass kg
over 250 to 300	260	70	20	300	240	31	134	31	40	M30	M30	3.297
	280						142	33				
	300						150	35				

Table 2. Extension to DIN 15 058 for shaft sizes over 250 up to 300

With the bolting out of the way, realism is required for fitting the dead eyes. Historically, these were fitted at the same centres as the bearings as per SANS 1669. On closer examination, the real issue is that clearance is required between the edge of the belt and any steelwork should the belt run off during running conditions. In opting for the single row of bolts for all sizes, these centres can be moved closer.

The industry does distinguish between wide and narrow bearing centres. What is not clear is how these sizes are derived. A simple rule would be to make the centres such that there is at least 100 mm clearance between the edge of the pulley and the support steelwork. An allowance is also required for the width of the dead eye.

The proposed arrangement has a 100 mm wide mounting width as being the largest. Formulating a rule then would mean that the fixing centres for all applications can be pulley face width plus 300 mm either side.

BELT WIDTH	SANS 1669		INDUSTRY NORM	INBOARD BEARINGS +150 PER SIDE
	FACE WIDTH	BEARING CENTRES	NARROW CENTRES	PROPOSED CENTRES
400	450	760		750
450	500	810		800
500	600	1050	810	900
600	700	1150	1020	1000
750	900	1350	1170	1200
900	1050	1550	1370	1350
1050	1200	1700	1520	1500
1200	1350	1850	1680	1650
1350	1500	2050	1830	1800
1500	1700	2300	1980	2000
1800	2000	2600		2300
2100	2300	2900		2600

Table 3. Proposed centres for inboard bearings

Due to the fact that provision for narrow bearing centres has not been published in the national pulley specification, the recommendation is to keep to the proposed centres. The crux of the matter is that once a decision has been made, one moves forward with it and eventually it will become the norm. A pulley working group should be petitioned to consider adding the proposed details to the standard at a later stage.

6. LUBRICATION

The successful operation and serviceability of a bearing is directly related to the quality of the lubrication. All bearings are fitted with seals and the purpose of the seals is twofold: one is to prevent the ingress of dirt and the other to retain the lubricant in the bearing.

With reference to pulleys equipped with external bearings, the majority of pulleys are fitted with labyrinth seals as the norm. This seal has no contact elements and has an extended

path through which the dirt must find its way before the bearing becomes contaminated. The other type of seal is a lip seal and the top of the range is considered to be the taconite type seal.

Lubricant retention in a labyrinth seal is by means of a simple ring of grease in the labyrinth path. The lubricant needs to be replenished more frequently in order to maintain acceptable operating levels. Lip seals have the disadvantage in that they have excellent lubrication properties but end up being pushed out when pumping fresh grease into the system during routine maintenance.

The taconite seal is considered extremely complicated from an assembly perspective to the point where it is virtually impossible to install it correctly without the aid of a specialist. These specialists are not readily available when maintenance is required on the units.

Pulleys equipped with internal bearings primarily make use of mechanical seals. These seals are excellent from a lubricant retention perspective and for the prevention of the ingress of dirt. For those who are familiar with pulleys being used in a stage loader for longwall applications, the pulley is literally running in slurry and the internal bearing with the mechanical seals is the only pulley that will give some service under these conditions.

The key issue with the seals is that the external bearings will require ongoing lubrication intervention while internal bearings could be considered as approaching the reality of being sealed for life. Direct comparisons indicate that external bearings require fortnightly intervention while internal bearings require annual intervention.

7. FINANCIAL IMPLICATIONS

Experience has indicated that the cost of producing one or the other arrangement is very similar from a capital cost perspective. The debate for deciding which is the better option is purely that of the technical issues.

The manufacturers have indicated that once they start producing this type of pulley in quantity, there should be a marginal financial advantage in supplying the pulleys fitted with internal bearings.

The financial implication from a total cost of ownership perspective is that less maintenance will be required for servicing the bearings. This cost is difficult to quantify as the end users have different approaches to these issues with respect to manning and frequency of maintenance actions.

There will be a distinct cost advantage in pulley refurbishment as it will not be necessary to replace the locking elements. The non-rotating pulley shaft is not subject to fatigue and may be re-used infinitely.

8. OTHER TECHNICAL CONSIDERATIONS

The majority of the South African industry specifications state a preference to Bikon, Tass, Ringfeder, to name but a few internationally acceptable locking element manufacturers and suppliers. There may be a clause with a statement to the effect that an equivalent component would be acceptable as well.

The fact of the matter is that the South African industry has not been directly supplied with these products for some time now. There is a local supplier manufacturing these products.

The point that needs to be made is that the pulley manufacturers are manufacturing their own brand or equivalent of these locking elements which are claimed as being the same and having identical properties to the imported units. This statement is made with the understanding that the local units are being made from locally produced steels as compared to the imported units being made from a different grade of steel.

In the final analysis, the different grades of steel equate to different strength values. One would thus expect to see different values from the one range to the other. If the local products use a higher grade steel, the equivalent rating of the local units should exceed that

of the imported units. As is common knowledge in the industry, these units have exactly the same rating.

On a similar note, the imported units are manufactured by companies specialising and dedicated to the manufacture of these units. The correct assumption is to state that these units are very high precision components and need attention to detail in the manufacturing process.

There are reputable pulley manufacturers in South Africa who supply their own units and have very successfully used them in their pulleys over a considerable period of time. Simplistically, the intention is to state that the end user must be aware of the fact that locking elements are a specialised field and that not everyone is in a position to correctly manufacture these units in accordance with the original specification and quality levels.

At this point it must be highlighted that pulleys fitted with internal bearings do not have locking elements and the problem thus falls away. In its place a bearing housing needs to be manufactured. The bearing housing comprises a single piece of steel which needs to be accurately machined to house the bearing. The accuracy of machining required for this application is equivalent to that which would be expected from a reputable company specialising in machining.

On the other hand, in addition to accurate machining, locking elements have taper faces which need to be made extremely accurately, complete with holes drilled and high strength bolts fitted and torqued to a specific value to supply the correct mounting pressure. This work should and must be left to the specialists.

The design of a bearing housing falls well within the capability of a pulley manufacturer. The accuracy of shaft machining for both applications remains the same. The accuracy of machining the end plate for fitting the bearing housing to the end disk is equivalent to machining the end disk for mounting the locking element. More care would be required for machining the bearing housing close to where the bearing needs to be fitted.

On projects which the author has worked on in the past, there were problems in procuring the plummer blocks. What is convenient about the internal bearing approach is that the timeous procurement issue of the plummer blocks falls away.

9. INTERNATIONAL APPROACH

The question as to what is happening internationally is relevant. The answer is that internal bearings are being used all over the world. Pulley manufacturers in Australia have pulleys with internal bearings listed as a standard product. The same applies to Europe and the author has personally supplied these units to the US as well. This serves to confirm that the idea is not novel and should be considered for use by the local industry.

10. MISCELLANEOUS

Further work will need to be conducted in determining the ultimate profile of the end disk for the internally fitted bearing.

Every manufacturer is in a position where they can design and develop their own bearing housing and equivalent highly efficient sealing arrangement. These designs will, in the long run, become their company signature as to how successful they will ultimately become in the industry with respect to quality of product and reliability from a time perspective.

11. CONCLUSION

- Plummer block bearings require specific attention and time to install correctly from a maintenance perspective
- Pulleys fitted with internal bearings do not require special attention when replacing pulleys during maintenance

- A four-bolt bearing arrangement is difficult to install from an application perspective. Two-bolt fixings are preferred and easier to manage overall
- Using pulleys with internal bearings is not novel; it is merely necessary to accept the paradigm shift that these units should be used more frequently by the local industry.

12. RECOMMENDATIONS

- Serious considerations should be given to specifying pulleys fitted with internal bearings on all future applications
- The national standard should be expanded to include the parameters stated for pulleys fitted with internal bearings
- Pulleys fitted with internal bearings are a proven product internationally and should thus be classed under the heading of proven technology for current and future projects in South Africa.

REFERENCES

SANS 1669 Conveyor belt pulleys Part 1: Pulley types, construction and dimensions.
DIN 15 058 ACHSHALTER AUGUST 1974

ABOUT THE AUTHOR

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To date the author has been directly involved in the conveyor industry for over 30 years. During this time he has been exposed to all facets of the conveyor industry ranging from mechanical design, manufacture, installation, commissioning, visual and forensic ore clearance audits and feasibility studies. The engineering of conveyor systems for both underground and surface applications are second nature to him. As current chairman of the Conveyor Manufacturers Association he is also actively serving on the SABS' technical committees responsible for reviewing the national standards relative to all conveyor related issues.

Highlights of his career are the four full patents and one provisional patent that he has registered as well as various firsts in conveyor installation conveyor systems like the first powered tripper drive in South Africa. Another milestone worth mentioning is the class 1250 PVC dual booster conveyor designed for an underground application at an overall length of 7 300 metres.

Current employment is with Bateman Engineered Technologies as project engineer responsible for the Kusile power station materials handling in the stockyard area.

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