ThermaCom

The Taming of The Screw

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“The Taming of The Screw”

If you use or maintain Screw compressors, then waiting for failure before effecting in depth maintenance could lead to some very expensive bills and inconvenience when least needed. The following describes a different approach to the routine overhaul of these increasingly popular compressors.

Screw compressors are now a very popular choice in both Refrigeration and Air-conditioning system applications of medium to large capacity. However, many users and maintainers are unaware of the importance of regular bearing replacement overhaul upon these machines.

The more familiar reciprocating compressor is routinely regarded as a *“ run it until it stops ”* machine, and with most popular models widely available from the re-manufacturing industry at a generally attractive price, most users and maintainers effect minimal routine maintenance to the compressor itself. Whereas much can be done to extend compressor longevity, most reciprocating compressors can be repaired, regardless of the actual nature and extent of a particular failure.

As a re-manufacturer we generally reckon about 1 in 10 exchange unit returns shall be beyond sensible repair. With plenty of redundant equipment available, we generally manage to make up this gradual loss and maintain a balance to the market demand.

This, alas, is not the case with Screw Compressors !

There are two principle designs of screw compressor in common use, twin rotor, and single rotor / star wheel (single or double star). Moving parts are restricted to one or two rotors with associated star wheels on the latter type. Additionally there is commonly a slide valve device providing capacity variation.

Critically the operational clearances between the rotors is extremely small, and herein lays a big problem when failure does occur.

Screw compressors run much faster than equivalent reciprocating type compressors, typically the drive motor runs just below 3,000 rpm on the UK 50 Hz supply, twice the speed of most reciprocating compressors. When a mechanical failure occurs much particulate debris is produced before the machine finally comes to rest, this normally due to: seizure, motor failure, safety device operation, or very occasionally manual shut down. Due to the very effective pumping action of the screw rotor profiles this debris is dragged and gouged through the Screw mechanism, and it’s tight clearances, produce yet more debris and damage in the process. It is this very effect that renders the machine very rapidly beyond effective or economic repair. As many as 3 out of 5 screws we receive that have suffered failure are beyond repair.

With far fewer machines present in the market, most models are simply not available as redundant castings, thus the only available option is the relatively high expense of a new compressor. Invariably failure shall occur at the least convenient moment, leading to an urgent and even more expensive repair solution

So what can be done ?

Firstly we must consider the nature of the failures experienced. Screw compressors are generally very robust compressors, and will routinely suffer external problems that would destroy the best reciprocating models. Thus it is necessary to look further into the actual construction of the Screw compressor to find the principle problem.

In order to achieve the close running tolerances and high operational speed plain bearings are simply not suitable, except on larger capacity industrial machines. Additionally there is a heavy tendency for the screw compressor rotors to pull toward the direction of the suction gas entry point, thus the designer makes considerable provision to oppose this effect. In virtually all makes and models of twin rotor type this thrust is resisted by “Angular Contact Ball Race Bearings”.

Rolling element bearings are subject to a finite fatigue life measured in billions of rotations, and whereas a billion sounds a lot, when divided by the operational speed of each revolving element within the bearing race, this actually resolves merely into a few tens of thousand hours operation.

Probably the commonest Screw compressor found in the UK air-conditioning water chiller market is the Hitachi SRM type Screw compressor. These compressors are certainly tough and very well designed. They are also quiet and power efficient. However, their Achilles heel is the routine requirement for a full replacement of all ten internal bearings

<u>Hitachi Screw Compressor</u>

We understand Hitachi recommend bearing overhaul of these compressors based upon the running time of the machine, and it’s application. Running time reduces with more arduous usage i.e. higher head operating pressure. Originally these compressors typically required service at 12,000 hours for the more commonly found air-cooled chiller units.

More recently Hitachi introduced a newer style of bearing from the original bearing maker, NSK, and they have now effectively doubled operating life recommendation for the bearing service interval, when using these newer bearings.

In our experience bearing failure of these compressors is commonly linked to other factors ...

1 Copper plating. This is prevalent in over 70 % of compressors we examine. If allowed to build up the generated copper debris interferes with the close running tolerances of the compressor bearings and rotors and leads to seizure. This problem is caused by trace quantities of moisture entrained within the fridge circuit, leading to electrolytic deposition of copper ions from the associated system pipework. In reciprocating compressors copper plate is generally an indication of system malaise, but rarely

actually causes compressor failure. However, the copper plating severely impairs the close running tolerances required by the screw compressor, leading to binding or excessive loading upon the rolling element bearings.

2 Light load running. Whereas these compressors will tire more quickly at high head pressures, compressors that run consistently at low load settings generally display more internal wear than fully loaded machines, thus we recommend staging of these compressors to allow full load running wherever feasible, obviously without pushing the head pressure through the ceiling.

3 Spalling of the bearing. Rolling element bearings do not actually wear in the conventional sense. Instead bearing failure is caused by a fatigue condition known as spalling. The rolling element is basically a malleable core with a case hardened shell. As each element (ball or roller) rotates under load it is microscopically squeezed out of shape by the applied loading. This effectively flexes the inner material of the element. Like all materials, metal under a flexing condition, below it's ultimate tensile strength, will be subject to fatigue, and after many millions of revolutions small fissures form beneath the hardened surface at the interface with the more malleable core. Eventually these fissures allow a piece of the surface material to flake off, and this is referred to as a spall.

Once the spall has occurred two immediate effects occur. The element can no longer roll smoothly and this causes massive build up of friction heat, accelerating the failure, plus the generated particles fouls the close operating clearance of the bearing, leading to complete failure of the bearing.

Critical to Screw compressors are the thrust bearings which bear the relatively high load caused by the natural tendency for the screw rotors to pull towards the direction of the incoming suction gases. If this control of thrust is lost the immediate effect is a catastrophic failure as the screw rotor effectively collides with the stationary housing at the suction end, leading to secondary seizure and overheat damage. It is this secondary damage that renders the compressor irreparable.

The key point is that had the machine been stopped at any point prior to bearing failure for routine renewal of the bearings, the latter damage will almost always be avoided. The actual time period between initial spall and total failure can also be very brief and upon machinery expected to operate in a remote condition there is little chance for an operator to stop the machine. No conventional safety device exists to detect the actual failure in the early stages, thus the machine relies upon other safety devices to operate, e.g. fuses, thermal overloads, or circuit breaker.

Whereas other Screw compressor manufacturers such as Bitzer do not, to our knowledge, suggest specific intervals for effecting this routine maintenance, the actual technology employed is not dissimilar to the Hitachi models and therefore the running interval suggested for Hitachi could also be reasonably used as a similar rule of thumb for the other Makes.

Of the above High Hours running as the principle attributable problem to Spalling is probably the most common and certainly the most preventable failure. Thus periodic replacement of the rolling element bearings will extend life and whilst the compressor is dismantled any other gathering problems can be identified and corrected before further problems develop.

In Situ Overhaul Method

Replacing the rolling element bearings requires a good deal of direct experience, but is not a technically complex task. Providing the work is instigated prior to any signs of distress, many machines can be simply overhauled without removing the compressor from site, or even in many cases from it's bedplate.

It is most important to note that site inconvenience by using the 'In situ' method for Screw compressors is minimised, and providing no other damage is found within the compressor then complete removal is obviated. This aspect is a major advantage for the 'In situ' method and offers additionally substantial economy in the job overall, particularly when the compressor is sited on a roof or in an awkward plant room.

Not all Screw models are suited to the "In Situ" method, but even so prudent maintenance planning to include provision of replacement bearings either on or off site cannot be understated in terms of cost effectiveness and longevity of the machine itself.

Screw Compressors represent approximately 10% of the throughput at ThermaCom Ltd. Makes commonly overhauled include: Hitachi, Bitzer, Trane, Kobe, Daikin, Stal, Refcomp, Hall, McQuay, Carrier, Sabroe and York. If you require further information upon the techniques available to reduce maintenance and renewal costs upon these machines then why not give our technical staff a call.

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