A view of reciprocating compressor development

Sabroe reciprocating compressors have been providing reliable refrigeration solutions for over a century. The SMC 100 series has been the 'workhorse' of the industry since 1955, but of course, has been continuously developed over time to maintain the exacting demands for efficiency, low service cost/interval and, above all, reliability.

A 'state of the art' research and end-of-line testing facility, totalling over 3500 m^2, at Johnson Controls' headquarters in Denmark (Sabroe factory) provides the continuous improvement for existing products as well as the development of new products. This is one of the world's leading centres of technology for compressor and refrigeration development.

The humble reciprocating compressor is frequently regarded as 'old fashioned', says Derek Moore, Manager of Sabroe's product operations in the UK and Ireland, yet it continues to provide the highest operating efficiency and best life cycle cost for many refrigeration applications. There is often a discussion about speed, bore, stoke and maintenance which is, frankly, based on early 20th century views that do not reflect the significant technological improvements, or the operating experience, that has been gained over the years.

If the compressor design is optimised for the operating speed, the performance and longevity will equal or better that of many machines designed for lower speeds. The imperative is to optimise these parameters. For example, the SMC series has various stroke length options to suit different refrigerants, but even with the longest stoke, used for the lighter gases e.g. ammonia, we do not exceed a piston speed of 6 m/s, which is very modest when compared to the 25 m/s or more attained in a formula one racing car.

Moreover, speed is important and beneficial. It drives the hydrodynamic oil film in bearings and on the cylinder walls. In fact, it is the stop and reversal at top and bottom dead centre that causes a breakdown of lubricating film that can exacerbate wear. Sabroe's development programme led to specially hardened cylinder liners and piston ring materials that minimise these effects.

Reduced speed will extend the service intervals for most compressors, but what are the key drivers? The primary wear parts are the suction and discharge valves; the speed has negligible effect on pistons, liners and bearings and only minor effect on piston rings (if treated like the SMC). Again, development over the years has enabled Sabroe to predict the benefit of reduced speed and the extension to the inspection interval. No other manufacturer offers such precise guidance. Furthermore, the machine design has to be considered. For example, the SMC has a maximum design speed of 1500 rpm and may have a recommended service interval of 10000 h. If this machine is only operated at 1000 rpm, the service interval

would be extended to 15000 h. A comparable machine may have a maximum design speed of 1000 rpm, but does this mean that the service interval is 15000h? No, the recommendation could be a little as 3000h.

Similarly, debates over bore and stoke are esoteric. They affect the compressor design, but there is no “one size fits all” and it is inappropriate to try to apply the design parameters from one manufactures machine to another. Each will have been optimised for the specific range of speed, refrigerants, pressures, etc.

What has to be evaluated is the actual operation; the full load and part load performance, the annual operating and ambient cycle and the annualised service costs. The life cycle cost can then be calculated over the expected lifetime for the plant to determine the best solution for each application. At Sabroe, we have developed the sophisticated software to perform these detailed analyses.

Sabroe’s extensive R&D work currently involves over 20 projects; from new product development to improving existing products. Two recent examples relating to the continued improvements of the SMC reciprocating compressor involve:

Firstly, significant new work has been undertaken to measure the behaviour and performance of the compressor valves in operation. This has provided a superior understanding of the valve behaviour resulting in new valve geometry and management which improves the operating efficiency over a wider range of refrigerants and conditions, without any penalty to the operating lifetime.

Secondly, variable speed drives have been beneficially introduced by many compressor manufactures, but it has long been recognised that particular frequencies can result in exceptional mechanical or torsional vibration. A substantial body of new research and testing has developed a design of base frame and coupling that allow Sabroe reciprocating compressors to operate over the full range of speed without any of the ‘skip’ frequencies that previously had to be avoided.

These are just two of the many developments that are continuing to extend the technological boundaries of existing products, both reciprocating and screw compressors, alongside the development of the products of the future.