Oil-injected or dry-running?

Producing clean compressed air in the food and beverages sector

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Introduction

Producing clean compressed air is vital for many processes where the risk of oil contamination within the compressed air system is unthinkable, such as in the food and beverage industries. During the process of planning a compressed air station, eventually a decision has to be made on the type of compressor to be installed. One major choice will be between dry-running or oil-injected compressors. In this whitepaper we provide a detailed comparison of both designs and highlight the key advantages of each compressor type, as well as which applications they are best suited to.

“Producing clean compressed air is vital for many processes where the risk of oil contamination is unthinkable”

Oil-injected versus dry-running

One major distinguishing factor among compressors is whether they are fluid-cooled or dry-running.

Fluid-cooled means that a fluid – often oil, but sometimes water – is injected directly into the compression chamber. Without this internal cooling mechanism, extremely high temperatures occur during the air compression process. The injected fluid therefore provides dual advantages: cooling action, on the one hand, as well as absorbing any contaminants present in the air, on the other.

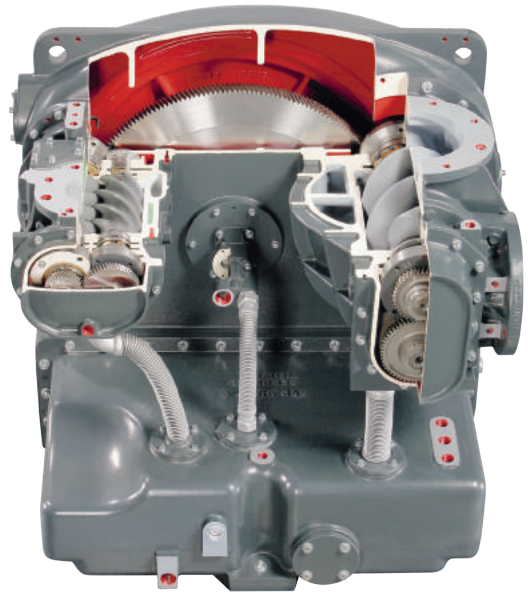
Then there are the dry-running systems, in which the compression chamber is not normally flooded with a fluid. Some common examples in the lower pressure range include rotary and screw blowers; as well as rotary screw compressors in the higher pressure range.

As in this type of compressor there is no fluid to deliver cooling action, the internal compressor temperatures are significantly higher. This is especially the case when operating beyond a certain compression ratio, and to compensate, dry-running compressors employ two compression stages to attain the required pressure.

The first stage compresses the air to an absolute value of around 4 bar, while the second further compresses it to within the range of 9 to 11 bar (absolute pressure). This extended process, as well as the interim cooling, condensate separation and pulsation dampening that must also be taken into account, results in elevated energy requirements. Ultimately, from an energy balance standpoint, this means that fluid-cooled compressors are more efficient as they deliver the same output with a single compression stage and lower temperatures.

Another somewhat misleading aspect is that dry-running compressors are often referred to as “oil-free”. In most cases, however, they are certainly not “free of oil”, as the compressor

bearings, for example, may likely be lubricated with oil. The compressed air produced by “oil-free” compressors is not necessarily “oil-free” either, as the compressed air discharged by a compressor is only as clean as the ambient air used to produce it. If this air contains micro-particles of oil, as a result of industrial or engine combustion processes, for instance, the compressed air will also contain such particles – unless the compressed air is treated downstream of the compression process.



So what criteria is relevant for determining which system is optimal in any given case?

It is often assumed that the main criterion should be the quality of compressed air required for a specific application. This is erroneous, however, as treatment of compressed air is almost always required to ensure an appropriately high level of compressed air quality. In fact, compressed air quality is defined according to a precise, graduated scale in ISO 8573-1, where smaller numbers indicate higher quality classes.

Compressed air quality classes below Class 4 (for particles), 4 (for oil) and 6 (for moisture) require that all types of compressor employ a suitable form of downstream compressed air treatment, such as dryers and/or filters, to achieve the required quality. This means the type of compressor technology used is not the main factor in determining compressed air quality, and as such, should not be the main factor in deciding between a dry-running and fluid-injected design.

Naturally, this raises the question of what are the relevant factors one should rely on when making the choice.

The differences between the two systems are evident when you take a look inside; for example, dry-runners have two compressor stages

Compressor selection criteria

The four essential criteria that will aid users in selecting the right type of compressor are:

Criterion 1: Pressure

The range of the required pressures or compression ratios is an excellent starting point.

Dry-running compressors are highly advantageous for compression ratios of 1:2 and 1:4 (applications that require absolute pressure values of 0.5 to 4 bar). In this lower pressure range, the compressors deliver their output with just a single compression stage and do not require any additional compressed air cooling. Quite the opposite, in fact: the resulting warm air is often advantageous for the compressed air applications themselves (e.g. pneumatic transport of cement).

Once the compression ratio exceeds 1:4, however, the situation changes. Beyond this value dry-running systems require a second compression stage, as described above – making the specific output of fluid-cooled systems superior, at least when oil is the fluid used.

In the pressure range from 1:4 to 1:11, oil-injected compressors are therefore more efficient than dry-running ones, based on specific output. They also have the advantage of delivering a greater range of higher pressures, easily providing compression ratios up to 1:16.

Conversely dry-running compressors require two stages beyond the relatively low ratio of 1:4 and even then are only capable of exceeding compression ratios of 1:11 in special cases.

Criterion 2: Size

In addition to the compression ratio, the size of the compressors is another important criterion.

Consider the following comparison of specific output: in the range from 2 to 100 kW, oil-injected compressors perform up to 20 percent better than dry-running ones. In the range from 100 to 250 kW this advantage falls to around ten percent and between 250 and 400 kW, falls yet further to around only five percent.

Oil-injected compressors cannot operate beyond 400 kW in isolation and are installed as tandem systems up to a maximum output of around 800 kW – yet dry-running compressors can individually deliver up to 900 kW of output. Turbo compressors are generally employed to achieve outputs beyond this value.

Criterion 3: Application

The application for which the compressors are destined also plays a key role.

If the determination is based exclusively on specific output, oil-injected compressors generally come out ahead.

There are some areas, however, in which dry-running compressors deliver certain technical advantages, especially when the nature of the work processes themselves requires high temperatures. For example, this applies to certain compressed air applications in the area of food manufacture, as well as jet mills and conveying granulated medium.

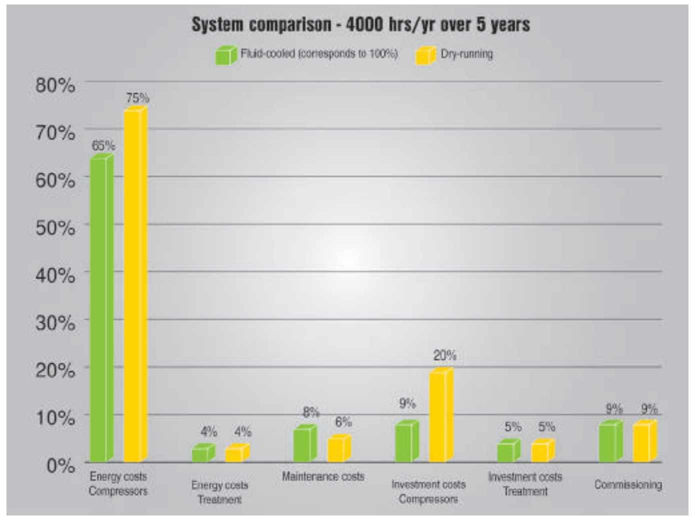
In these cases, the hot compressed air produced by dry-running compressors – which can reach temperatures of 200°C and beyond – is a huge benefit as the heat is already available and does not need to be supplied separately. This saves energy costs and improves the overall energy cost balance of the plant.

Dry-running compressors are often preferred for some applications, such as in the food and pharmaceutical industries, based on the argument that they do not contain any oil.

Since compressed air requires treatment regardless of its manner of production in order to comply with certain quality classes, this preference is not entirely based in fact and may be a result of emotional decision-making – while in other cases internal company regulations actually require the use of dry-running systems.

Criterion 4: Costs

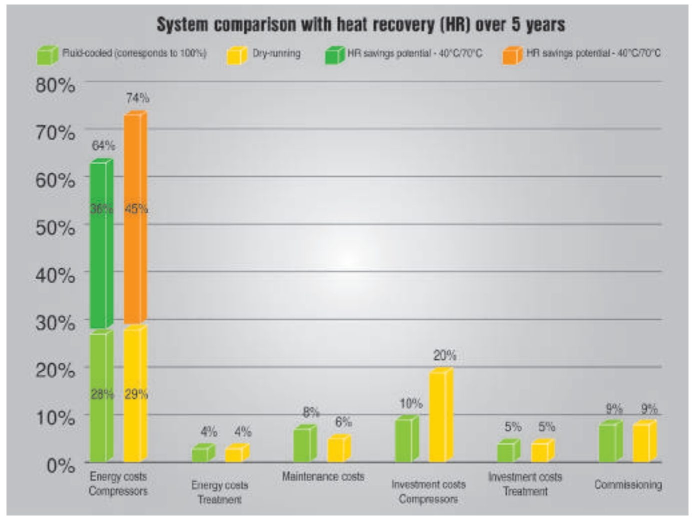
A more varied assessment results when the situation is examined from a cost perspective, taking into account the investment, acquisition and maintenance costs. For instance, oil-injected rotary screw compressors are considerably less expensive than dry-running systems in terms of acquisition and energy costs, yet they are slightly more expensive when it comes to maintenance (comparison based on 4000 operating hours over five years). In all other respects the costs associated with each system are comparable.



System cost comparison between an oil-injected and dry-running rotary screw compressor system

If heat recovery is included in the calculations, however, the balance changes depending on the temperatures required.

System cost comparison between an oil-injected and dry-running rotary screw compressor system with heat recovery

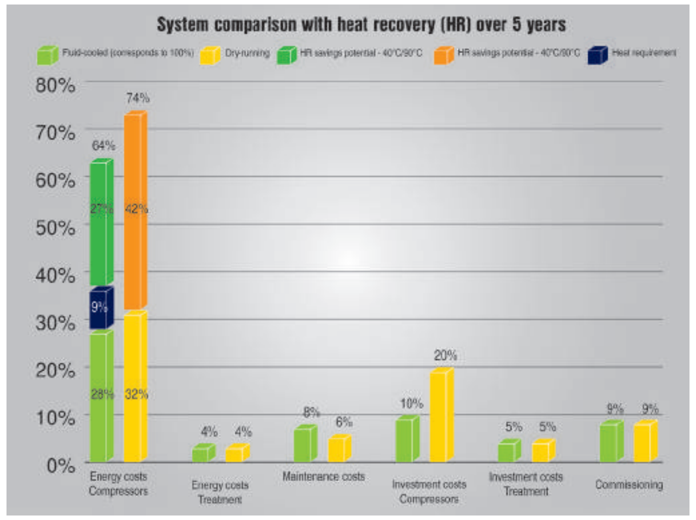


Oil-injected compressors can easily generate temperatures that allow for usage up to 70°C as part of a heat recovery system while dry-running compressors offer an even larger range, extending up to 90°C.

If process water is required at temperatures between 40 and 60°C, for instance, oil-injected compressors can deliver total energy cost savings of up to 36 percent, while dry-running systems can achieve savings up to 45 percent.

The cost situation is more clear-cut when higher temperatures up to 90°C are required.

In this range dry-running compressors offer a significantly greater advantage, delivering potential savings of 42 percent as compared to just 27 percent for oil-injected systems. This is because in the latter case, the difference between the temperature generated by the compressor and the target process temperature must be compensated for through additional heating.



System cost comparison between an oil-injected and dry-running rotary screw compressor system with heat recovery (HR)

"Dry-running compressors are often preferred for some applications, such as in the food industries"

Conclusion

As always when considering compressed air systems, it is impossible to make a universally valid statement about which system is preferable.
Oil-injected systems offer decisive advantages in terms of specific output and costs while dry-running systems provide certain benefits in specific output ranges and for some specific applications.

On the other hand, in many cases sector-specific regulations or internal company regulations explicitly require the use of a particular type of system.

Perhaps the only general rule is that it is always advisable to study each individual case in detail before deciding which system best meets the needs of the specific application.

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