

# SCREW COMPRESSOR SERVICES

Takao Koga, Kobelco EDTI Compressors Inc., USA, describes how oil free screw gas compressors can be used for dirty or difficult gas services in oil refinery plants and other industries.



**T**here are three main types of process gas compressor: centrifugal (API-617), reciprocating (API-618) and screw (API-619). Among the above three types of process gas compressors, while oil injected screw gas compressors have been developing various new applications by replacing reciprocating compressors (especially for high pressure (up to 1500 psig) and hydrogen services in oil refineries), the demand for oil free screw gas compressors is returning once again and is increasing due to recent stricter environmental requirements.

Generally, screw compressors are positive displacement types, but are rotational so that this compressor is categorised as being inbetween centrifugal and reciprocating compressor (Figure 1). As a result, the following are advantages of using screw gas compressors:

- High reliability and long maintenance intervals. The maintenance interval is typically between four and five years. A spare compressor is not typically installed even for critical services.
- Low vibration and pulsation. The screw compressor utilises a positive displacement mechanism, which is continuously rotational. It provides continuously smooth gas compression from drawing to discharging so that pulsation from the compressor is negligible. There is no pulsation issue with a rotary screw compressor, and pulsation bottles are not required, so dampening is not an issue. This can provide simple foundation design.
- Ease of operation by stiff shaft design. Operation speed is always below critical speed so that there are no issues for and no unstable vibration above critical speed.

- Flexible operating conditions. Due to screw gas compressors being of the positive displacement type, they are flexible for various changes of operation such as pressure ratio changes and gas composition changes.

## General description

Figure 2 shows a cutaway drawing of a typical oil free screw gas compressor; there are two rotors inside the casing of the screw compressor. One rotor is referred to as male, and the other rotor is female. The male rotor and the female rotor keep a small clearance so no contact is made and their phasing can be kept. To keep

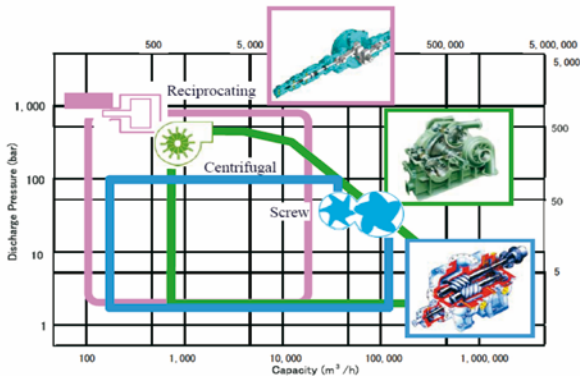


Figure 1. Applicable range of three types of gas compressors.

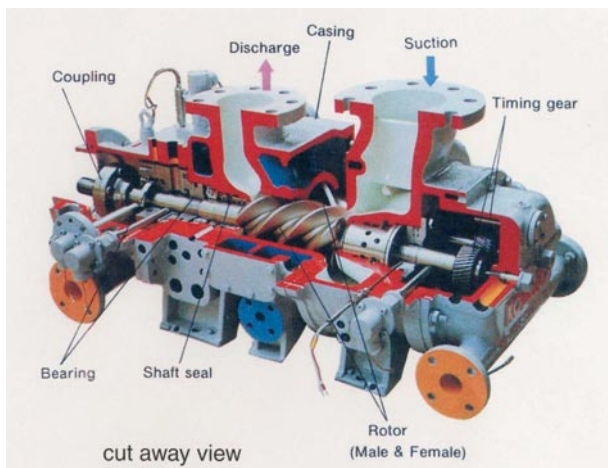


Figure 2. Typical cutaway drawing of oil free screw compressor.

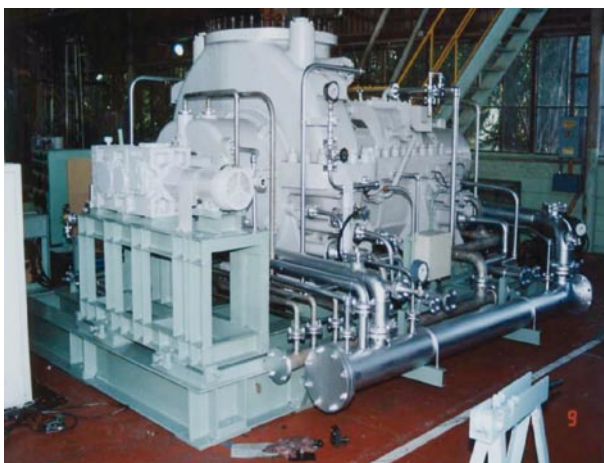


Figure 3. Oil free screw gas compressor for styrene monomer process.

phase with each other, a set of timing gears are furnished to drive another rotor.

To isolate the rotor lobe with oil free from bearing with oil atmosphere, a seal is furnished just beside the rotor lobe. There are several options for seal designs, for example dry gas seal (gas buffered dry gas seal or self acting dry gas seal), mechanical seal, bearing oil film seal, carbon ring seal, etc. There are journal bearings outside the seal area; a sleeve type is typically used. Thrust bearings are located on the outer side of the journal bearings, and a tilting pad type is typically used.

The major characteristics of the oil free screw gas compressors are as follows:

- Any gas can be compressed. Process gas is completely free of oil; there is no contamination at all so any gas can be handled with the oil free screw compressor. Thanks to the positive displacement compression even polymer gas or dirty gas, which contains impurities, can be easily handled without any concerns. This is one of the biggest advantages compared to oil injected screw gas compressors and other types of compressors.
- Nozzle arrangement is flexibly arranged to meet the character of handled gas and site piping plans. When process gas has condensation or liquid, a 'top suction and bottom discharge' nozzle arrangement is usually selected, because such condensation or liquid can be smoothly drained out of the discharge portion to avoid any excessive erosion and/or corrosion.
- The rotor speed is typically high, but never exceeds any critical speed, so there are no issues or critical speed problems. On the other hand, the rotor speed can be higher than an oil injected screw compressor, so oil free screw compressors can handle much larger gas volumes than oil injected screw compressors. The current maximum capacity of an oil free screw compressor is up to 110 000 m<sup>3</sup>/hr.
- Discharge temperature is typically high due to compression heat. To avoid excessive heat deformation, there is a cooling system on the casing jacket and holes inside the rotor shaft. Some applications utilise water or a solvent to cool the gas directly by injection into the rotor chamber from the suction portion.
- Due to its longer rotor span by seal area, rotor clearance and limitation of discharge temperature, there is a limit to the pressure ratio (up to approximately 5:1 - 6:1 ratio per stage, subject to the gas) but even 10:1 can be done with liquid injection at any single stage.

The main advantage of an oil free screw gas compressor is that 'any gas can be compressed'. Because process gas is compressed under conditions completely free of oil, there is no concern about the contamination during compression and its principle is positive displacement compression. Therefore, oil free screw gas compressors have been used for 'dirty or difficult gas services', such as refinery offgas, flare gas, vent gas, vapour recovery at onshore and offshore, coke oven gas, petrochemical process polymer forming gas etc., without any difficulties. For instance, even if tar or pitch is in the gas, an oil free

screw gas compressor can handle it. The impurities will be accumulated on the rotor surface and the compressor can run continuously with no problems. Also such gas composition is unstable and unexpected, but oil free screw gas compressors are suitable for such situations due to the above features.

Recently, since the environmental requirements have been getting stricter all over the world, no flare or vapour gas is allowed from oil refineries, offshore and other industries. Also wasted gas is being used for other purposes such as recovering hydrogen and utilisation as fuel etc. In such cases, highly reliable gas compressors are required under such severe operational conditions. An oil free screw gas compressor is the best suited for such offgas, flare gas and vapour recovery services in oil refinery plants, offshore and other industries.

In addition, in some applications dirty or difficult gas is required to be compressed with a large volume and high compression ratio. In such cases, a centrifugal compressor is not suitable because of the gas contents and high compression ratio (requiring multi casings) and a reciprocating compressor is not suitable because of the large volume and high compression ratio (requiring multi sets and also multi cylinders). As a unique and more economical option for this case, 'dry and wet' combination can be used. This consists of two stages. The first stage uses the oil free screw gas compressor, and second stage the oil injected screw gas compressor (because an oil free screw gas compressor is suitable for such dirty or difficult gas and large gas volume and an oil injected screw gas compressor is suitable for high compression ratio). So, by utilising the advantages of both types of screw gas compressors, this suitable option can be realised (Figure 6).


As indicated by the market tendency, dirty or difficult gas needs to be recovered and utilised for other process purposes and its gas pressure is normally quite low, almost the same as atmospheric pressure. Therefore it needs to be compressed. For this purpose, an oil free screw gas compressor is quite beneficial and suitable for its long term reliable operation. 



Figure 4. Oil free screw gas compressor for refinery offgas service.

## TYPICAL APPLICATION EXAMPLES

- Oil refinery gas:
  - ◆ Offgas.
  - ◆ Vent gas.
  - ◆ Flare gas.
  - ◆ Vapour recovery.
  - ◆ Coker process wet gas.
- Petrochemical process gas:
  - ◆ Styrene monomer offgas.
  - ◆ LAB H<sub>2</sub> recycling.
  - ◆ Butadiene gas.
  - ◆ CO<sub>2</sub> in soda ash plant HDPE.
- Offshore:
  - ◆ Vapour recovery unit.
  - ◆ LP and MP gas.



Figure 5. Oil free screw gas compressor for vapour recovery service on offshore platform.



Figure 6. 'Wet and dry combination' for Ladle Gas Service in steel mill.