



Experimental Study on the Performance of Single Screw Expander with 195 mm Diameter Screw

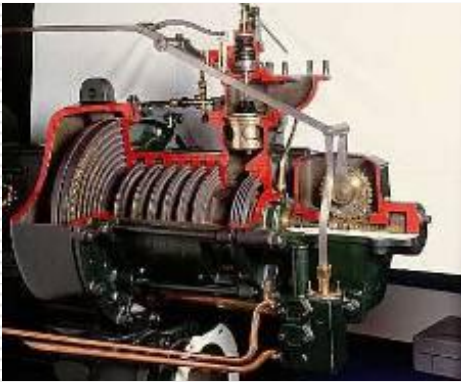
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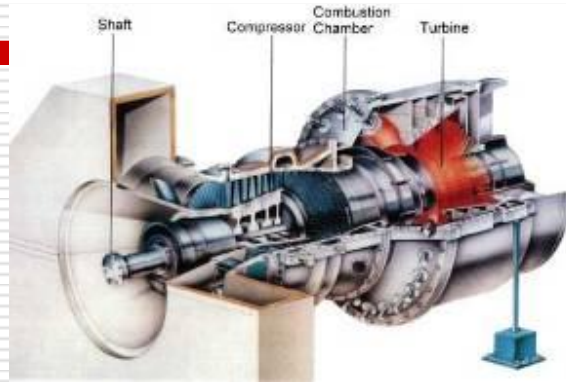
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Beijing University of Technology

Expander Types



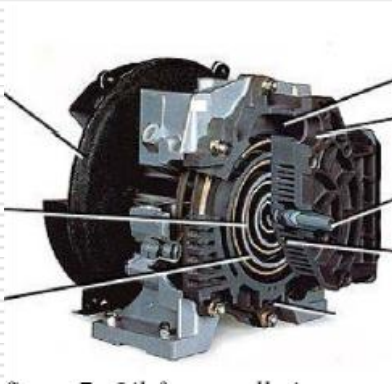
Steam Turbine



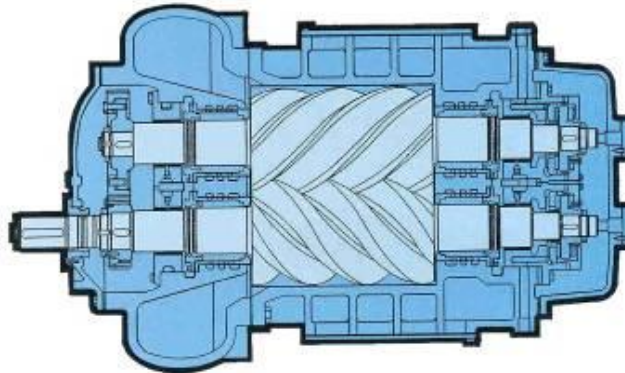
Gas Turbine



Piston



Scroll Expander



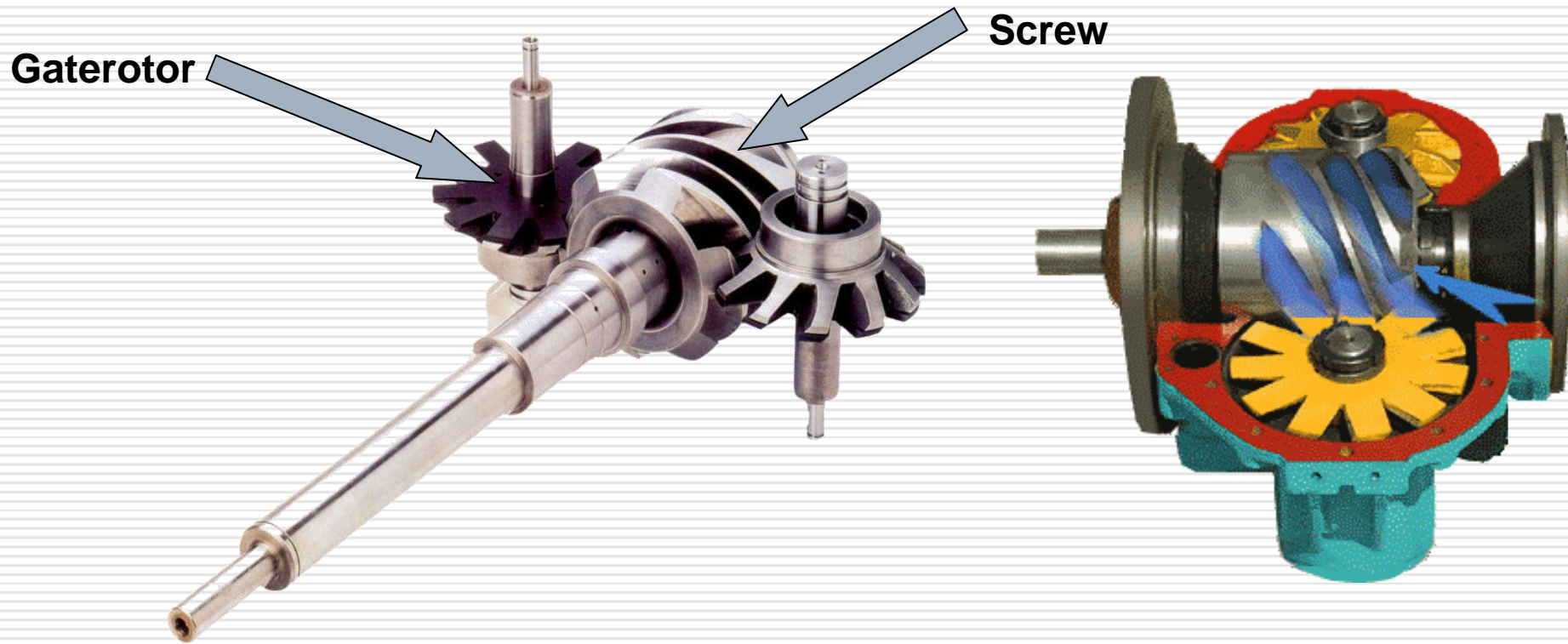
Twin Screw



Single Screw

1. What is Single Screw Technology

A machine which can realize volume change by means of a screw and two gaterotors!



Advantages of Single Screw Expanders

- long working life, balanced loading of the main screw, high volumetric efficiency, low leakage, low vibration and simple configuration;
 - Suitable for small/medium scale system from 1 to 1000 kW in power capacity;
 - Total flow expansion: allows admission of wet vapor, which raises cycle efficiency and decreases cost of heat exchangers. The expander is suitable for many kinds of heat sources such as overheated vapor, saturated vapor, vapor-liquid mixture, and smoky gas, waste gas, hot water etc.
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2. Application of single screw expanders in sustainable energy

2.1 Organic Rankine Cycle Power System

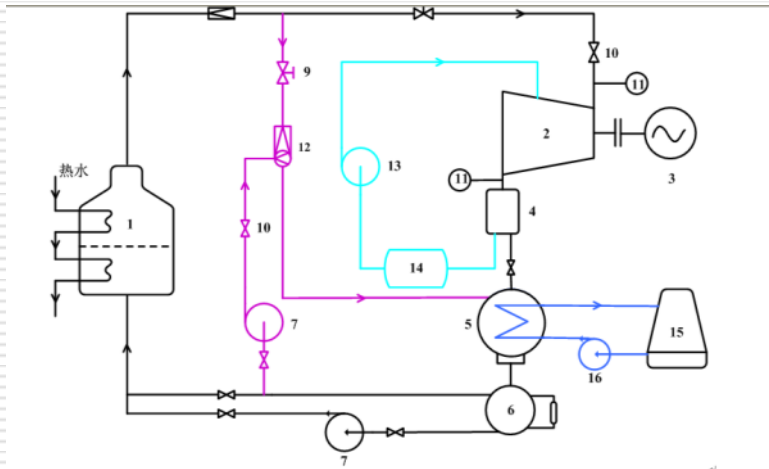
2.2 Waste Pressure Recovery

Our innovation solution:

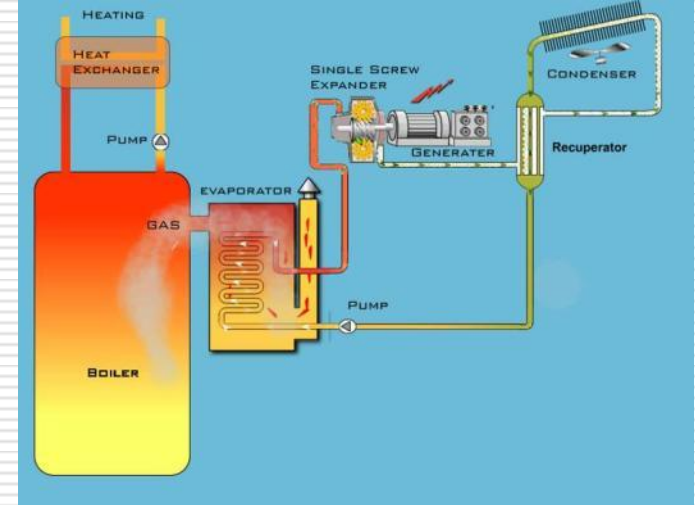
Single screw expander plus organic rankine cycle

2.1 Organic Rankine Cycle Power System

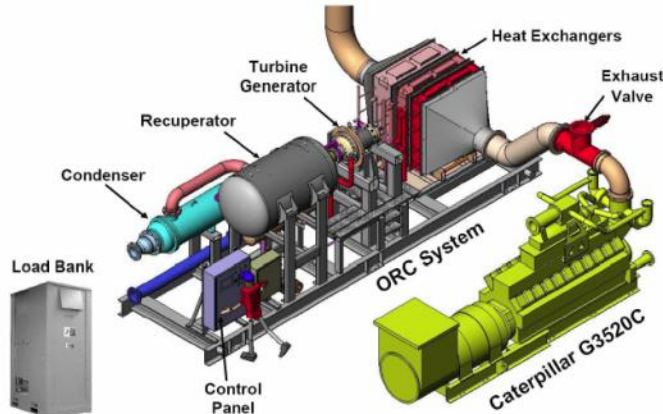
◆Waste heat recovery



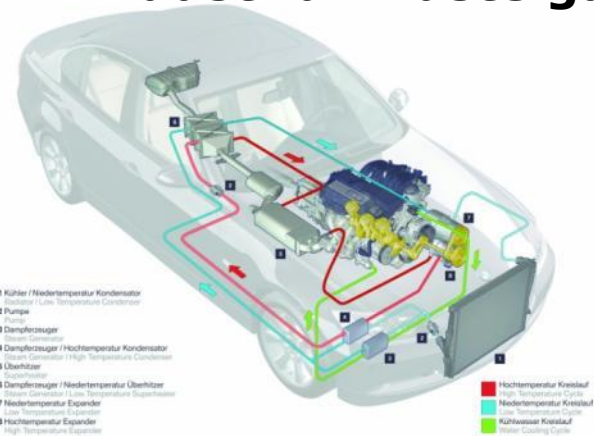
**Industrial Waste liquid
Demonstration System Layout**



Industrial Waste gas



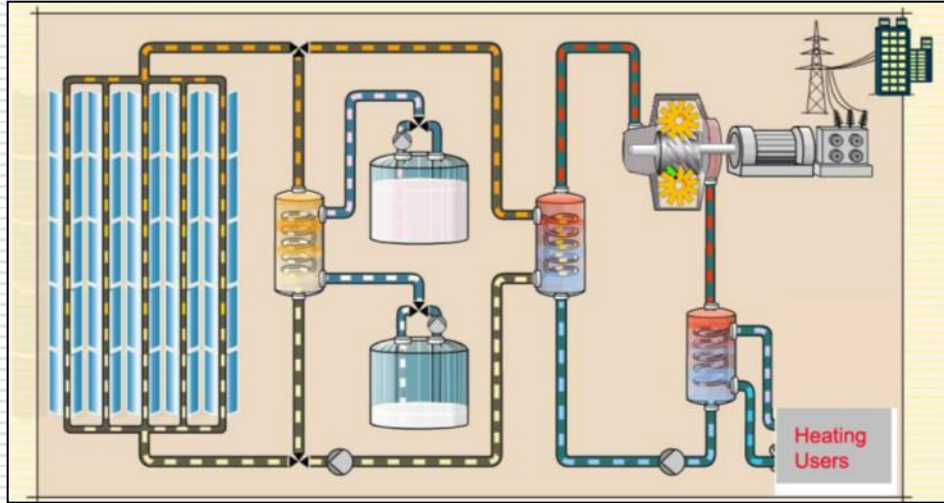
Fixed internal combustion engine



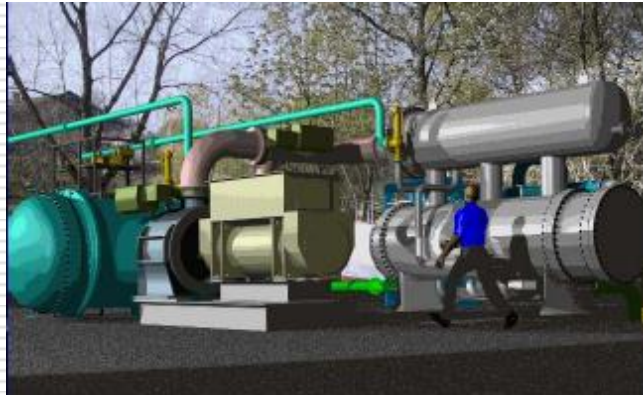
vehicle engine

2.1 Organic Rankine Cycle Power System

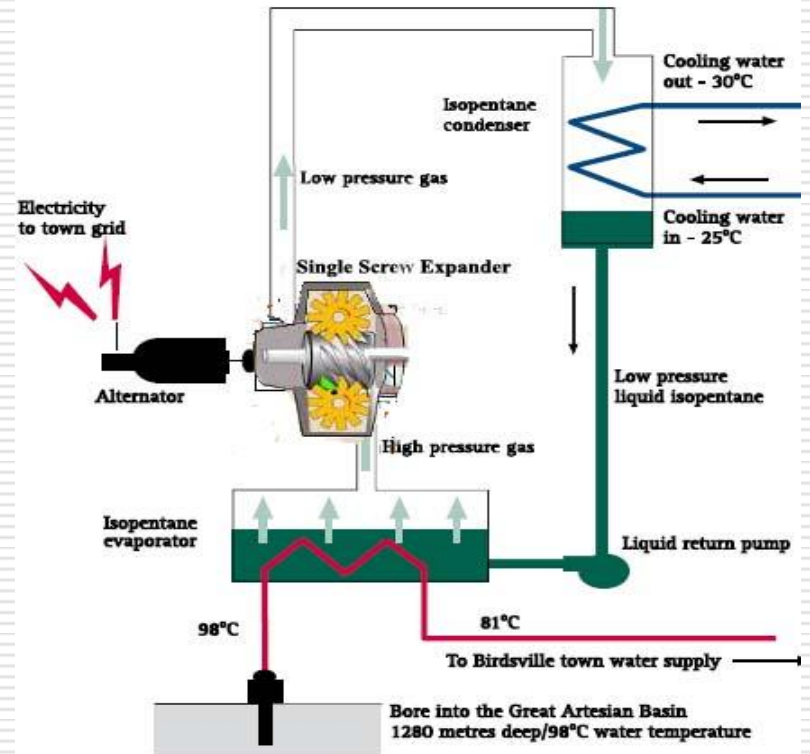
◆ Distributed Renewable Energy Power system



Solar Thermal Power

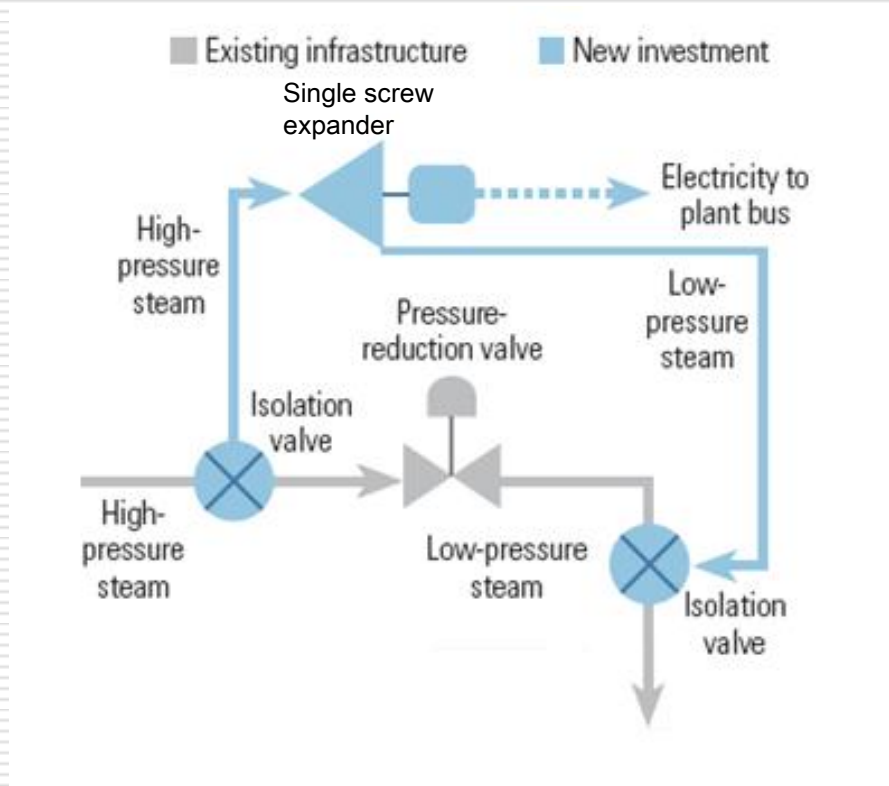


Biomass power system



Geothermal Power

2.2 Waste Pressure Recovery



Applied Area:

- ◆ Conventional Heating Network
- ◆ Steam Process
- ◆ Nature gas pipeline
- ◆ other gas process

By using single screw expander to replace pressure reduction valve, pressure energy can be recovery into electricity and cold energy.

3 Single Screw Expanders

the use of single screw machine as an expander is a new concept and no prototype of single screw expander except for those made by our team has yet been publicly reported

Developed four module Expanders

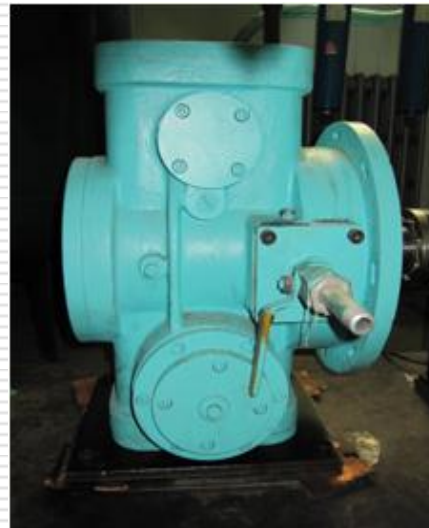
Φ117mm Screw



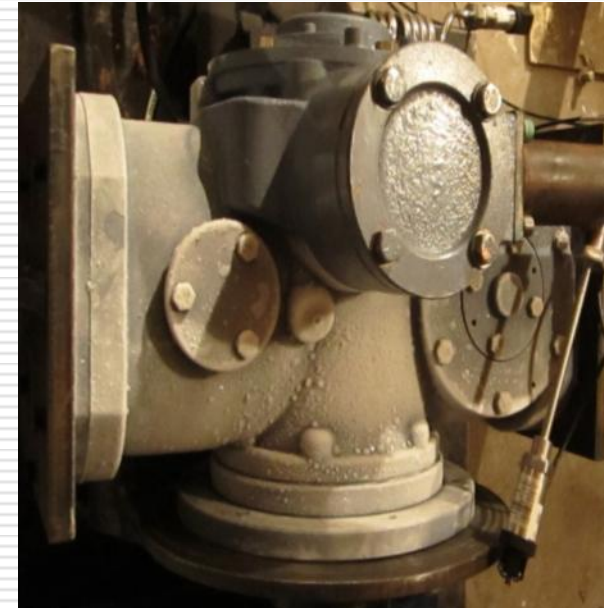
Φ155mm Screw



Φ175mm Screw



Φ195 mm Screw

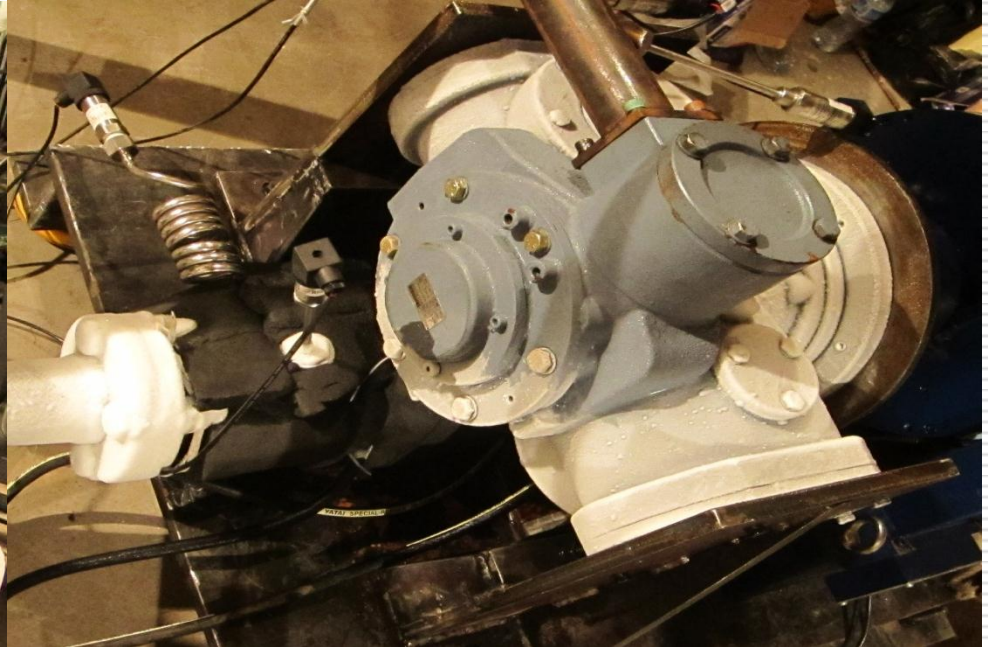




Experiment System

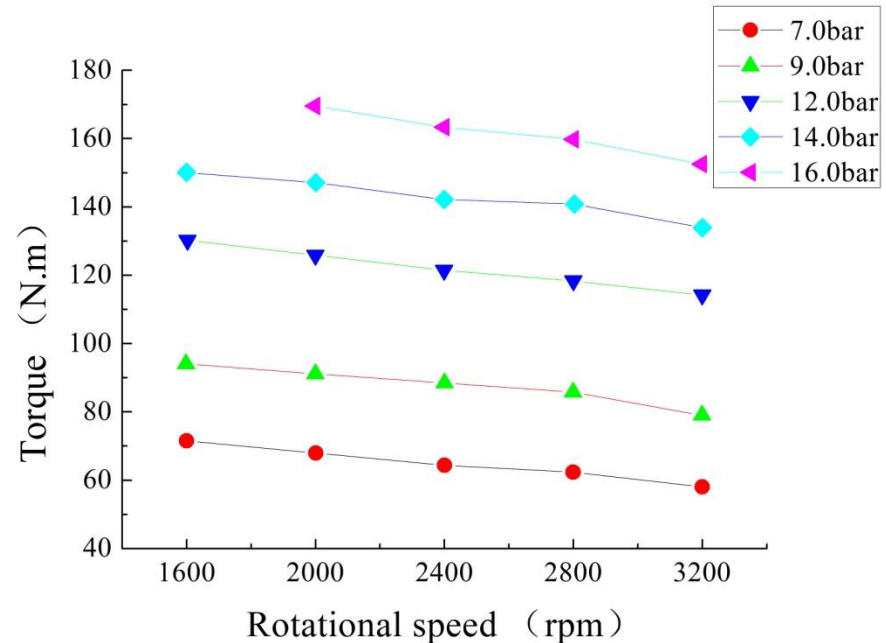
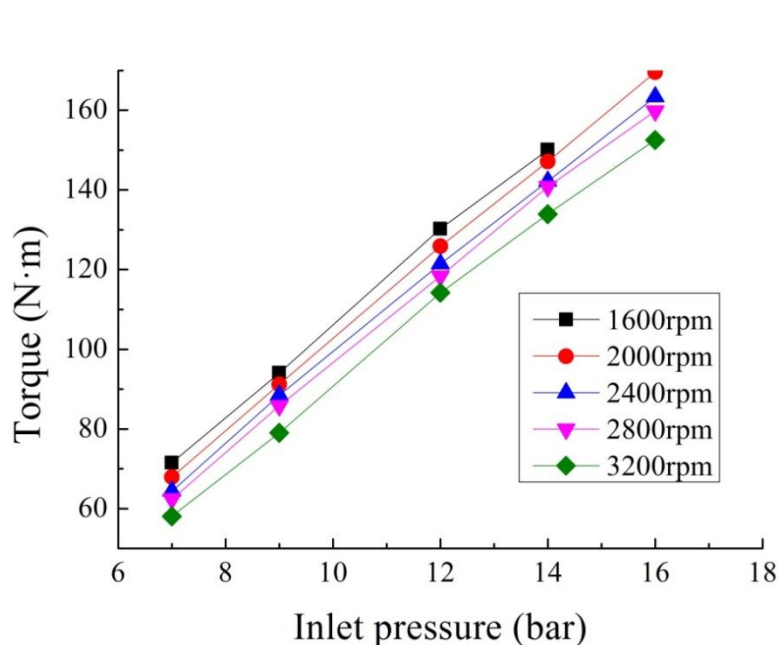
The experiment used compressed air as working fluid. Compressed air with different pressure from gas tank entered into single screw expander by adjusting the inlet valve. Exhaust gas led to outdoors. Through an eddy current dynamometer for the load, the shaft power of expander was changed to heat carried away by cooling water.

Frost phenomena of expander in work



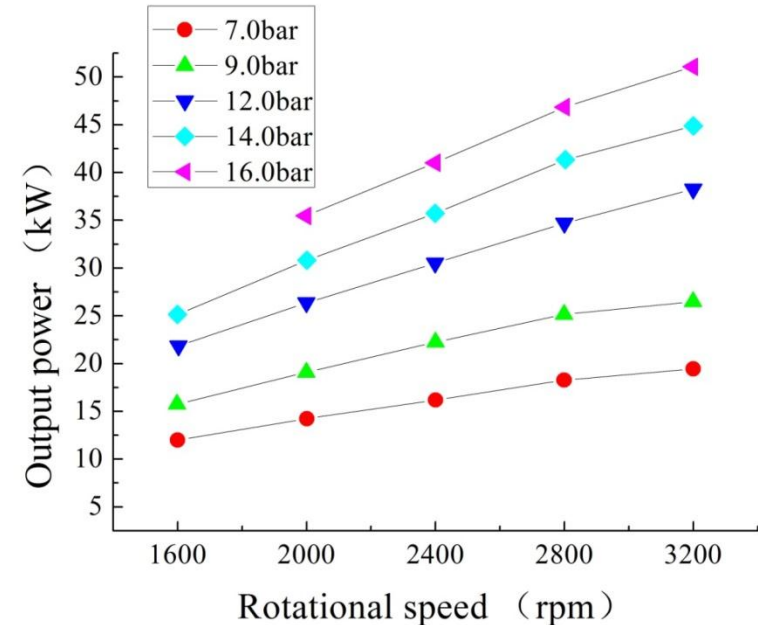
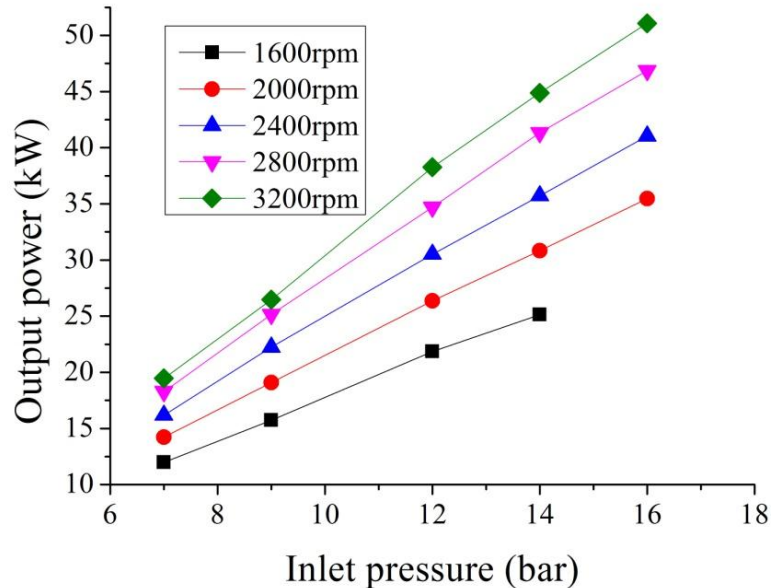
The lowest temperature is -78.63°C in the test, and the temperature drop is 87.20°C . The frost covers with the face of the oil-gas separator, export pipeline and the shell of the single screw expander.

Performance test



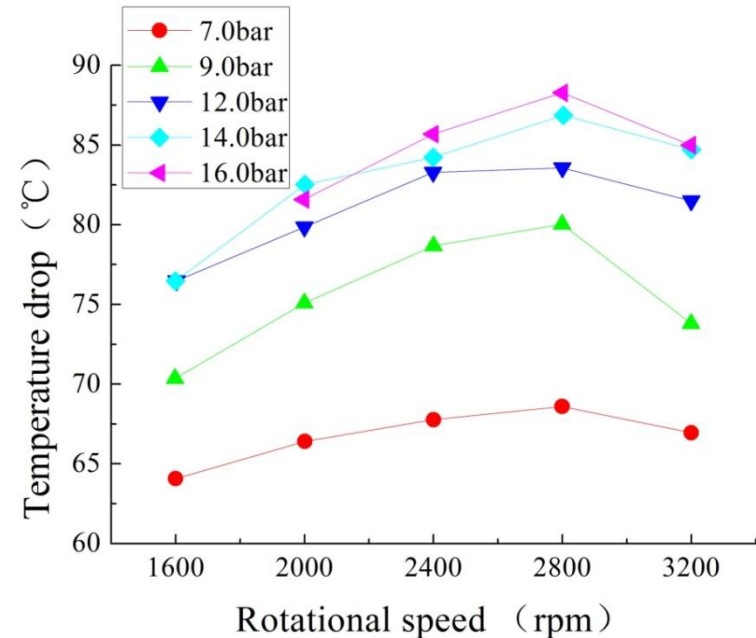
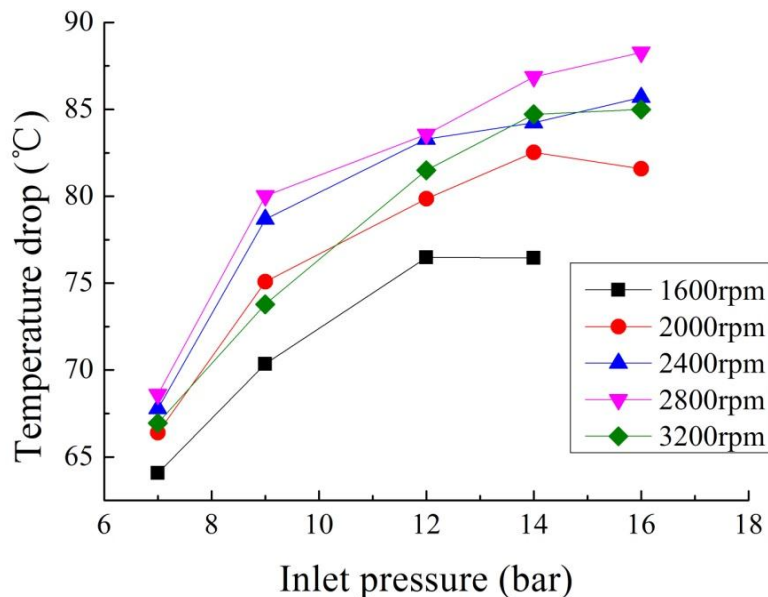
The torque has a good linear increase with the increase of inlet pressure, but has a decrease with the increase of rotational speed. So, the increasing of the inlet pressure or decreasing of the rotational speed can effectively determine an increasing of the engine torque. The biggest torque can reach to nearly 170N·m.

Performance test



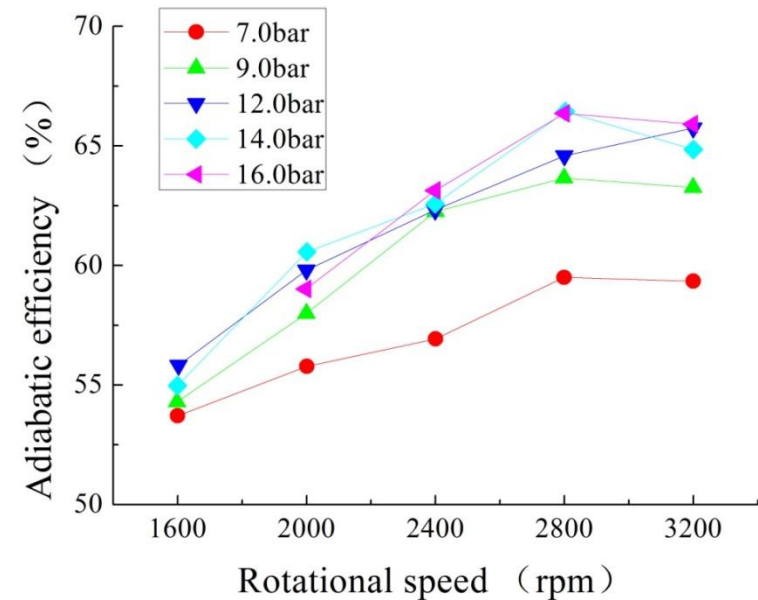
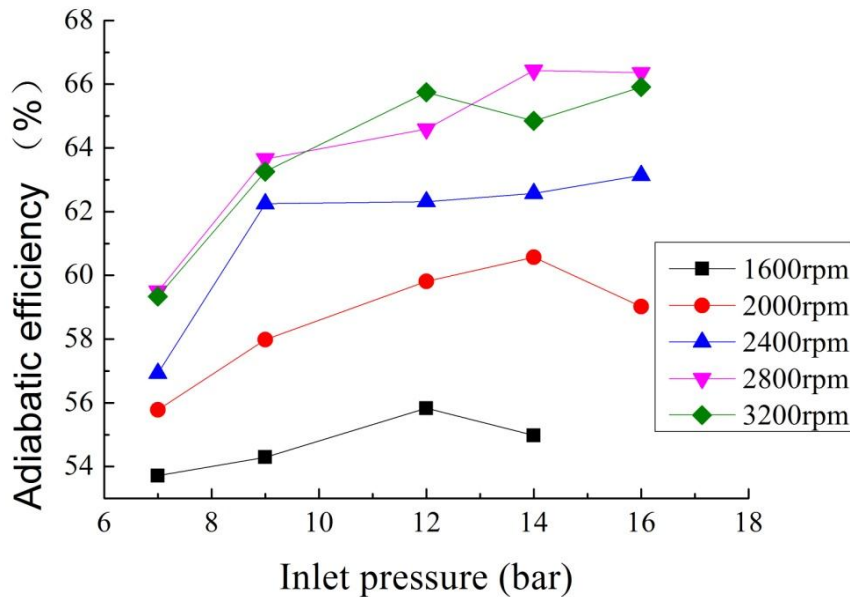
The output power increases with inlet pressure and rotational speed, for the intake mass flow increases with inlet pressure and rotational speed. The ability of work fluid increases with inlet pressure also.

Performance test



Temperature drop has an increase with the increase of inlet pressure and rotational speed. Generally, bigger temperature drop can be produced with higher inlet pressure. The biggest temperature drop is obtained with the speed of 2800rpm in the condition of high inlet pressure. The biggest temperature drop can reach more than 88°C. Therefore, good temperature drop can be obtained in the condition of high inlet pressure and high rotational speed.

Performance test

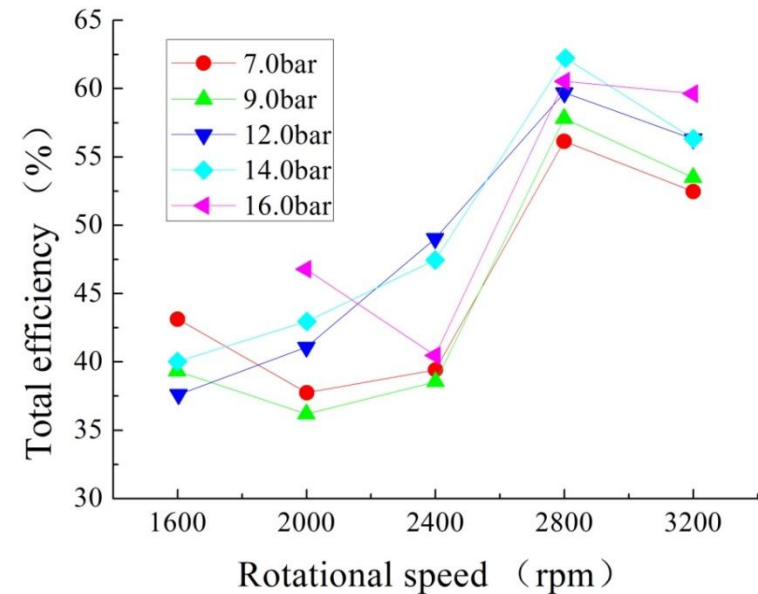
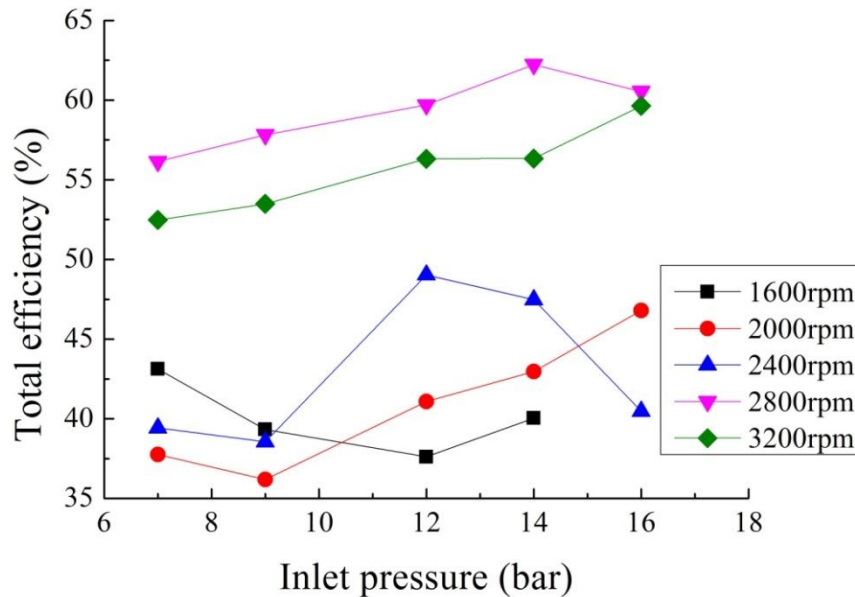


The influencing factors of adiabatic efficiency are irreversible losses, such as internal leakage, eddy current, friction and so on. From the figure, it is shown that the adiabatic efficiency increases with rotational speed obviously and the maximum is gotten at 2800rpm. With the increase of rotational speed, the intake mass flow is increased, the internal leakage decreases correspondingly.

$$\eta_{c,s} = \frac{\Delta h}{\Delta h'}$$

Δh is the actual enthalpy drop of work fluid between inlet and outlet of single-screw expander,
 $\Delta h'$ is the ideal enthalpy drop of work fluid during adiabatic processes.

Performance test



The total efficiency at 2800rpm is better than others with same inlet pressure and the max total efficiency, 62.23%, is gotten at the condition of 14.0bar and 2800rpm.

$$\eta = 100 \times P / P_k$$

P_k is the ideal output power during an adiabatic and reversible process.

Conclusions

- ◆Single screw expanders have a bright application in sustainable energy such as waste heat and pressure recovery , distributed renewable energy thermal power plants;
 - ◆The power output increases with the increase of intake pressure and rotational speed. The total efficiency is not regular, but can obtain best values at 2800rpm.
 - ◆Higher output power and higher total efficiency are along with higher intake pressure.
 - ◆For the self-developed single-screw expander, the highest adiabatic efficiency is 66.43% and total efficiency is 62.23%, respectively. The biggest power output is 51.08kW.
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Thank you for your attention
