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DEPARTMENT OF AGRICULTURAL ENGINEERING

COURSE CODE & NAME: 19AGT301 & HEAT POWER ENGINEERING

III YEAR / V SEMESTER

UNIT : IV IC ENGINE PERFORMANCE AND AIR COMPRESSORS

TOPIC 6 : Working principles of Stirling engine

A Stirling engine is a heat engine operating on cyclic compression and expansion of air or any other gas. It was once called hot air engine.

This engine was invented much before the invention of gasoline and diesel engines. In Stirling engine the working fluid is kept at different temperature levels. Because of this, there is a net conversion of heat energy to mechanical work.

The Stirling engine is vastly different from the internal-combustion engine used in automobiles. Invented by Robert Stirling in 1816, the Stirling engine has the potential to be much more efficient than a gasoline or diesel engine.

Principle of Operation

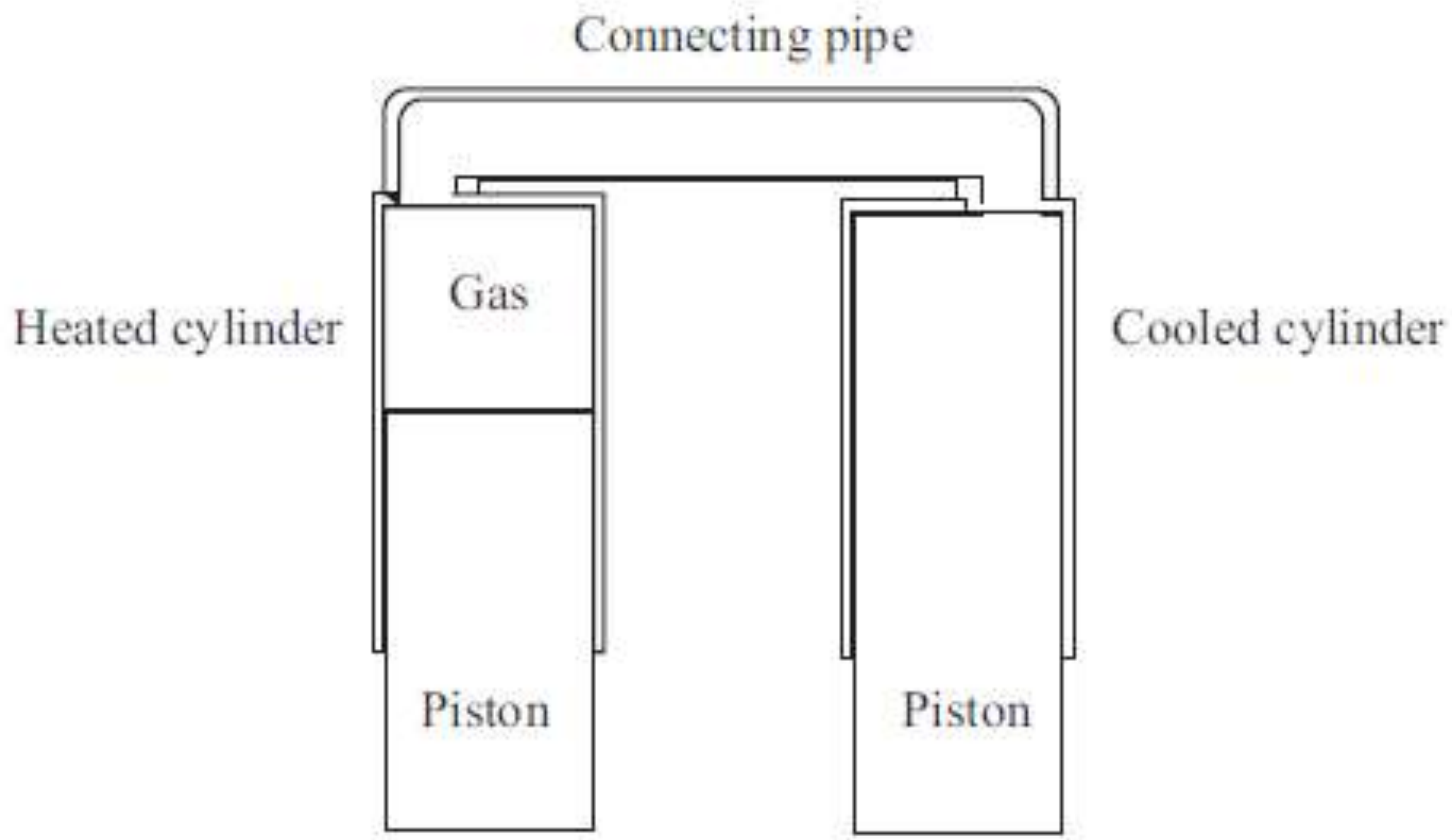

Fig. 20.13 Working Principle of a Stirling Engine

Types of Stirling Engines

There are two major types of Stirling engines. They are distinguished by the way they move the air between the hot and cold sides of the cylinder:

(i) The two piston alpha type: In this design, pistons are in two independent cylinders, and gas is driven between the hot and cold spaces.

(ii) The displacement type: This design is known as beta and gamma types. This type uses an insulated mechanical displacer to push the working gas between the hot and cold sides of the cylinder. The displacer is large enough to insulate the hot and cold sides of the cylinder thermally and to displace a large quantity of gas. There must be enough gap between the displacer and the cylinder wall to allow gas to flow around the displacer easily.

Alpha Stirling Engine

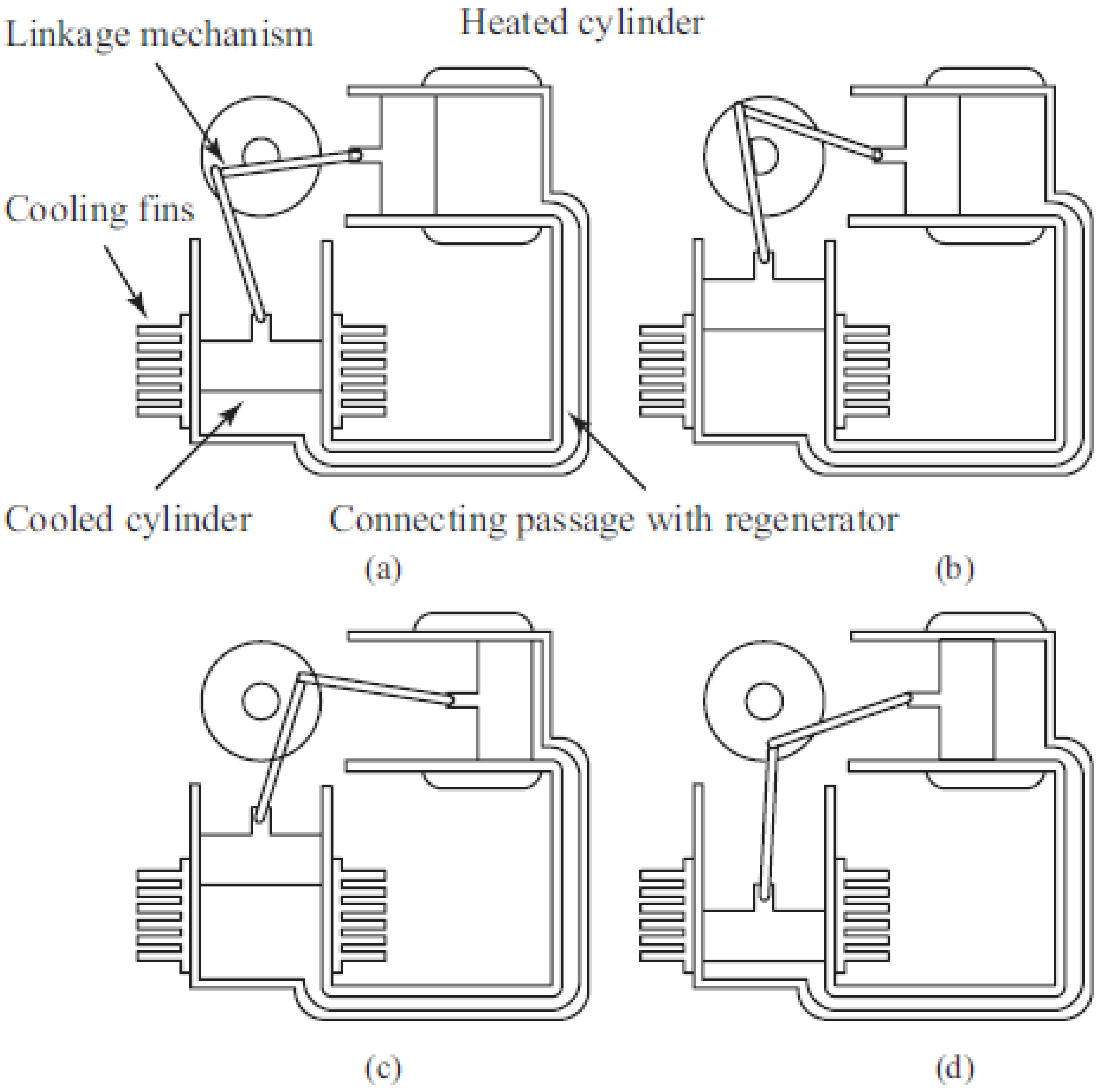

Fig. 20.14 Stirling engine

Beta Stirling Engine

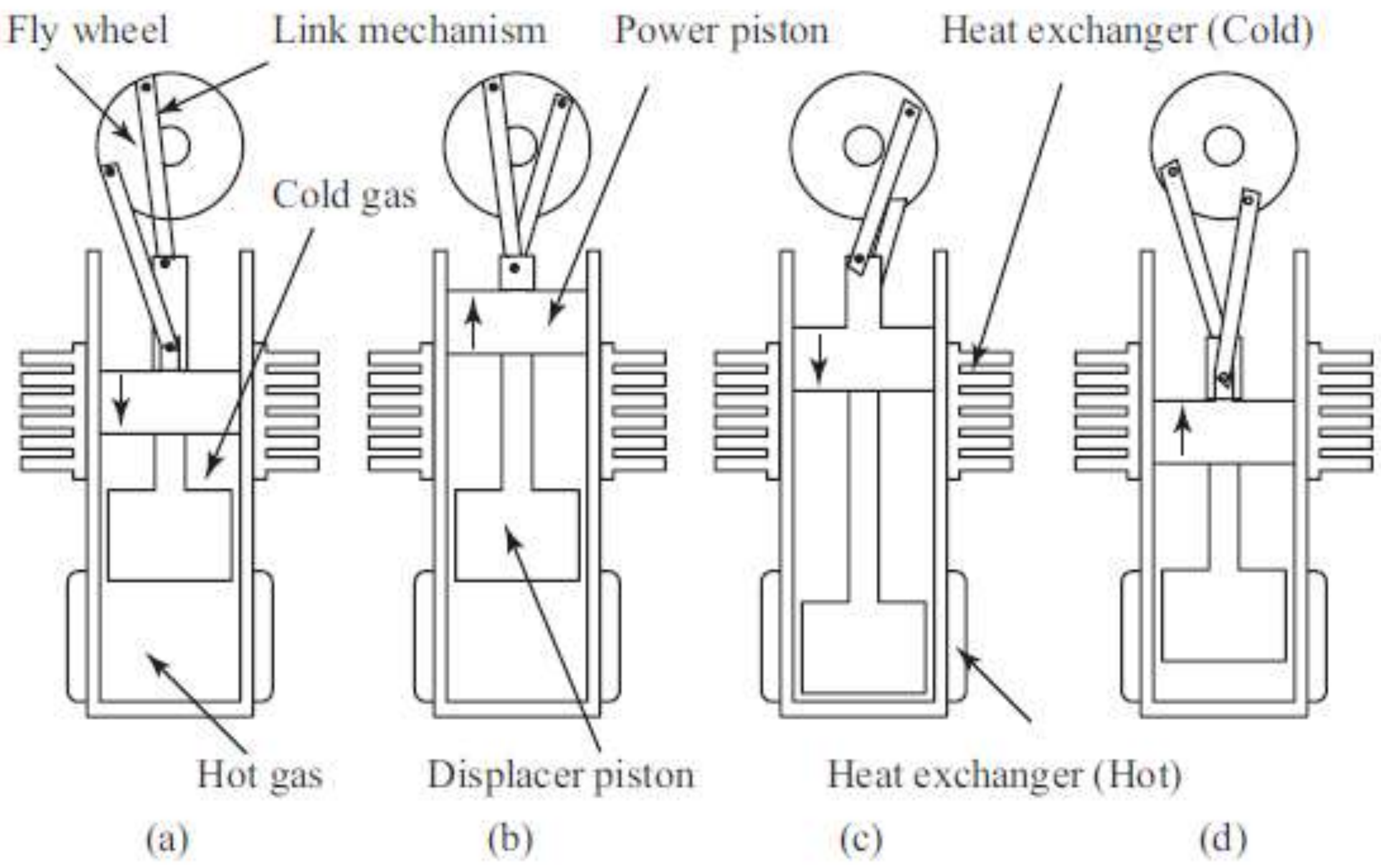

Fig. 20.15 Working Principle of a Beta Type Stirling Engine

Advantages:

(i) Stirling engines can run directly on any available heat source, not just one produced by combustion, so they can run on heat from biological, geothermal, nuclear sources, solar or waste heat from industrial processes.

(ii) A continuous combustion process can be used to supply heat, so those emissions associated with the intermittent combustion processes of a reciprocating internal combustion engine can be reduced.

(iii) Most types of Stirling engines have the bearing and seals on the cool side of the engine. They require only less lubricant and last longer than other reciprocating engine types.

(iv) The engine mechanisms are in some ways simpler than other reciprocating engine types. No valves are needed, and the burner system can be relatively simple. Crude Stirling engines can be made using common household materials.

(v) A Stirling engine uses a single-phase working fluid which maintains an internal pressure close to the design pressure. Thus for a properly designed system the risk of explosion is low. In comparison, a steam engine uses a two-phase gas/liquid working fluid, so a faulty release valve can cause an explosion.

(vi) In some cases, low operating pressure allows the use of lightweight cylinders.

(vii) They can be built to run quietly and without an air supply, for airindependent propulsion use in submarines.

Disadvantages:

Size and cost issues

(i) Stirling engine designs require heat exchangers for heat input and for heat output. They must be able to withstand the pressure of the working fluid. Note that the pressure is proportional to the engine power output. In addition, the expansion-side heat exchanger is often at very high temperature, so the materials must resist the corrosive effects of the heat source, and have low creep (deformation). Typically these material requirements substantially increase the cost of the engine. The materials and assembly costs for a high temperature heat exchanger typically accounts for 40% of the total engine cost.

(ii) All thermodynamic cycles require large temperature differentials for efficient operation. In an external combustion engine, the heater temperature always equals or exceeds the expansion temperature. This means that the metallurgical requirements for the heater material are very demanding, which is similar to a gas turbine. But is in contrast to gasoline or diesel engine, where the expansion temperature can far exceed the metallurgical limit of the engine materials. This is because the input heat source is not conducted through the engine, so engine materials operate closer to the average temperature of the working gas.

(iii) Dissipation of waste heat is especially complicated because the coolant temperature is kept as low as possible to maximize thermal efficiency. This increases the size of the radiators, which can make packaging difficult. Along with materials cost, this has been one of the factors limiting the adoption of Stirling engines as automotive prime movers. For other applications such as ship propulsion and stationary micro-generation systems using combined heat and power (CHP) high power density is not required.

Thank You