# RESEARCH ON NEW ISOCHORIC PROCESS

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***Abstract*— In a closed system at constant volume, the average molecule concentration is constant. However, the possibility of compressing a gaseous fluid at constant volume with a theoretically nil mechanical energy input has been studied at the Auroville Centre for Scientific Research (CSR). Only thermal energy is used. It can be solar and renewable. The process is explained and numerical calculations show its potential for the conversion of thermal energy into work.**

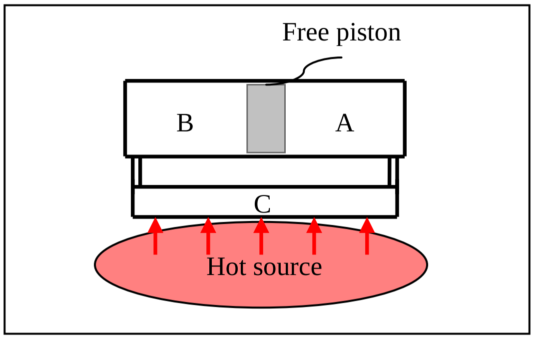
***Index Terms*— Isochoric process, isobaric process, hot source, heat exchanger, displacer piston.**

## INTRODUCTION

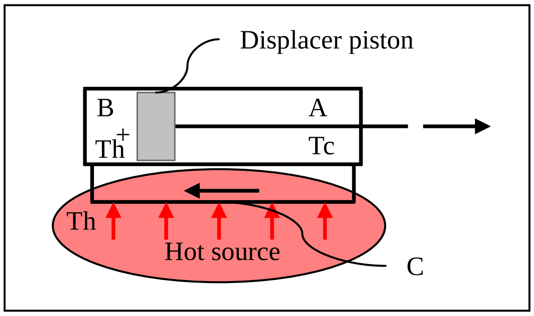
The compression of a gaseous fluid is defined as an increase of its molecular concentration by work exchange. If a gaseous fluid at constant volume is heated up, then its pressure increases, but there is no compression. On the other hand, if, at constant volume, the fluid is heated up locally then the localized variations of volume will provoke work exchanges with all the other molecules of the fluid.

A rigid and adiabatic container is divided into two compartments A and B by a free piston (cf. figure 1). A second rigid container C is connected to compartments A and B. The system thus defined is filled with a gaseous fluid which can circulate between the C container and compartments A and B. If we heat up the molecules of the fluid which are in compartment C, then the concentration decreases in C and increases in A and B. However the average concentration of all the gas molecules remains constant.

The CSR has discovered that it is possible to amplify considerably this compression effect in compartments A and B while using a C container of very small volume. We describe a device which, at constant volume, uses the thermal energy of a hot source. It allows the molecule concentration of a gaseous fluid to increase and to raise its temperature beyond that of the hot source which is heating it. It could be profitable to use this process to convert the thermal energy of a hot source into work.



Localized variations of the molecular concentration.
Fig. 1



Amplified variations of the molecular concentration.
Fig. 2

### *A. Description of figure 2*

Figure 2 shows a piston which displaces a gaseous fluid from compartment A to compartment B through a heat exchanger C. It is moved by a device which is not represented (cf arrow on the right). The displacer piston causes a pressure variation which is almost nil when it moves slowly. The heat exchanger is maintained at temperature Th, the temperature of a hot source.

The temperature and volume of a small cluster of molecules which passes by the heat exchanger from compartment A to compartment B increases. When it enters compartment B it is at a temperature which is equal (ideally) to that of the hot source and it then occupies a volume which is greater than what it occupied when leaving compartment A. Consequently, the volume of the other molecules of the fluid which remain in compartments A and B is reduced.

*There is a temperature and volume increase of a cluster of molecules when it is heated up while passing through the heat exchanger. It enters the hot compartment at the same temperature as the hot source before its volume decreases (since the other clusters increase in volume while passing through the heat exchanger). Its temperature continues to increase, by adiabatic compression, beyond the temperature of the hot source*. This temperature, higher than Th, is indicated by Th+.

The temperature variations occurring in compartment A and B come from the work exchange between the molecule clusters when they pass through the regenerator (where their volume increases) and all the other molecules of the gaseous fluid. The gas which is in compartment A undergoes an adiabatic compression before passing through the heat exchanger C. The gas which is in compartment B undergoes an adiabatic compression after its passage through the heat exchanger C. It is not the displacer piston which provides the compression. It is not the use of mechanical energy which provokes a temperature increase beyond Th: it is the thermal exchanges which provide this energy.

## II. METHOD

The thermodynamic processes has been defined and a simplified calculation method has been used in order to estimate the evolution of the pressure and temperature of the gas.

### *A. The system*

- Closed system, number of molecules n = cte
- Rigid container, volume total Vt = cte
- Ideal gas
- Compartments A, B and piston are adiabatic
- The volume of the heat exchanger Vc is regarded as very small in comparison to Vt: $Vc \approx 0$
- The displacer piston divides Vt into two compartments, A and B, of variable volumes Va and Vb. Since Vc is insignificant, we have: Va + Vb = Vt = cte.
- The displacer piston causes a pressure variation which is almost nil when it moves slowly. The energetic input of the displacer piston is supposed to be nil: $w \approx 0$ (no charge loss in the heat exchanger and no friction). The pressure in compartment A is supposed to be equal to the one in compartment B: Pa = Pb.
- Initial state: compartment A is full. The temperature of the gas in compartment A is Tc = 300k. Compartment B is empty.

### *B. The calculation method*

Clusters of nc molecules follow each other while passing through the heat exchanger. There, their volume and temperature is altered by thermal exchanges. Since the total volume is constant, a variation in volume (for a cluster of nc molecules) localized inside the heat exchanger is compensated by a volume variation which is equal and opposite and involves all the other molecules. The gas inside the compartments A and B undergoes an adiabatic compression. It goes through variations of volume, pressure and temperature. In order to quantify these variations, we have simplified the problem by using the method described hereafter.

A cluster of nc gas molecules passes through the heat exchanger. Its volume variation is equal to dVnc. If nc is small compared to the total number of n molecules, then dVnc is small compared to Vt. The smaller dVnc is compared to Vt the more the pressure variation is reduced. With a very small nc, dVnc can be calculated with a pressure considered as constant. According to this method, the smaller the nc, the more precise the calculation of dVnc.

The thermodynamic processes have been defined for a cluster of nc molecules located in compartment A, then passing from compartment A to compartment B:

1-adiabatic compression in compartment A. 2-isobaric heat addition in the heat exchanger. 3-adiabatic compression in compartment B.

Calculation of the volume variation at constant pressure for nc molecules passing through the heat exchanger with:

$$PV = nRT \qquad (1)$$

Calculation of the pressure variation by adiabatic compression of the molecules inside compartments A and B with:

$$\frac{PV}{T} = \text{const.} \qquad (2)$$

$$PV^{k} = \text{const.} \qquad (3)$$

Calculation of the temperature variations resulting from the adiabatic compression with:

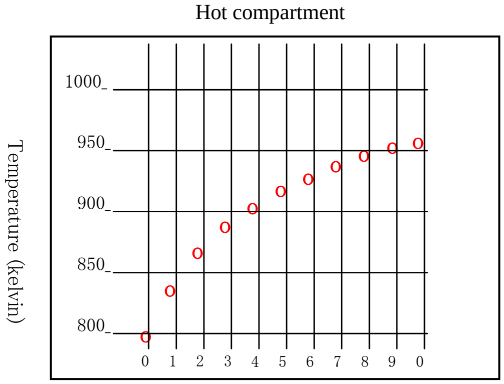
$$T2 = T1(P2/P1)^{\frac{k-1}{k}} \qquad (4)$$

The calculation of the change of temperature differs depending on whether a compartment is filled up or emptied. When a compartment is emptied, its temperature follows the pressure variations. When a compartment is filled up, the gas entering the compartment is at a different temperature than the gas already in the compartment. The gas entering in the hot compartment cools down the gas which is at a higher temperature than Th (with which it mixes). It limits the temperature rise above Th.

## RESULTS

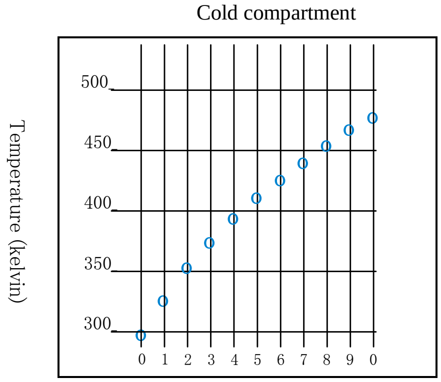
Figure 3 shows the change of temperature in the hot compartment for the values Tc=300k and Th=800k, with k=Cp/Cv=1.67 for an ideal gas. These are theoretical maximums, calculated without dead volume. The gaseous fluid enters the hot compartment at the temperature of the hot source Th. During the filling of the hot compartment, the temperature of the gas increases from 800 to 960k. The gas reaches the maximum temperature of 960k when the hot compartment is full.

Figure 4 shows the change of temperature in the cold compartment for the values Tc=300k and Th=800k, with k=Cp/Cv=1.67 for an ideal gas. These are theoretical maximums, calculated without dead volume. During the draining of the cold compartment, the temperature of the gas increases from 300 to 480k. The gas reaches the maximum temperature of 480k when the cold compartment is empty.



Filling the hot compartment

Fig. 3



Draining the cold compartment

Fig. 4

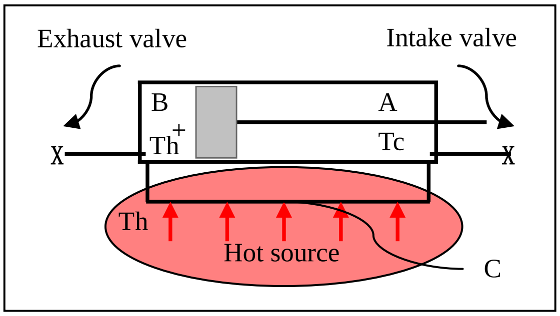
## IV. DISCUSSION

When a molecular cluster passes through the heat exchanger C, its concentration drops steeply. Now, for a closed system at constant volume (the volume A+B is constant and the volume C is constant), the average concentration of molecules is constant. Consequently, the concentration drop of the gas passing through C has to be compensated by a concentration increase of the other gas molecules. Thus, all the molecules which are in compartments A and B undergo an adiabatic compression. The compression work is performed by the molecule clusters passing through the heat exchanger C (where their volume changes).

*The compression of a gaseous fluid is defined as an increase of its molecular concentration by work exchange. The concentration increases in compartment A and compartment B from the initial state (compartment A full and compartment B empty) to the final state (compartment B full and compartment A empty). Thus, although the average concentration is constant, the compression of the gaseous fluid explain the rise of the temperature above Th in compartment B and above Tc in compartment A.*

*The system that we study is, thermodynamically, a compressor operating at constant volume without spending mechanical energy.*

The addition of intake and exhaust valves ensures a functioning in cycles (cf. figure 5). It is thus possible to use this process to convert thermal energy into work.



Compressor at constant volume

Fig. 5

## V. CONCLUSION

A device has been presented which uses the thermal energy of a hot source. At constant volume, it allows the molecule concentration of a gaseous fluid to increase without spending mechanical energy. It can produce a significant temperature increase above the temperature of the hot source which is heating it. It could be profitable to use this process to convert the thermal energy of a hot source into work.

## REFERENCES

[1] Remy Mercier “Research on new heat pump process” ICREU 2012. Auroville Centre for Scientific Research (CSR).

[2] Ahmad Fakheri “Heat Exchanger Efficiency” Journal of Heat Transfer, Vol. 129, SEPTEMBER 2007, pp. 1268–1275 .

[3] ASME Boiler and Pressure Vessel Code, Sec. VIII, Div. 1, Rules for Construction of Pressure Vessels, American Society of Mechanical Engineers, New York, ASME, 1998.

[4] Kays, W. M., and A. L. London, 1998, Compact Heat Exchangers, reprint 3rd ed., Krieger Publishing,Malabar, FL.

[5] Shah, R. K., 1991b, Industrial heat exchangers—functions and types, in Industrial Heat Exchangers,J-M. Buchlin, ed., Lecture Series No. 1991-04, von Ka´rma´n Institute for Fluid Dynamics,Belgium.

[6] Saunders, E. A. D., 1988, Heat Exchangers: Selection, Design and Construction, Wiley, New York.

[7] Walker, G., 1990, Industrial Heat Exchangers: A Basic Guide, 2nd ed., Hemisphere Publishing,Washington, DC.

[8] Shah, R. K., and A. D. Giovannelli, 1988, Heat pipe heat exchanger design theory, in Heat Transfer Equipment Design, R. K. Shah, E. C. Subbarao, and R. A. Mashelkar, eds., Hemisphere Publishing, Washington DC, pp. 267–296.

[9] Classification of heat exchanger: http://media.wiley.com/product_data/excerpt/10/04713217/0471321710.pdf

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