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A turbocharger assembly
Abgasturbolader
Ensemble turbocompresseur

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References cited:
DE-C- 4 218 145
US-A- 4 107 927
US-A- 4 400 945
US-A- 3 270 951
US-A- 4 376 617

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Description

[0001] This invention relates to a turbocharger assembly for an internal combustion engine.

[0002] The practice of supercharging internal combustion engines by means of turbochargers to improve their power output is well known. It is also known to provide turbocharger modules in which several turbochargers are mounted together in a wall of a supporting enclosure associated with a turbocharged engine, the turbochargers being mounted such that their turbine rotors project into the enclosure and their compressor impellers are outside the enclosure.

[0003] An engine utilising this arrangement is described in the publication LSM, August 1993, pages 53-54 "High Speed Variety - Paxman's new high performing 12 VP185 boasts a genuinely versatile design". In this prior art arrangement, two sets of 2-stage turbochargers are mounted in a single integrated unit tailored to the requirements of the engine for which they were designed. Another enclosure is disclosed in US 4 400 945 A. A turbocharger comprising a cooled wall enclosure is disclosed in DE 4 218 145 A.

[0004] However, problems have been experienced by certain prior art turbochargers, wherein heat from the hot turbine housing flows to cooler regions of the turbocharger via the turbocharger housing, so establishing a high thermal gradient between the turbine housing (which can be at red heat) and the cooler regions. If an engine has to be suddenly shut down under these conditions, the oil pump providing forced lubrication (and cooling) of the turbocharger bearings ceases to operate and the heat transferred to the bearings can be such as to cause carbonization of the lubricating oil in the bearings.

[0005] Accordingly, the invention provides a turbocharger module for a turbocharged internal combustion engine, comprising a plurality of turbocharger cartridges, each cartridge having a turbine rotor and a compressor impeller mounted on a common shaft running in bearings, each cartridge being mounted in a respective bore in a wall of a supporting enclosure such that its turbine rotor projects into the enclosure and its compressor impeller is outside the enclosure, characterised in that for each bore a face of a turbine housing is tightly secured to an internal surface region of the wall surrounding said bore, said internal wall surface region and said face being a good mechanical fit to each other thereby to provide a low thermal resistance path to heat flow by conduction from the turbine housing into the wall, each turbine housing receiving a turbine rotor of a respective cartridge therein, the cartridge being held concentric with the turbine housing by a contact region between the turbine housing and the cartridge, which contact region is substantially smaller in area than the area of contact between the face of the turbine housing and the internal wall surface region, the contact region providing the only significant region of direct mechanical contact between the turbine housing and the cartridge, whereby during operation of the cartridges, heat from the turbine casing is shunted away from the cartridges into the wall of the enclosure.

[0006] Conveniently, the contact region between the turbine housing and the cartridge comprises a spigot of the cartridge having a close fit in a circular register in the turbine housing. Except at the contact region between the turbine housing and the cartridge, an air gap is preferably provided between the outside of the cartridge and the turbine housing. A heat shield may shield the bearings from hot exhaust gases in the turbine.

[0007] Preferably, the wall of the enclosure is adapted to allow coolant to pass therethrough for cooling the wall.

[0008] A flange of each cartridge may be secured to an external wall surface region surrounding said bore. A compressor housing having a compressor outlet port may be assembled to the cartridge and secured in place by means of a clamping ring, the radial orientation of the housing with respect to the axis of rotation of the cartridge being adjustable so as to bring the compressor outlet port to any desired radial position.

[0009] Where the design is such as to allow exhaust gas leakage from the turbines and/or the ducting associated therewith, the enclosure may advantageously serve to collect such leakage and channel it to an exhaust duct. Alternatively, the enclosure may be made gas tight so as to allow a back pressure build up inside it thereby preventing further leakage.

[0010] Further aspects of the invention will be apparent from a perusal of the accompanying description and claims.

[0011] Embodiments of the invention will now be described by way of example, with reference to the drawings, in which

Figure 1 shows a plan view of a turbocharger module in accordance with the invention;

Figure 2 shows a plan view of three turbocharger modules in accordance with the invention;

Figure 3 shows a partly sectioned side view of Figure 2;

Figure 4 shows a plan view of a first diesel engine in accordance with the invention;

Figure 5 shows a plan view of a second diesel engine in accordance with the invention;

Figures 6 to 8 illustrate a turbocharger suitable for use with the invention.

[0012] Referring to Figure 1, a turbocharger module 100 comprises three turbochargers. Each turbocharger comprises a turbine housing, a compressor housing, and a cartridge assembly comprising a turbine wheel and a compressor impeller mounted on a common shaft, and bearings for the shaft.

[0013] A first turbocharger comprises turbine housing 1 and a compressor housing 2. A second turbocharger
comprises a second turbine housing 3 and a second compressor housing 4. A third turbocharger comprises a third turbine housing 5 and a third compressor housing 6. The turbochargers are mounted on the walls of a supporting enclosure. The construction of the turbochargers and their mode of support will be described later with reference to Figures 6 to 8.

[0014] The gas outlet of the first turbine housing is connected to the gas inlets of the second and third turbine housings in common via a branch conduit 10. The joints between the branch conduit 10 and the low pressure turbine housings 3, 5 comprise respective laterally-sliding flanges 50, 51 mounted with a close-clearance on their respective turbine housing flanges 52, 53. The respective ends of the branches of the branch conduit are axially slidably mounted inside the sliding flanges with a close clearance. The gas outlets of the second and third turbine housings 3, 5 are coupled to respective trumpets 7, 8 which direct the exhaust gas into an exhaust pipe, not shown. The first turbine housing 1 has a gas inlet arranged to receive exhaust gas at high pressure. The second and third turbochargers are symmetrically disposed on opposite sides of the first turbocharger. This arrangement provides a compact layout and allows the exhaust gas inlet pipe and the exhaust pipe to be disposed on a central axis.

[0015] The arrangement of one high pressure turbine in series with two low pressure turbines allows satisfactory performance to be obtained when a common design of cartridge is utilised for all three turbochargers. While acceptable performance may be attained by using a common design of turbine housing, it may be preferable for the first turbine housing 1 to be different from the second and third turbine housings 3, 5 in order to optimise efficiency.

[0016] The enclosure 9 has hollow walls to allow coolant to be passed therethrough. The enclosure has a lid, not shown in Figure 1, which is likewise of hollow construction. Apertures 11 allow for passage of coolant between the enclosure and the lid. The input and output connections for passage of coolant have been omitted from the figures for clarity. The compressor housings 2, 4, 6 have respective air inlet ports 13, 14, 15 and respective air inlet ports 16, 17, 18. The compressor housings can be oriented at any desired angle with respect to the enclosure and are secured in position by tightening their respective V-band clamps 12.

[0017] In Figures 2 and 3 three turbocharger modules 21, 22, 23, each as shown in Figure 1, are shown arranged in a line on an engine, for use as two-stage turbochargers.

[0018] In Figure 2, module 23 is shown with its lid 19 in position. Module 21 is shown partly cut away to illustrate the recess provided to allow clearance for the intermediate pressure duct 27b, 27c associated with an adjacent turbocharger module. Figure 3 is a sectional view of Figure 2 along III-III with all lids in position.

[0019] Each lid 19 has a respective seating 30 to accommodate a respective exhaust pipe 40 and sealing gasket 31. The seating is disposed about an aperture aligned with the ends of trumpets 7, 8 such that a clearance exists between the trumpets and the wall 32 of the aperture.

[0020] The base of each box has a respective aperture 41 to accommodate a respective exhaust conduit 42 which brings exhaust gas from the exhaust manifold, not shown, to the engine to a respective input port 111 of each high pressure turbine housing 1. In the present embodiment, the exhaust manifold is jacketed to prevent escape of any exhaust gas which might leak from joints in the exhaust system to the immediate vicinity of the engine. The aperture 41 provides communication between the space enclosed by the jacket of the exhaust, not shown, and the interior of the enclosure 9. The interior of enclosure 9 communicates with the interior of the exhaust pipe 40 via the clearance between the trumpets 7, 8 and the wall 32 referred to earlier. This arrangement allows any gas which may escape from joints in the exhaust ductwork to escape via the exhaust pipe.

[0021] Figure 4 shows an arrangement in accordance with the invention as applied to an 18 cylinder engine 400. Only the turbocharger modules and their associated ductwork and coolers have been shown for clarity. The engine has three turbocharger modules 21, 22, 23 arranged in a line along the engine. The turbocharger modules are connected to function as two-stage turbochargers. The respective outlets 14a, 14b, 14c of each of the second compressors 4a, 4b, 4c are connected in parallel to a first intermediate pressure (I.P.) air inlet duct 24a. The respective outlets of each of the third compressors 6a, 6b, 6c are likewise connected in parallel to a second I.P. air inlet duct 24b. Air at atmospheric pressure is brought to the inputs of the respective second and third compressors via air filters and ductwork which has been omitted for clarity. The first and second I.P. inlet ducts 24a, 24b terminate at respective inlet ports 25a, 25b of intercoolers 26a, 26b. After being cooled, the cooled air at intermediate pressure passes along one or more I.P. outlet ducts, not shown. In the present embodiment the engine is of Vee block construction with two rows of cylinders, and this duct may be conveniently routed in the space between the rows of cylinders.

[0022] Branch pipes 27a, 27b, 27c convey air from the I.P. outlet duct to respective input ports of the respective first, high pressure, compressors 2a, 2b, 2c of turbocharger modules 21, 22, 23. The high pressure outlet of compressor 2c is connected to an input port of an aftercooler 28 via a first high pressure (HP) duct 200, the outlet of high pressure compressor 2b to a second input port of aftercooler 28 via a second HP duct 201, the outlet of high pressure compressor 2a is connected to the input ports of the aftercooler via a balancing pipe 203 which communicates with both HP ducts 200, 201. After being cooled, the air leaving the aftercooler 28 is supplied to the inlet manifolds of the engine, not shown, via
The turbocharger comprises four principal components. These are

(a) a turbine housing 800
(b) a compressor housing 810
(c) a cartridge 850 comprising the moving parts of the turbocharger; and
(d) an intermediate portion 950 of the wall 90 of the housing 9.

The cartridge 850 comprises a compressor impeller 812 and a turbine rotor 814 mounted on a common shaft 816 running in bearings 809. The cartridge 850 has oilways 861 adapted to supply lubricating oil to the bearings 809 and an oil drain duct 862 for oil emerging from the bearings 809. The oilways 861 and duct 862 terminate in an axial face 807 of the cartridge 850. A heat shield 830 shields the bearings from hot exhaust gases in the turbine in known manner. The housing wall 90 has an oil feed conduit 802 terminating at a first face 803 of the wall 90 and arranged to communicate with the oilway 861 in the cartridge 850 when the cartridge 850 is inserted into the bore 851. The region 950 has a second face 803 adapted to engage with the axial face 817 of the cartridge 850. The thickness of the region 950 is such that, when face 807 engages face 803, the turbine rotor 814 is correctly disposed with respect to the turbine housing 800. The cartridge is held concentric with the turbine casing by a spigot 870 having a close fit in a narrow circular register 871 in the turbine housing 800. The cartridge 850 is secured to the second face 803 by fasteners 920 and washers 922 which engage tapped holes 924 in the region 950. On tightening the fasteners 920, the "O" ring seals 805, 806 are compressed to seal the oil feed and the oil drain connections.

Finally the compressor housing 810 is assembled to the cartridge 850 and secured in place by means of a Vee-section clamping ring 12. This allows the radial orientation of the housing 810 to be adjusted so as to bring the compressor outlet port 813 to any desired position. It will be seen that, on completion of the assembly, the region 950 becomes an integrated part of the turbocharger assembly, its thickness determining the alignment of the turbine rotor relative to the turbine housing.

It can be seen that, should a turbocharger become faulty in service, to replace the cartridge 850 carrying the moving parts it is only necessary to disconnect the air inlet duct (not shown) from the air inlet, the air outlet duct from the air outlet 803, remove clamp 12, pull off the compressor casing 810, release the fasteners 920 and withdraw the cartridge 850. A replacement cartridge can then be refitted in the manner described previously. It is not necessary to disturb the turbine housing 800 or the exhaust conduits coupled to the turbine inlet or outlet ports. Thus when, as in the embodiments described above, the turbine is mounted in a sealed enclosure, the integrity of the sealing of the enclosure is not broken. This affords simple and rapid turbine removal and replacement.

Attaching the turbine housing directly to the wall of the casing provides significant advantages in heat transfer, as much of the heat transferred from the exhaust gases to the turbine casing is diverted away from the bearings and flows directly to the wall whence it can be removed via the coolant therein. This avoids problems experienced by certain prior art turbochargers, wherein heat from the hot turbine housing flows via that portion of the turbocharger housing intermediate the turbine and the compressor to cooler regions and, should an engine have to be suddenly shut down and as a consequence, the oil pump providing forced lubrication (and cooling) of the turbocharger bearings ceases to operate, the high thermal gradient between the tur-
bine casing (which can be at red heat) and the cooler regions can be such as to cause carbonization of the lubricating oil in the bearings.

In the turbocharger described above, the relatively narrow annular region where the spigot 870 mates with the register 871 is the only significant region where direct mechanical contact offering a low thermal resistance exists between the hot turbine casing 800 and the cartridge 850 containing the bearings. The air gap associated with the relatively loose fit between the other regions provides an increased thermal resistance to heat flow by conduction. Further, the direct connection between the turbine casing 800 and the wall 90, which, as noted may be hollow to accommodate coolant, is via mating surfaces 871 and 807 which have been machined to provide a good mechanical fit, and which therefore provide a low thermal resistance path to heat flow by conduction, which path shunts heat away from the bearings within cartridge 850.

The arrangements described above are given by way of example only, and a number of modifications are possible within the scope of the invention.

While the type of turbocharger described above is preferred, it is not essential, and any other suitable turbocharger may be employed.

A balancing pipe may be provided where there are an uneven number of turbocharger modules. Alternatively, the inlet casing to a single (rather than twin) aftercooler may be used as a mixing plenum. The compressor outlets may be connected to the air inlets of their associated change air coolers via individual conduits rather than by means of branches to a common conduit. Where a jacketed exhaust is employed, this need not communicate with the interior of the housing which supports the turbochargers. While it is advantageous in the interests of manufacturing economy for all turbochargers to be identical, it is not essential. It may be found that to obtain the highest efficiency, the high pressure turbocharger needs to be different from the low pressure turbochargers. However, the arrangement will still provide significant space advantageous compared with arrangements utilising a single low-pressure compressor to supply a single high pressure compressor. The enclosure need not be water-cooled.

The enclosure may be sealed, with no communication between the interior of the enclosure and the exhaust pipe. The back-pressure developed within the enclosure will tend to inhibit further leakage of exhaust gas.

The enclosure need not be sealed. The support need not be an enclosure if the turbocharger is used on an engine which is installed in a situation where ventilation is such that the removal of the heat radiated by the turbines and the dissipation of any leaking of exhaust gas is not a problem. In such situations the turbochargers may be supported by their exhaust gas inlet and/or outlet ports or the ductwork connected thereto or by support brackets in known manner.

The intermediate pressure air conduit may comprise two or more discrete conduits rather than a single conduit. A number of groups of intercoolers and/or aftercoolers may be provided, distributed about the engine so as to minimise the length of air ducts.

The second and third compressors of the or each module may be connected in parallel with each other. Such an arrangement is particularly suitable for smaller engines requiring only one turbocharger assembly, but may also be utilised where a plurality of turbocharger assemblies are employed.

Claims

1. A turbocharger module (100) for a turbocharged internal combustion engine, comprising a plurality of turbocharger cartridges (850), each cartridge having a turbine rotor (814) and a compressor impeller (812) mounted on a common shaft (816) running in bearings (809), each cartridge being mounted in a respective bore (851) in a wall (90) of a supporting enclosure (9) such that its turbine rotor projects into the enclosure and its compressor impeller is outside the enclosure, characterised in that for each bore (851) a face (820) of a turbine housing (800) is tightly secured to an internal surface region (807) of the wall (90) surrounding said bore, said internal wall surface region and said face being a good mechanical fit to each other thereby to provide a low thermal resistance path to heat flow by conduction from the turbine housing (800) into the wall (90), each turbine housing receiving a turbine rotor of a respective cartridge therein, the cartridge being held concentric with the turbine housing by a contact region (870, 871) between the turbine housing and the cartridge, which contact region is substantially smaller in area than the area of contact between the face (820) of the turbine housing (800) and the internal wall surface region (807), the contact region providing the only significant region of direct mechanical contact between the turbine housing (800) and the cartridge (850), whereby during operation of the cartridges, heat from the turbine casing is shunted away from the cartridges into the wall (90) of the enclosure (9).

2. A turbocharger module according to claim 1, in which the contact region between the turbine housing and the cartridge comprises a spigot (870) of the cartridge having a close fit in a circular register (871) in the turbine housing.

3. A turbocharger module according to claim 1 or claim 2, in which except at the contact region between the turbine housing and the cartridge, an air gap is provided between the outside of the cartridge and the turbine housing.
4. A turbocharger module according to any preceding claim, in which a heat shield (830) shields the bearings (809) from hot exhaust gases in the turbine.

5. A turbocharger module according to any preceding claim, in which the wall (90) of the enclosure (9) is adapted to allow coolant to pass therethrough for cooling the wall.

6. A turbocharger module according to any preceding claim, in which a flange (817) of each cartridge (850) is secured to an external wall surface region (803) surrounding said bore (851).

7. A turbocharger module according to any preceding claim, in which a compressor housing (810) having a compressor outlet port (813) is assembled to the cartridge (850) and secured in place by means of a clamping ring (12), the radial orientation of the housing (810) with respect to the axis of rotation of the cartridge being adjustable so as to bring the compressor outlet port (813) to any desired radial position.

8. A turbocharger module as claimed in any preceding claim, in which the enclosure serves to prevent passage of any exhaust gas which may leak from the turbines to the immediate vicinity of the exterior of the enclosure.

9. A turbocharger module as claimed in any preceding claim, in which the enclosure comprises an aperture for passage of exhaust gas from the turbines, means to secure an exhaust pipe about the aperture in a gas-tight manner, and exhaust gas ductwork within the enclosure arranged to direct exhaust gas from the outlets of the turbines through the aperture, and to allow communication between the interior of the enclosure and the interior of the exhaust pipe such that any exhaust gas escaping from the turbines or the ductwork is free to escape via the exhaust pipe.

10. A turbocharger module as claimed in Claim 9 in which the enclosure is gas-tight so as to allow a back pressure to build up therein to inhibit further leakage of exhaust gas.

11. An internal combustion engine comprising one or more turbocharger modules as claimed in any preceding claim.

Patentansprüche

1. Turboladermodul (100) für einen turbogeladenen Verbrennungsmotor, das eine Mehrzahl von Turboladereinsätzen (850) umfasst, wobei jeder Einsatz einen Turbinenrotor (814) und ein Verdichterrad (812) aufweist, die auf einer gemeinsamen Welle (816) montiert sind, welche in Lagern (809) läuft, wobei jeder Einsatz in einem jeweiligen Loch (851) in einer Wand (90) eines haltenden Gehäuses (9) derart montiert ist, dass dessen Turbinenrotor in das Gehäuse hineinragt und dessen Verdichterrad sich außerhalb des Gehäuses befindet.


4. Turboladermodul nach einem der vorhergehenden Ansprüche, bei welchem ein Hitzeschild (830) die Lager (809) von heißen Abgasen in der Turbine abschirmt.

5. Turboladermodul nach einem der vorhergehenden Ansprüche, bei welchem die Lager (809) von heißen Abgasen in der Turbine abschirmt.
6. Turboladermodul nach einem der vorhergehenden Ansprüche, bei welchem ein Flansch (817) jedes Einsatzes (850) an einem das Loch (851) umgebenden Außenseitenbereich (803) der Wand befestigt ist.

7. Turboladermodul nach einem der vorhergehenden Ansprüche, bei welchem ein Verdichtergehäuse (810), das einen Verdichterauslassanschluss (813) aufweist, an dem Einsatz (850) angebaut ist und an Ort und Stelle mit Hilfe eines Spannringes (12) befestigt ist, wobei die radiale Ausrichtung des Gehäuses (810) in Bezug auf die Rotationsachse des Einsatzes derart angepasst werden kann, dass der Verdichterauslassanschluss (813) in eine beliebige gewünschte radiale Stellung gebracht wird.

8. Turboladermodul nach einem der vorhergehenden Ansprüche, bei welchem das Gehäuse dazu dient, den Durchtritt etwaiger Abgase, die aus den Turbinen entweichen könnten, in die unmittelbare Nähe der Außenseite des Gehäuses zu verhindern.


10. Turboladermodul nach Anspruch 9, bei welchem das Gehäuse gasdicht ist, sodass sich in diesem ein Rückdruck aufbauen kann, um ein weiteres Austreten von Abgas zu verhindern.

11. Verbrennungsmotor, der ein oder mehrere Turboladermodule nach einem der vorhergehenden Ansprüche umfasst.

Revendications

1. Module de turbocompresseur (100) destiné à un moteur à combustion interne turbocompressé, comprenant une pluralité de cartouches de turbocompresseur (850), chaque cartouche comportant un rotor turbine (814) et une roue de compresseur (812) montés sur un arbre commun (816) courant dans des paliers (809), chaque cartouche étant montée dans un alésage respectif (851) dans une paroi (90) d’une enceinte de support (9) de telle sorte que son rotor turbine fasse saillie dans l’enceinte et sa roue de compresseur soit à l’extérieur de l’enceinte, caractérisé en ce que, pour chaque alésage (851), une face (820) d’un logement de turbine (800) est fixée fermement sur une région de surface interne (807) de la paroi (90) entourant ledit alésage, ladite région de surface de paroi interne et ladite face étant un bon ajustement mécanique l’une par rapport à l’autre, formant ainsi un trajet de faible résistance thermique au flux de chaleur par conduction depuis le logement de turbine (800) vers l’intérieur de la paroi (90), chaque logement de turbine recevant un rotor turbine d’une cartouche respective à l’intérieur, la cartouche étant maintenue concentrique avec le logement de turbine par une région de contact (870, 871) entre le logement de turbine et la cartouche, laquelle région de contact est sensiblement plus petite en aire que l’aire de contact entre la face (820) du logement de turbine (800) et la région de surface de paroi interne (807), la région de contact formant la seule région significative de contact mécanique direct entre le logement de turbine (800) et la cartouche (850), moyennant quoi pendant un fonctionnement des cartouches, la chaleur provenant du carter de turbine est évacuée des cartouches vers l’intérieur de la paroi (90) de l’enceinte (9).

2. Module de turbocompresseur selon la revendication 1, dans lequel la région de contact entre le logement de turbine et la cartouche comprend un ergot (870) de la cartouche ayant un ajustement fermé dans un registre circulaire (871) dans le logement de turbine.

3. Module de turbocompresseur selon la revendication 1 ou 2, dans lequel excepté au niveau de la région de contact entre le logement de turbine et la cartouche, un espace d’air est prévu entre l’extérieur de la cartouche et le logement de turbine.

4. Module de turbocompresseur selon l’une quelconque des revendications précédentes, dans lequel une chemise thermique (830) protège les paliers (809) des gaz d’échappement chauds dans la turbine.

5. Module de turbocompresseur selon l’une quelconque des revendications précédentes, dans lequel la paroi (90) de l’enceinte (9) est adaptée pour permettre à un liquide de refroidissement de passer au travers afin de refroidir la paroi.

6. Module de turbocompresseur selon l’une quelconque des revendications précédentes, dans lequel une bride (817) de chaque cartouche (850) est fixée à une région de surface de paroi externe (803) entourant ledit alésage (851).
7. Module de turbocompresseur selon l’une quelconque des revendications précédentes, dans lequel un logement de compresseur (810) comportant un orifice de sortie de compresseur (813) est assemblé sur la cartouche (850) et fixé sur place au moyen d’une bague de fixation (12), l’orientation radiale du logement (810) par rapport à l’axe de rotation de la cartouche étant ajustable de façon à amener l’orifice de sortie de compresseur (813) en toute position radiale souhaitée.

8. Module de turbocompresseur selon l’une quelconque des revendications précédentes, dans lequel l’enceinte sert à empêcher le passage de tout gaz d’échappement qui peut fuir des turbines vers le voisinage immédiat de l’extérieur de l’enceinte.

9. Module de turbocompresseur selon l’une quelconque des revendications précédentes, dans lequel l’enceinte comprend une ouverture destinée au passage des gaz d’échappement provenant des turbines, des moyens destinés à fixer un tuyau d’échappement autour de l’ouverture d’une manière étanche aux gaz, et un système de gaines de gaz d’échappement au sein de l’enceinte agencé pour diriger les gaz d’échappement à partir des sorties des turbines à travers l’ouverture, et pour permettre une communication entre l’intérieur de l’enceinte et l’intérieur du tuyau d’échappement de telle sorte que tout gaz d’échappement s’échappant des turbines ou du système de gaines soit libre de s’échapper via le tuyau d’échappement.

10. Module de turbocompresseur selon la revendication 9, dans lequel l’enceinte est étanche aux gaz de façon à permettre à une contre-pression de s’y accumuler pour inhiber une fuite supplémentaire des gaz d’échappement.

11. Moteur à combustion interne comprenant un ou plusieurs modules de turbocompresseur tels que revendiqués dans l’une quelconque des revendications précédentes.