An exhaust turbine for an internal combustion engine, which may either serve as a compressor for turbocharging or a turbogenerator for a hybrid vehicle, has its turbine surfaces and the internal surfaces of the exhaust turbine housing coated with a catalyst so the exhaust gases are treated to catalytic conversion as they pass through the exhaust turbine. The turbine wheel is equipped with a disk-like slinger at its input end that carries particulate matter in the exhaust outward radially into a particulate trap and combustion chamber formed on the interior of the turbine housing. The combustion chamber is heated by the exhaust gases and artificial heating such as electrical heating may be used to preheat the chamber. The combustion products from the burned particulate matter are added to the exhaust.

Exhaust Gas Turbine (EGT) Wheel with Extended Flange Turbocharger Bearing And Compressor Are Not Shown

1 - Exhaust Gas Turbine Wheel
2 - Slinger Flange Extension To The Turbine Wheel
3 - Exhaust Gas Turbine Engine
4 - Particulate Trap And Combustion Chamber
5 - Exhaust Gas Chamber; Exhaust Entrance Nct Shown
6 - Turbine Drive Shaft to Turbocharger Bearing And Compressor Wheel

The exhaust gas chamber (5) and the exhaust turbine wheel (1) will be coated with catalysts as appropriate to control regulated emissions.
The exhaust gas chamber (5) and the exhaust turbine wheel (1) will be coated with catalysts as appropriate to control regulated emissions.
COMBINATION EXHAUST GAS TURBINE-CATALYTIC CONVERTER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority of U.S. Provisional Patent Application Ser. No. 60/909,549 filed Apr. 2, 2007, which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention relates to an exhaust turbine for an internal combustion engine and more particularly to an exhaust turbine having coatings of catalytic converting material so that the turbine acts as a catalytic converter.

BACKGROUND OF THE INVENTION

[0003] The densely populated regions of the world typically regulate the permitted levels of several pollutants, or unwanted emissions, in the exhaust gases generated by transportation vehicles powered by internal combustion engines (ICE). These engines are usually fueled by diesel fuel(s), motor gasoline(s), other reasonable hydrocarbon fuels, alternative fuels from other than petroleum sources, and combinations thereof.

[0004] Currently diesel-fueled ICE have to comply with regulations for the amount of non-methane hydrocarbons (NMHC) from non-methane organic gases (NMOG), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM). Controlling these unwanted emissions to the regulated levels usually requires the use of special equipment such as catalytic converters and particulate traps to remove these unwanted emissions from the exhaust. Engine manufacturers and their customers are continually seeking better solutions for controlling these unwanted emissions.

[0005] Diesel engines typically are equipped with a turbocharger, which consists of an exhaust gas turbine (EGT) coupled to and driving an intake air compressor. This turbocharger is used to increase the airflow to the engine so that more fuel can be burned whenever extra power is needed. This typically permits the use of a smaller ICE (displacement and weight) for the same power requirements.

SUMMARY OF THE INVENTION

[0006] This invention combines the operations of the catalytic converter, particulate trap, and turbocharger in one device. As the exhaust passes through the EGT, catalysts coating the rotor and housing will provide the same functions as they do in a catalytic converter. In order to ensure removal of all the PM, a slinger will be used to direct the PM to a trap in the housing where it will be oxidized. Energy from these reactions will increase the power output of the EGT, recovering energy that was once lost to the atmosphere.

[0007] The EGT typically spins at high speeds in the range of 50,000 rpm to 150,000 rpm or even higher. This turbine wheel acts as a slinger which slings the PM to the circumference of the interior of the EGT housing. A strong oxidation catalyst and electrically-powered resistors can be placed in the housing in the location where the PM is directed as required to ensure that all of the PM is oxidized. Any other reasonable heat source may also be used for this purpose. Energy from the oxidation of the PM will add to the total energy that is used to power the exhaust gas turbine, thus recovering some of the energy which would normally be lost to the atmosphere. The turbine wheel and the EGT housing can be designed to improve the efficiency of the slinger function and the PM trap. For example, the diameter of the solid facing of the turbine wheel can be increased so that it is slightly greater that the outer diameter of the turbine blades as shown in FIG. 1. This will provide for a stronger centrifugal separation of the heavier PM from the exhaust gas.

[0008] Broad application of catalyzed diesel particulate filter (CDPF) systems for the control or PM began with the introduction of 2007 model year heavy-duty diesel trucks in the United States. These systems typically operate as a trap for the PM with periodic oxidation of the PM. An advantage of the EGTCC is that it would provide for continuous removal of the PM in a passive system. The EPA reports that there are more than 1.2 million diesel-powered vehicles were operating with some type of CDPF system in Europe prior to 2007.

[0009] A catalyst(s) can be added to the EGT housing and turbine wheel to enhance the oxidation of the PM. Catalyst(s) can also be added to the EGT turbine wheel and housing to reduce the NOx and other targeted pollutants to regulated levels. The catalysts typically used for this purpose are the precious group metals platinum, palladium, rhodium, vanadium, etc. These catalysts are typically deposited using a washcoat (typically a mixture of silicon and aluminum) onto a ceramic, stainless steel, or other suitable substrate. For example, the housing and turbine wheel of the EGT might also use such materials as heat resistant cast steel, titanium, titanium aluminate (TiAl), high strength ceramics, aluminum, or other suitable materials.

[0010] The most important component of the catalytic reaction is usually the “loading” of the washcoat with the catalysts (in suspension) that is applied to the substrate. The washcoat, when added to the core, forms a rough, irregular surface which has a far greater surface area than the flat core surfaces. This gives the converter core a larger surface area, and therefore more places for active precious metal sites. Heavier concentrations, or loadings, of the precious metals that cause catalytic reactions typically increase the effectiveness of the process, with no increase in substrate surface area. Rhodium, platinum, palladium, vanadium, etc. which are used in various concentrations in the washcoat are relatively expensive metals, so it is important to achieve the proper balance of cost and effectiveness for each EGTCC application.

[0011] The use of the zeolite family of catalysts may be very well suited for this EGTCC. Zeolite catalysts are currently used in some applications in combination with redox-tants such as ammonia/area, especially for the removal of NOx from flue gases, diesel exhausts, etc. This is commonly referred to as selective catalyst reduction (SLR). Vanadium catalysts are also used for these SLR applications and several other catalysts are under consideration. The EPA has noted that vanadium and base-metal (Cu or Fe) SCR catalysts can achieve significant NOx reduction in heavy duty diesel engines. The EPA notes that SCR is a mature, cost-effective solution for NOx reduction on heavy-duty diesel engines.

[0012] Studies done by Argonne National Laboratory, Sandia National Laboratory, Adherent Technologies, Degussa Aktiengesellschaft, Toyota, and others show that these zeolite catalysts are effective at controlling exhaust emissions of ICE. For example, Argonne has demonstrated that a zeolite-based catalyst such as Cu-ZSM-5 with a cerium oxide coating can be very effective for reducing NOx as well as other unwanted emissions from the exhaust gases. This catalyst, similar zeolite catalysts, and/or other suitable current and
future catalysts or combinations of these catalysts could be very effective for this EGTCC application.

**[0013]** Currently ammonia/urea is the most commonly used reductant for the SLR of the NOx in the exhaust gases. Argonne proposes that an alternative method is to use a hydrocarbon in place of the ammonia/urea reductant. In the case of the exhaust from ICE, Argonne proposes that the hydrocarbon fuel used for the engine be used as the reductant. This could reduce the cost of the emission control system and its operation. It eliminates the need to store a separate material and ensures that the reductant is available whenever fuel is available for the ICE. The thermal energy resulting from the catalytic reactions which take place in the EGT will increase the power output of the EGT.

**[0014]** The design and operation of the EGT can be modified to increase the efficiency of the catalytic action without reducing its original function. The number of turbine blades can be increased to provide more catalyst area. If the turbine blades are coated with a ceramic substrate, the thickness of the blade might be decreased to keep the mass of the turbine wheel as low as reasonable. Another option might be to make the turbine wheel from a high-strength ceramic to reduce the mass and thus the spool-up time for the EGT.

**[0015]** The EGTCC will be running for all the time that the ICE is operating in order to ensure that total exhaust flow is presented to the PM removal system and the catalysts. Some turbochargers are controlled by a bypass control or wastegate which diverts a portion or all of the exhaust flow around the EGT. While the design and control of these turbochargers could be modified so that all of the exhaust would flow through the EGT, other turbocharger designs are already available that direct the entire exhaust flow through the EGT. These turbocharger designs are more recent and tend to be referred to as regulated, output control, or variable geometry turbochargers (VGT).

**[0016]** Some of these VGT are designed with an adjustable throat section at the inlet of the turbine wheel. The throat section can be adjusted to provide for varying engine speeds and desired boost pressures. Another VGT design provides the same function by using adjustable vanes which rotate relative to the turbine wheel axis. Examples of these designs are the Garrett® VNT™ turbocharger and the Garrett® VN™ Multivane turbocharger respectively.

**[0017]** Borg Warner Turbo Systems has similar models of regulated turbochargers or VGT which change the inflow angle and/or inflow speed at the turbine wheel inlet. The advantage for using this output control incorporated in the VGT over bypass control, which is usually accomplished by a wastegate, is that the entire exhaust mass flow is always directed through the EGT. The industry trend is toward increased use of output controls and these variable geometry turbochargers. Since for these VGT models, the entire exhaust flow is always moving through the EGT, these current and future designs are suitable for the proposed EGTCC.

**[0018]** Other turbocharger producers also have similar designs that direct the entire exhaust flow through the EGT.

**[0019]** The bypass control turbochargers that are installed on vehicles currently on the highway can easily be replaced by an EGTCC using output control. For those vehicles produced in 2007 or later the EGTCC could either replace the turbocharger and current control systems for PM, NOx, and the other pollutants or those systems could be left in place. Vehicles produced prior to 2007 can achieve major reductions in pollutant levels in the exhaust by replacing the current turbocharger with an EGTCC.

**[0020]** Combining the catalytic activity with the turbocharger operation offers the following advantages:

**[0021]** A significant portion of the thermal energy produced by the oxidation and reduction activities between the catalysts and the unwanted emissions will be converted to mechanical energy by the EGT.

**[0022]** The oxidation and reduction operations are located closer to the exhaust manifold and there will be less time required for the catalysts to “warm up” to their optimum operating temperature.

**[0023]** The ceramic coating on the EGT housing will act as an insulator and retain more of the thermal energy in the exhaust gas which will make more power available for the EGT.

**[0024]** A ceramic coating can be easily added to the exhaust manifold and exhaust connection between the exhaust manifold and the EGT for the purpose of insulation to maintain the highest reasonable thermal energy level at the entrance to the EGT.

**[0025]** Equipment costs are lower since the costs to produce, install, purchase, inventory, etc. a separate catalytic converter are eliminated.

**[0026]** The use of zeolite catalysts and the hydrocarbon reductant could replace some of the precious group metals catalysts, also saving costs.

**[0027]** Vehicle operating costs will be lowered since thermal energy that is lost to the atmosphere today will be converted into mechanical energy that can be used otherwise to reduce the overall energy consumption of the vehicle.

**[0028]** The problems of backpressure created by the currently-used catalytic converters will be eliminated, thus providing more power output and smoother engine operation.

**[0029]** Operating the turbocharger at all engine speeds will provide more power at a given engine speed so that the ICE can operate at lower rpm for the same power output permitting the vehicle to run in a higher gear, which generally is more economical and extends engine life and maintenance periods.

**[0030]** Operating the turbocharger at all engine speeds will improve oxygen availability throughout the operational range of the engine which will reduce the formation of elemental carbon PM.

**[0031]** Flowing all of the exhaust gas through the turbocharger all of the time will reduce turbine lag during periods of acceleration.

**[0032]** One or more additional EGT can be installed immediately after the EGTCC to capture and usefully employ more of the exhaust energy without having to be concerned about maintaining proper temperatures at the catalytic converter inlet. The additional EGT could also be of the EGTCC form.

**[0033]** The PM would be removed continuously rather than collecting the PM and then burning it periodically.

**[0034]** Using the ICE fuel as the reductant will eliminate the concern that ammonia may be present in the exhaust or that additional steps may have to be taken to remove excess ammonia from the exhaust.

**[0035]** Major reductions in exhaust pollutants can be achieved for vehicles already on the road by replacing the current turbocharger with an EGTCC.
If necessary, a small catalytic converter can be placed in the discharge of the EGT housing or just after the exit of the EGT. The design of this converter could be similar to current catalytic converters or a reticulated substrate could be used, in which case it would be prepared similar to the EGT rotor and housing.

The above proposal mainly addresses the needs to meet the regulations established for highway transportation vehicles with diesel engines. Many of the densely populated areas of the world have programs in place or planned that will require all diesel engines to meet similar emission levels in the near future, including marine, rail, all types of off-the-road equipment, electric power generation equipment, and any other equipment powered by diesel engines. This EGTCC could be used to reduce the regulated emissions for the diesel engines used for all of these applications. The EGTCC can also be used for any alternative fuels that might be used in combination with or substituted for typical diesel fuels in these applications.

Currently gasoline-fueled ICE have to comply with regulations for the amount of non-methane hydrocarbons (NMHC) or non-methane organic gases (NMOG), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM). While these regulations are often the same or similar for ICE regardless of the fuel used (gasoline, diesel, alternative fuels, etc.), gasoline ICE typically do not have a problem meeting the PM regulations without the use of special equipment such as particulate traps. Generally for gasoline-fueled ICE, controlling these unwanted emissions to the regulated levels is achieved by using catalytic converters to remove these unwanted emissions from the exhaust. ICE manufacturers and their customers are continually seeking better solutions for controlling these unwanted emissions.

Gasoline-fueled vehicles currently on the global highways when compared to diesel-fueled vehicles have a much lower percentage that are equipped with turbochargers. Typically turbochargers have been used on gasoline engines to improve performance and a significant portion of the turbochargers have been added as an aftermarket item. The recent emphasis on fuel economy due to the rapid increase in energy prices and taxes and the estimated impact of CO2 on climate changes has greatly increased the global automotive industry’s interest in the use of turbochargers. The industry, especially in Europe, has been moving to vehicles with smaller gasoline-fueled engines (displacement and weight) equipped with turbochargers to provide extra power for acceleration and as otherwise needed. This permits the use of smaller more fuel efficient engines without sacrificing performance. This trend is forecasted to grow rapidly for the foreseeable future.

This proposal is to combine the operations of the catalytic converter, and turbocharger in one device. As the exhaust passes through the EGT, catalysts coating the rotor and housing will provide the same functions as they do in a catalytic converter. In the event of a need for the removal of PM for new engine designs (for example “homogeneous charge compression ignition” or HCCI) or new fuel developments to ensure removal of all the PM, a slinger could be used to direct the PM to a trap in the housing where it will be oxidized. Energy from these reactions will increase the power output of the EGT, recovering energy that was once lost to the atmosphere. However, currently for gasoline, alternative fuels for gasoline-fueled engines, and combinations of those fuels, the currently used catalytic converter is all that is required to control the levels of the unwanted exhaust emissions to regulated levels.

The EGTCC for these applications will be the same as for the diesel-fueled ICE except that the special provisions to remove PM may not be required. All of the description above for diesel-powered vehicles also applies for gasoline-powered vehicles.

Gasoline engines typically control the engine power output by throttling the air available for combustion, and the fuel is controlled to match the air flow. Power output from diesel engines is controlled by the amount of fuel available for combustion and the air flow is not restricted or throttled. The diesel engines also operate over a smaller speed range than do gasoline engines. Therefore, the volume of exhaust flow for the gasoline engines varies much more than it does for diesel engines. Consequently, under normal operation the gasoline engine is operating with relatively small exhaust flows compared to full power high speed operations. The use of variable geometry turbochargers enhances the recovery of thermal exhaust energy at throttled conditions and can be designed to operate more efficiently at certain targeted operating conditions.

The hybrid operating configurations and conditions as outlined in the Hybrid Electric Conversion LLC proposal for a series-parallel hybrid electric drive system permits the internal combustion to be operated at all times in a full throttle or near full throttle condition and over a relatively narrow speed range, which will permit the EGTCC to extract significantly more of the thermal exhaust energy and thus reduce the fuel consumption of the engine. An example of this application is shown in FIG. 2.

The vehicle fleets in Western Europe, Japan, Canada, and the USA are mostly equipped with catalytic converters and not much advantage would be gained from equipping vehicles currently in use with an EGTCC. However, there are countries that could benefit from such retrofits to improve the emissions control and performance of the vehicles.

The above proposal mainly addresses the needs to meet the regulations established for highway transportation vehicles with gasoline engines. Many of the densely populated areas of the world have programs in place or planned that will require all gasoline engines to meet similar emission levels in the near future, including marine, rail, all types of off-the-road equipment, electric power generation equipment, and any other equipment powered by gasoline engines. This EGTCC could be used to reduce the regulated emissions for the current and future gasoline engines used for all of these applications. The EGTCC can also be used for any alternative fuels that might be used in combination with or substituted for typical gasoline fuels in these applications.

The benefits for the use of turbochargers generally apply to hybrid electric vehicles (HEV) as well. Both diesel powered and gasoline powered HEV would have most or all of the same benefits as listed above for those vehicles.

In addition, there are other benefits that can be derived from using an EGTCC on these HEV to power an electric generator. This EGTCC driven electrical generator (EGTDEG) may be added to an HEV that has no turbocharger or it may be added on the exhaust flow after a turbocharger that is already installed on the vehicle. Power supplied by the EGTDEG could be used in the following ways as relevant depending on the HEV design and personal preference:
1. To provide additional recharging power to the HEV's energy storage system(s)
2. To provide additional power to HEV's primary drive motor(s)
3. To provide additional power to the HEV's alternator/motor/starter system
4. To provide additional power to operate the HEV's electrically-powered accessories directly
5. To provide power to an electric motor or motor/generator added to the HEV to use the power generated by the EGTDEG to supply power to the motive drive system at either end of the ICE crankshaft or any other reasonable location in the drivetrain

Some mild hybrids are referred to as Stop/Start hybrids. This system conserves energy by shutting off the ICE when the vehicle is at rest, such as at a traffic light, and automatically re-starting it when the driver releases the brake and/or pushes the gas pedal to go forward. Examples of Stop/Start hybrids are the Chevrolet Silverado, Saturn Vue, BMW 1-series, Citroën C2, etc. While all the items listed above can be applicable for any HEV system, items 3, 4, and 5 generally would apply to a mild hybrid.

Medium strength hybrids, such as the current Honda Civic and Accord hybrids, strong hybrids, such as those currently offered by Toyota and those used for most of the current bus and other heavy duty vehicle applications, and other current and future hybrids also can benefit, usually more than most mild hybrids.

The Hybrid Electric Conversion LLC proposal for a series-parallel hybrid electric drive system would derive the most benefit from the use of the EGTDEG. In this system the ICE is always operating unthrottled and at or near to its most efficient operating conditions. Therefore, there is always a good opportunity to extract significant power from the EGTDEG. Series hybrids could have a similar benefit depending on the operating conditions for the ICE. An example of this application is shown in FIG. 2.

Any non-hybrid, or conventionally powered vehicle could be converted to a mild hybrid by the addition of an EGTDEG in combination with the addition of an electric motor or motor/generator to the vehicle to use the power generated by the EGTDEG. The EGTDEG could supply power to the motive drive system at either end of the ICE crankshaft; for example, through a starter/alternator and/or an additional motor/generator, or any other reasonable location. The addition of a battery and/or other energy storage and other associated equipment will convert the vehicle into an HEV to gain even greater operating efficiency.

All HEV configurations could benefit from the use of two or more EGTDEG in series to extract the maximum amount of energy from the exhaust. Depending on the application, most likely only one of these locations would require the use of an EGTCC to reduce the unwanted pollutants from the exhaust to within their regulated levels. The other two locations could use a conventional EGT. Since there is not a catalytic converter downstream of these EGTCCs and/or EGTs as the case may be, it is desirable to convert as much of the exhaust thermal energy as reasonable to power the vehicle. Some designers might prefer to use a turbocharger to improve the control the ICE intake air flows. Some designers may prefer to use a turbocharger in order to use a smaller ICE. Depending on the design of the vehicle, its designated use, and the designers' preferences there could be several combinations of exhaust-gas-driven equipment on the vehicle, some with EGTCC and other with a conventional EGT.

The same benefit could be achieved by using two or more EGTDEG in parallel and/or in series parallel combinations. The conditions for these arrangements would be similar to those described above for a series arrangement. At least one EGTCC must be used in each parallel exhaust train to ensure that the unwanted emissions are removed in accordance with the respective regulations. An example of two EGTCC in series is shown in FIG. 2.

Currently, radial turbines are most often used to extract the thermal energy from the ICE exhaust. However, axial turbines can be used with good results and often are used for ICE with larger displacements. An axial turbine would combine the functions of using multiple radial turbines to extract more of the thermal exhaust energy for use as motive power and could be especially effective for powering an electrical generator to provide power for HEV configurations.

This proposal is to combine the operations of the catalytic converter, and turbocharger and/or an exhaust gas-turbine-driven electrical generator in one device. As the exhaust passes through the axial exhaust gas turbine, catalysts coating the blades of the rotor and stator as well as the housing and turbine body will provide the same functions as they do in a catalytic converter. The application of these catalysts could be done in a manner similar to that used for the radial turbines and housings. The turbine blades of the axial turbine can be configured to provide for a stronger centrifugal separation of the heavier PM from the exhaust gas. The PM would be directed into traps in the housing where they can be oxidized using a strong oxidizing catalyst and heat which can be added to the trap as required. The smaller particles could be similar to that proposed for the radial turbine. Energy from these reactions as they take place in the exhaust gas turbine will increase the power output of the exhaust gas turbine, recovering energy from these reactions that currently is lost to the atmosphere.

The historic emphasis has been for the reduction of emissions from the exhausts of internal combustion engines and for improving the fuel economy of these engines. The recent increases in the cost for energy, especially liquid fuels; increasing taxes on liquid fuels, especially in Europe; further reduction of the currently regulated exhaust emissions; non-methane hydrocarbons, carbon monoxide, nitrogen oxides, and particulate matter; the seasonal concern for climate changes and the potential impact of carbon dioxide on the global atmosphere; and political instability in the major crude oil producing regions has created a significantly increased global interest for continued improvements in the performance of all internal combustion engines.

The focus of these efforts, which has been on highway transportation vehicles, is now expanding to include all internal combustion engines for all uses. This includes the use of these engines for small farm or home implements to the largest earthmover, ocean vessel, or electric generators. The fuel can be diesel, gasoline, alcohols, vegetable oils, hydrogen, natural gas, or any other fuels that are suitable for these internal combustion engines. The internal combustion engines may use different cycles, different ignition techniques, and use many different operating techniques.

The exhaust flows from these internal combustion engines, using any of these fuels or combinations of these fuels are very similar. Therefore, the proposed exhaust gas turbine catalytic converter combination can be used to clean
the exhausts from all of these combinations. This device can also be used to extract the thermal energy from the exhaust and used in various ways to significantly reduce the fuel consumption of these internal combustion engines.

[0064] Currently there are many uses of gas turbine engines for industrial applications and for power generation. The exhaust from these gas turbines, like that from internal combustion engines, contains unwanted pollutants as well as large quantities of thermal energy. These applications could derive the same benefits as the other internal combustion engines by using an exhaust gas turbine catalytic converter combination to reduce the unwanted emissions and increase the fuel efficiency.

[0065] Currently the exhaust gases from these plants have the same pollutants as do the internal combustion engines and contain very large quantities of thermal energy. They also contain other pollutants such as sulfur compounds and mercury. After the sulfur has been removed from these exhaust gases the exhaust gas turbine catalytic converter combination could be used to extract the unwanted pollutants such as hydrocarbons, carbon monoxide, nitrogen oxides, and particulate matter from these exhaust gases and recover large quantities of thermal energy and direct that to electric power generation at the same time. Another option could be to remove the sulfur using an exhaust gas turbine catalytic converter combination specially designed to remove the sulfur, followed by those exhaust gas turbine catalytic converter combinations designed to remove the other pollutants. As for the other applications, energy from these reactions as they take place in the exhaust gas turbine catalytic converter will increase the power output of the exhaust gas turbine, recovering energy from these reactions that currently is lost to the atmosphere.

[0066] The exhaust gas turbine catalytic converter combinations as described above are used either to drive an air compressor to provide additional air to the internal combustion engine or to power an electrical generator. Another application for the use of the power provided by the exhaust gas turbine catalytic converter combination is to drive a hydraulic pump. This hydraulic power could be used to drive a hydraulic motor in the same manner as the electric generator is used to drive an electric motor. This hydraulic system would have similar applications as described above for the electric generator. However, a hydraulic energy storage system would be used in place of an electrical energy storage system and the hybrid electric vehicle system would be replaced by current or future hydraulic hybrid vehicle systems.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0069] The preferred embodiment of the invention constitutes a turbine driven by exhaust gases from an internal combustion vehicle, which may be gasoline or diesel type. The output shaft of the turbine which is driven by the exhaust gases may be used to power either a compressor, for conventional turbocharging purposes, or an alternator/generator for providing electric power for a hybrid vehicle.

[0070] In the cross section of the exhaust driven turbine of the drawing, the numeral 1 represents the exhaust gas turbine wheel. The turbine wheel is conventional with a number of vanes.

[0071] While FIG. 1 depicts a radial compressor, the invention could be equally applicable to an axial compressor. The input end of the compressor, which receives the exhaust, shown to the right of FIG. 1, has a disk-like radial slinger extension 2 which receives the incoming exhaust gases. The slinger extends radially beyond the ends of the turbine wheels. The particulate matter in the incoming exhaust gases, being of higher density than the gases themselves, tends to move outward radially along the slinger 2 and are thrown into a particulate trap and combustion chamber 4 formed in the exhaust gas turbine housing 3. This particulate trap and combustion chamber 4 is of course heated by the exhaust gases. It may be preheated to reach combustion temperatures by electrical resistive heating elements or the like. The particulate matter slung into the trap is combusted and the combustion gases from the particulate matter mix with the entering exhaust gases which enter through a chamber 5 extending around the perimeter of the turbine. The chamber 5 narrows in cross section as it extends from the entrance of the exhaust gases to the outlet which feeds the turbine blades.

[0072] Both the surfaces of the turbine blades and the interior surface of the exhaust turbine housing are coated with a catalyst of the conventional type used in catalytic converters, such as precious group metals deposited as taught in the Summary of the Invention. Alternatively, zeolite or vanadium catalysts may be used, depending upon the combustion fuel.

[0073] The output shaft 6 of the turbine may be used to drive a compressor for turbocharging applications, or a generator for providing electrical power to a hybrid vehicle.

[0074] A supplemental catalytic converter may be provided downstream of the converter/turbine to further reduce the pollutants in the exhaust.

Having thus described my invention, I claim:
1. An exhaust turbine driven by the exhaust of an internal combustion engine, having a catalytic coating on the turbine surface which contacts the exhaust gases to catalytically reduce noxious products in the gases.
2. The turbine of claim 1 wherein the catalyst includes metal from the group consisting of platinum, palladium, rhodium, and vanadium.
3. The exhaust gas turbine of claim 1 wherein the catalyst constitutes a zeolite.
4. The exhaust gas turbine of claim 1 having a radially extending slinger disposed at its input end and a radially inward directed particulate trap formed in the turbine housing in opposition to the radially outward end of the slinger whereby particulate matter combined with the exhaust is directed radially outward into the trap where it is combusted and added to the input exhaust gases.

* * * * *