Quasiturbine strategic potential as photodetonation engine

*Article from a correspondence between **Dr. Gilles Saint-Hilaire** of Quasiturbine Agence Inc.*
quasiturbine@promci.qc.ca and

Mr. George Marchetti

marchetti4@aol.com
Vice-chairman of the Chicago Chapter of the Electrochemical Society

Mr. George Marchetti is vice-chairman of the Chicago Chapter of the Electrochemical Society, and he did quite an extensive analysis of the Quasiturbine technology. Mr. Marchetti agreed to make public the instructive correspondence about the Quasiturbine and its strategic potential as a photodetonation engine.

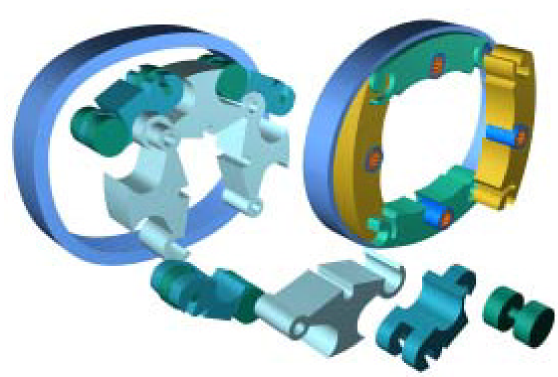
Please note that the Quasiturbine QT-SC can also run very well in Otto cycle, and that is the focus of the work at present.

****

CONTEXT AND SUMMARY

The principal difference between the Otto and the photodetonation Quasiturbine is the mechanism of fuel ignition and combustion. The Otto mode Quasiturbine uses a spark ignition. The photodetonation Quasiturbine eliminates the need for spark plugs and an electrical ignition system. In photodetonation mode, the fuel/air charge autoignites with a short, powerful pressure pulse in the Quasiturbine's combustion chamber. With the exception of the method of fuel ignition and combustion, the operational characteristics of the Quasiturbine engines in both mode are essentially the same.

Regardless of the method of ignition and combustion, the Quasiturbine is a uniquely "clean combustion" engine. The pollution-related products of commercially-available internal combustion engines include carbon monoxide, other uncombusted hydrocarbons and oxides of nitrogen. Carbon monoxide and uncombusted hydrocarbons are the result of incomplete combustion of the fuel in the engine. Oxides of nitrogen are formed because of the relatively long residence time of nitrogen (from the air) in the combustion chamber. The Quasiturbine's unique engine architecture minimizes the formation of these pollution-related engine products. Uniform ignition, and complete fuel combustion, can never be achieved in a piston engine at relatively high RPM, because the thermal ignition wave cannot follow the falling piston. With respect to carbon monoxide and uncombusted hydrocarbons, the Quasiturbine's combustion chamber movement, which is near-linear, favors uniform ignition of the fuel/air charge to all areas of the chamber. With respect to oxides of nitrogen, the high pressure residence time of nitrogen in the Quasiturbine combustion chamber is significantly reduced. Consequently, the chemical reaction that leads to the formation of oxides of nitrogen is retarded or prevented. If the reduction in "tailpipe" emissions were the Quasiturbine's only benefit, it would be a major advance in engine technology. But there is more.



Quasiturbine Model AC and SC

The Quasiturbine offers the potential for significant increases in fuel efficiency due to several factors, including: virtually complete combustion of the fuel/air charge, high compression ratios, early and late mechanical conversion, absence of peripheral accessories like camshaft, and more. Each of these factors is addressed in more detail on the Quasiturbine website

www.quasiturbine.com

When taken together, these various improvements increase fuel efficiency, while simultaneously reducing pollutant emissions.

Dr. Alan Lloyd, the chairman of the influential California Air Resources Board (CARB), recently adopted the position that (Wall Street Journal, October 24, 2002), in order to meet California's more stringent new clean air standards, combustion engines **must become cleaner** (to reduce the local effects of smog-related pollutants) **and must also become more efficient** (to reduce the global effects of greenhouse gas emissions, primarily carbon dioxide). Given the current state of combustion engine technology in the industry, **these two very different environmental goals will not prove to be easily compatible.** Diesel engines are inherently more efficient than conventional gasoline engines. But diesel engines generate significantly more sooty, particulate emissions and oxides of nitrogen than gasoline engines. In contrast, the Quasiturbine avoids the emissions / efficiency dilemma entirely. The Quasiturbine, unlike other combustion engines, is capable of responding to both local and global CARB goals, without sacrificing either fuel efficiency or its clean combustion characteristics.

The only other new technology, which could offer comparable benefits is the PEM fuel cell. However, PEM fuel cells are limited to hydrogen as the fuel. Hydrogen must be processed from some other fuel source, such as natural gas, with a corresponding loss of at least 30% of the energy value of the fuel during processing. When the energy loss associated with processing is taken into account, PEM fuel cells will only be about 35% fuel-efficient. In addition, because fuel cells are dependent on hydrogen, there are serious issues about production, transmission and storage of hydrogen fuel that must be addressed before fuel cells can become a generally available option. While hydrogen is the "Achilles heel" of fuel cells, the Quasiturbine has no such limitations. It is a multi-fuel engine and can use existing fuels and infrastructure (and even hydrogen, if and when, available). While the fuel cell may be an option for some distant tomorrow, the Quasiturbine is an option for today.

The following correspondence between Mr. Saint-Hilaire and Mr. Marchetti is a "short course" in understanding the principles of Quasiturbine design and performance, especially as they relate to photodetonation. The question and answer format is presented as is, which explains Quasiturbine principles in a logical, step-by-step sequence. Hopefully, this correspondence will prove useful in understanding the potential of Quasiturbine technology.

****

The starting point: A letter from Quasiturbine to Mr. Kolber of SEAS

SEAS Z-Prize contest at:
http://www.seaspower.com/pressrelease093002.htm
www.seaspower.com

Bonjour Monsieur Kolber,

Merci de votre mot et intérêt envers la technologie Quasiturbine.

If you ask a chemist the absolute best way to burn fuel, he will tell you about photodetonation... For the past 10 years, several engine research labs have been essentially trying to control the thermal ignition in piston machines, and none succeeded yet. A good report about this research at GM and Ford can be found in scientific American of June 2002 "A Low-Pollution Engine Solution - New sparkless-ignition automotive engines gear up to meet the challenge of cleaner combustion" Other infos are available at:

http://www.llnl.gov/str/Westbrook.html

We have shown that the piston is not appropriate for such a violent combustion as photodetonation, and that the successful solution must get rid of the crankshaft... The Quasiturbine AC has been design with a much shorter pressure pulse, which is the logical requirement, and the reason of the piston failure in this regard (trying to control ignition is not the way to go). Just like the parapente or the deltaplane, the difficulty of the Quasiturbine is in its concept, not in its construction. It does involve only conventional mechanic, and all solutions are on the shelf in the public domain from conventional piston and rotary engine researches. We already have good research prototypes, requiring only construction techniques tuning... We also have shown that the Wankel engine has theoretical flaws which make it efficiently unviable, theoretical flaws that the Quasiturbine does not have (see our explanation about the P-V diagram).

As you may have found on our website, we only have two pages about vehicles, which are:
http://quasiturbine.promci.qc.ca/FQTReMotorisationQ.html
http://quasiturbine.promci.qc.ca/QTVehicule.html
For one, there is so much to do apart from vehicle (pneumatic, steam, Stirling, air compressor, turbo-pump..) For two, it is not advisable to unnecessary provoque the automobile industry as we found at SAE and during the 1999 Munchen autoshow, where all car manufacturers of the world have been in skeptical contact with the Quasiturbine. Finally, the vehicle application is probably the most severe, in the sense that the engine must be packaged to withstand 200,000 miles and 10 years with minimal maintenance. Initial industrial applications can be better monitored, and periodic supervision and maintenance sheet is a standard procedure for so many equipments there...

Quasiturbine energy saving comes from the thermodynamic of shorter pulse, from getting rid of the non efficient depressurization Otto cycle, but also from the fact that the engine has no accessories to drive like cam shafts... Other savings in transportation applications come from the simplification of the gearbox (8 to 12% there) and from the lighter weight carried by the vehicle... 10 other sources of saving are describe in the QT-book. Furthermore, the Quasiturbine is suitable for combine heat cycle, like QT-IC and steam Quasiturbine, or QT-IC and Stirling Quasiturbine, where estimates show possible combined engine efficiency up to 60% range without even using the photodetonation mode!
http://quasiturbine.promci.qc.ca/GHGAlberta0205.html
(This is not for now, but very feasible within the decade). In fact, saving is so important, that even if the Quasiturbine would cost much more (which is not the case), the fuel saving on a vehicle live time would make the QT-engine free! (even in Otto mode where photodetonation would not be used).

Nevertheless, a local group in Montréal is considering implanting an automobile retrofitting company, with the intention of manufacturing also standard kits for private owners and mechanics. The plant would be for new vehicles bought from manufacturers without the engine and the gearbox. The equivalent power Quasiturbine occupies only a quarter of the space now used by piston engine and a simplified gearbox (only for reverse?) is needed. No vibration and low noise lower compartment requirements. This could be done competitively as the Quasiturbine engine will be built economically in large series. Engine certification for environment and safety, and civil responsibility and vehicle registration approbation should also be dealt with in this context. Ultimately, why not manufacture and ship QT engines directly to car manufacturers? (They probably hate this idea at this time, but its is becoming a consumer request!)

Our website got 230,000 hits plus about an other 75,000 by the back door, which are not accounted. We currently get about 300 to 400 hits a day, which is not bad for a technical site! Already, Google references over 700 websites about Quasiturbine in several countries. Universities and students around de world are making homework on this technology. Militaries in many countries are most interested, as we have been invited 4 days in a US naval base in Florida in November 2001... Great interest there! However, conventional engine manufacturers (including our neighbour Bombardier-Rotax and Pratt&Witney...) are not ready to welcome the Quasiturbine at this time. We are not in production yet, and orders come-in by thousands. We are just about to quit risk capital for growth capital, considering the soundness of the technologies (notice that some de-information occurred in the past years, but not any more, as the consensus is finally quite unanimous) Even considering that... the cartels and interests prefer to see the status quo continue... The Quasiturbine is there to stay! In fact, the major international companies may not be our best partners yet at this time, but we are open to consider all forms of appropriate partnerships…

****

George Marchetti wrote to Quasiturbine:

In regard to your letter to Mr. Kolber at SEAS, here is one possible (or maybe crazy) gasoline engine retrofit concept. What if you used the heat generated by a standard internally-cooled gasoline engine block to generate steam. A pressure (or temperature actuated valve) would release the superheated water or steam to a steam QT (not to a radiator). The steam QT/ condenser system replaces the radiator system. You would use the steam power to turn the vehicle's electric generator - that is, the generator would no longer be attached by a belt drive to the gasoline engine. The cooled water from the condenser would be returned to the engine block.

I think (but am not sure) that the electrical systems of an idle car use sometime up to 25% of the energy generated by the engine. By running the electrical system off of the steam QT, you should be able to increase vehicle efficiency by retrofitting.

This is not a true combined cycle engine. I guess you could call it a “parallel cycle” engine??? In effect, the vehicle's drive system and its electrical system would operate independently.

Of course, there is the antifreeze problem, but maybe that can be dealt with. What do you think?

****

Quasiturbine wrote to George Marchetti:

I think the best vehicle retrofit would be to replace the whole piston engine. There is no point in claiming a better engine and keeping the piston engine into place!

Just buy new cars (without engine and gearbox) from several manufacturers, and retrofit a Quasiturbine inside!

****

George Marchetti wrote to Quasiturbine:

I was thinking about the Otto Cycle efficiency of the combustion QT because of your prior email about the Otto and Diesel Cycles. Based on my limited understanding, it seems that in order to approach ideal Otto Cycle efficiency, compression of the fuel/ air charge should be maximized at top dead center and the use of electronic ignition (spark plug) should be eliminated. I now see why you have repeatedly emphasized photodetonation as a key goal of your work.

Like other high compression engines, e.g. the diesel engine, the combustion QT's power (and to some extent fuel economy) should benefit from a turbocharger, which would increase the density of the air charge. Since the turbocharger would run off the combusted exhaust gases from the combustion QT, some of the waste heat of combustion would be effectively recycled to the engine. Right?

Next, at some temperature and pressure in the combustion QT, the fuel/air charge will photodetonate at top dead center. The parameters for photodetonation include:

(1) the self-ignition point of the particular fuel/air charge at a given temperature and pressure;
(2) the density of the air charge;
(3) the volatility of the fuel; and
(4) maintaining the stator and rotor at the photodetonation temperature, yet preventing premature ignition of the fuel/air charge.

Points 1 and 3 depend primarily on the type of fuel.
Point 2 relates to the turbocharger.
Point 4 relates to the water jacket idea.

Assuming that you use a turbocharger, then a consistent, dense air charge can be delivered to the QT intake chamber. The amount of fuel added to the air charge can also be consistently metered and injected. Then, you would have to keep the combustion QT at the appropriate photodetonation temperature for that particular fuel/air charge. To do so, the water jacket could be beneficial. The fluid in the “water” jacket wouldn't be water, of course. It would have to be a high boiling point fluid like (?) diethylene glycol (boiling point of ~250C at STP). The fluid in the jacket would boil at the photodetonation temperature. The boiling fluid from the jacket would be delivered as steam (no pump) to the condenser to be cooled (like the steam QT model). The photodetonation temperature would be maintained in the jacket by the high-temperature “water” jacket/condenser cooling system and, more importantly, the temperature would also be maintained in the adjacent stator area of the combustion QT.

So, a portion of the "waste heat" of combustion would be recycled in two ways to increase the QT's Otto Cycle efficiency - through the turbocharger (using hot exhaust gases) and through the water jacket to maintain photodetonation temperature (using heat from the engine block).

At start up, a spark plug would be necessary. But, as the QT heats up to the photodetonation temperature for the particular fuel/air charge, the water jacket/ condenser would serve to maintain that temperature at a consistent level and the spark plug would no longer be fired. That type of QT engine would then be operating on the higher efficiency Otto Cycle rather than the lower efficiency Diesel Cycle. Right? What would be your estimate of the efficiency of a turbocharged, photodetonation QT?

For a stationary power plant, natural gas is probably the fuel of choice. However, to assist the photodetonation of natural gas, I would consider adding a certain amount of a high volatility fuel to natural gas in the intake chamber, as is done in gas diesels. The small amount of high volatility fuel would photodetonate at top dead center and then ignite the less volatile natural gas. Maybe gasoline or methanol (which autoignites at 470C @ STP in air) could serve as the volatile fuel additive?

In any event, I think I now see why photodetonation is so crucial to the QT's efficiency.
Thank you for the education!!!!

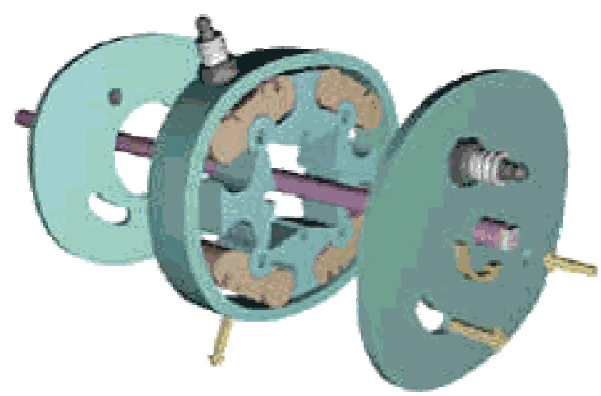
****

Quasiturbine wrote to George Marchetti:

J'apprécie beaucoup votre persévérance... Je pense que vous êtes un des rares à comprendre mes intentions... mais je devrai détailler encore plus mes explications. In your text, you keep thinking like a piston engine expert! I will help you get rid of that piston minded view...

First, Otto cycle required compressing fuel mixture (not pure air). Further, intake air pressure is controlled by throttle valve, making the intake manifold at vacuum, this to proper mix air with small fuel quantity coming in... Otto is a near stochiometric engine. Otto cycle cannot be made an efficient photodetonation mode, because of lower intake vacuum pressure, which one when compressed cannot generally provide the amount of heat required for photodetonation, and the combustion temperature would be too high.

Unlike Otto, Diesel compresses pure air (no fuel mixture). Air temperature raises due to high compression ratio, to such a level that any fuel injected does burn. The problem is that the fuel injected goes through the 3 combustion modes: air-excess on the exterior injector jet, stochiometric in mid area¸ and fuel-rich in the center (a situation very bad and difficult to control...). Because the Diesel accepts all intake air, its efficiency is not reduced by the intake vacuum as Otto. Diesel is an overall air-rich-engine.



Quasiturbine Model AC

Photo detonation is the best of both. It is homogeneous combustion without vacuum intake manifold. All piston minded experts think the research work should go toward the "thermal ignition control", where all 4 considerations you do mentioned make sense. This is not at all the way with Quasiturbine, because of a much shorted pressure pulse, the Quasiturbine does not care about your 4 considerations, temperature increases mainly at the pressure tip, and exceed by far all ignition and combustion parameters (does not care the engine wall temperature or otherwise...).

> QT's power (and to some extent fuel economy) should benefit from a turbocharger, which would increase the density of the air charge. Since the turbocharger would run off the combusted exhaust gases

from the combustion QT, some of the waste heat of combustion would be effectively recycled to the engine. Right?
Not really, because energy spent in increasing the charge does increase de specific engine power, but does not affect substantially the efficiency...

> Next, at some temperature and pressure in the combustion QT, the fuel/air charge will photodetonate at top dead center. The parameters for photodetonation include:
(1) the self-ignition point of the particular fuel/air charge at a given temperature and pressure;
(2) the density of the air charge;
(3) the volatility of the fuel; and
(4) maintaining the stator and rotor at the photodetonation temperature, yet preventing premature ignition of the fuel/air charge.
None of this apply to Quasiturbine short pressure pulse device.

> That type of QT engine would then be operating on the higher efficiency Otto Cycle rather than the lower efficiency Diesel Cycle. Right?
Rather the contrary, because as you know Otto cycle is less efficient that Diesel, in part due to the vacuum intake manifold. However, Otto cycle cannot be made an efficient photodetonation mode, and combustion temperature would be too high!

> What would be your estimate of the efficiency of a turbocharged, photodetonation QT?
Much better than current engine! Turbo is no obstacle to photodetonation. However, extra charge will be mechanically more demanding... In all cases, it would be better to use a fuel without high octane

Site général à :
http://quasiturbine.promci.qc.ca
Le livre "La Quasiturbine écologique" ISBN 2-922888-00-2 à :
http://quasiturbine.promci.qc.ca/QTLivreFrancais.html
La technologie Quasiturbine remporte 4 premiers prix à :
http://quasiturbine.promci.qc.ca/Rimous0105.html
Répertoriée sur le site d'Industrie Canada à :
http://prods.businesscanada.ic.gc.ca/Ces_Web/_display_air_agriculture_prob_info_.cfm?problemId=6840&target=french
Répertoriée sur le site d'environnement Québec à :
http://www.menv.gouv.qc.ca/air/vehicule/partenaires.htm
Répertoriée sur le site de INIS - Intl Atomic Energy Agency à :
http://www.iaea.or.at/programmes/inis/ws/d2/r1785.html
Répertoriée par la Communauté Européenne sur Cordis à :
http://quasiturbine.promci.qc.ca/CordisApril2001QT.html
Répertoriée sur le très sélect site américain de Steve Spence à
http://67.82.213.252:8383/2000/enginetechnology/quasiturbine.htm
Répertoriée comme technologie militaire à turbocarburant (jet fuel) à :
http://quasiturbine.promci.qc.ca/QTMilitaireUsages.html
Un filet de sécurité pour les travailleurs de l'automobile du Québec à:
http://quasiturbine.promci.qc.ca/FQTReMotorisationQ.html
Présentée au Centre des Sciences du Vieux Port de Montréal à :
http://www.isci.ca/FR/index.asp
Sondage sur l'intérêt d'investir dans la tronçonneuse à :
http://quasiturbine.promci.qc.ca/QTTronconneuseInv2002.html
Le projet d'une voiture de course FORMULE QT
http://www.quasiturbine.com/FQTAutoFormuleQT.html
Les moteurs de recherche donnent plus de 700 autres références à :
http://www.google.com/search?q=Quasiturbine
Tous sont bienvenus d'adhérer sans frais à l'APUQ
http://www.pureinvention.com/apuq

****

level additives, which additives are in fact “photo absorbants”. Absence of additives is another environment friendly advantage...

> *Natural gas is probably the fuel of choice. However, to assist the photodetonation of natural gas, I would consider adding a certain amount of a high volatility fuel to natural gas in the intake chamber, as is done in gas diesels.*

The Quasiturbine true photodetonation mode would not require any added fuel.

****

George Marchetti wrote to Quasiturbine:

Thank you again for the detailed explanation. Now I see that the combustion QT is a combination of the best elements of other internal combustion engines:

(1) Quasiturbine photodetonation of the homogenous fuel/air charge eliminates the electronic ignition requirement for most fuel. Electronic ignition in the gasoline engine is required because of intake vacuum and incompatible long duration compression “pulse structure” limitations in the cylinder.

(2) Photodetonation will completely combust the fuel in the fuel/air charge because of the short, but powerful, pressure pulse and because of the fast nearly linear variation of the QT maximum pressure zone, which rapidly closes and re-opens the combustion chamber. The diesel engine can only incompletely combust the fuel injected into the heated, compressed air in the cylinder. The QT (unlike the diesel) is therefore a “clean combustion” engine. It will have virtually no emissions other than the standard products of combustion, e.g., CO_2 and H_2O. “Clean combustion” also implies that the QT engine is more fuel efficient than the diesel.

(3) Photodetonation in the QT occurs rapidly at top dead center. In the diesel engine, ignition of the injected fuel occurs somewhat after top dead center, usually about 12 degrees or so, and is progressive with time to mechanically protect the piston. The QT's power stroke is therefore somewhat longer “with early and late mechanical energy conversion” and the exhaust somewhat cooler, which also implies a more efficient engine.

(4) Because the temperature of stator/rotor is not significant in photodetonation mode (light ignition), and because the shorter QT pressure pulse is self-timing, premature ignition is not a concern. The combustion QT can have a very simple cooling mechanism, such as air cooling, even when operating on a low volatility fuel like natural gas.

(5) The Quasiturbine is suitable for multi-fuel use, including hydrogen combustion. It can also be operated in a combine thermal cycle mode (including steam and Stirling mode hook-up on the same shaft) thereby increasing further the efficiency.

(6) Finally, the Quasiturbine can operate in the more conventional Otto mode, yet retains its added value characteristics when compared to the piston engine.

I may still have some of it wrong. But I think I'm learning where you intend to go!

****

Quasiturbine wrote to George Marchetti:

Vous partagez maintenant notre vision de la Quasiturbine!

As you say, this is where we like to go, but for now, we are still a little far from there. Fortunately, the Quasiturbine QT-SC can also run very well in Otto cycle, and this is our preoccupation for the moment...

I think you are one of the few on this planet who did put the effort to understand the strategic value of the Quasiturbine technology... Engine experts are generally shocked by this technology, and rather to study and understand it thoroughly, they inadvertently sometime mis-inform the engine research communities…

October 2002

www.quasiturbine.com