

White Papers

The Fence Jumper

Demand more from engines

Consider that we would be able to provide you with high efficient clean power in the range of 5 - 250 kW. Actually, soon we can. The generation of Fence Jumper engines are rugged designed engines that neither acquire complex fuel injection systems nor advanced valve train settings. With the

kerosene, diesel, propane/butane and biofuels. Adaption is made by simple add-on technology which can be mounted within minutes. Weight is perhaps important for your customers. The Fence Jumper has an excellent power-to-weight ratio, making the implementation of a



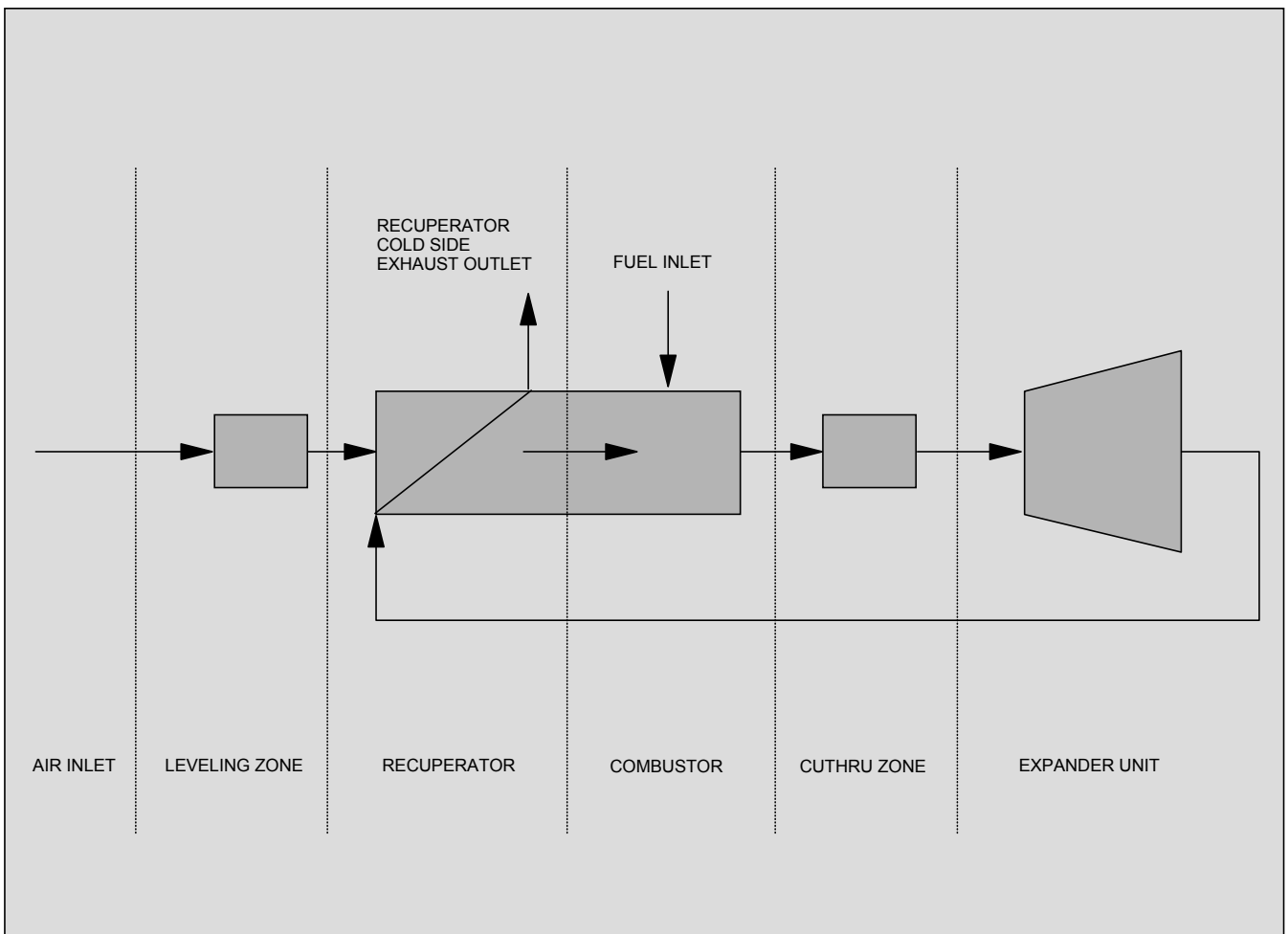
Fence Jumper, we've gone back to basics to take a look at what is thermodynamic and mechanically feasible. And here it is. An engine that provides non-pulsating vibrationless output at continuous torque by practically any power setting. The Fence Jumper solves some basic issues. It runs smooth and as the combustion is continuous, compared to the reciprocating engines pulsating process, outlet emissions are much better controlled and eliminates the use of expensive after treatment equipment. Fuel flexibility is another issue. It burns

mobile gen-set in the field, much easier than when compared to heavy reciprocating engines in the same power and efficiency class. The Fence Jumper will come in two versions. As a non-recuperated engine where the engine has been optimized for mobile applications and for stationary purposes as a recuperated version where the fuel efficiency is fully exploited, reducing your customers most expensive cost driver. At anytime, a non-recuperated Fence Jumper can be upgraded to the recuperated version if it is so required.

The Technical Reconsideration

If you are in the gen-set business, you would probably agree to, that the right direction for the future, is perhaps not to invest millions in existing engine technologies where improvements are only very modest on fields such as fuel efficiency and environmental issues, but to use the tremendous investment costs on considering something perhaps completely different. Maybe the millions would be much better spend on starting all over and complete re-think. Not everybody agree with us! But with the Fence Jumper, we have done exactly that. We have taken a clean sheet of paper and looked at the options we had. Not every option showed to be wise and not every idea fulfilled our expectations. But

would believe that sounded like a big objective. But not really. Similar to turbomachinery's suck, squeeze, bang and blow and the reciprocating engines up-and-down movement, is the Fence Jumpers cycle similar simple. Suck, backflow, continued bang and complete expansion over the whole operational envelope. Knocking is not an issue anymore just because the fuel composition is wrong or the fuel spray pattern not optimal. Compressor stall and pumping lays in the past and is impossible with the Fence Jumper. We have taken out as much hardware and software as possible for maintenance reasons and kept things the simple way. It is not without reason that we call the Fence Jumper engine



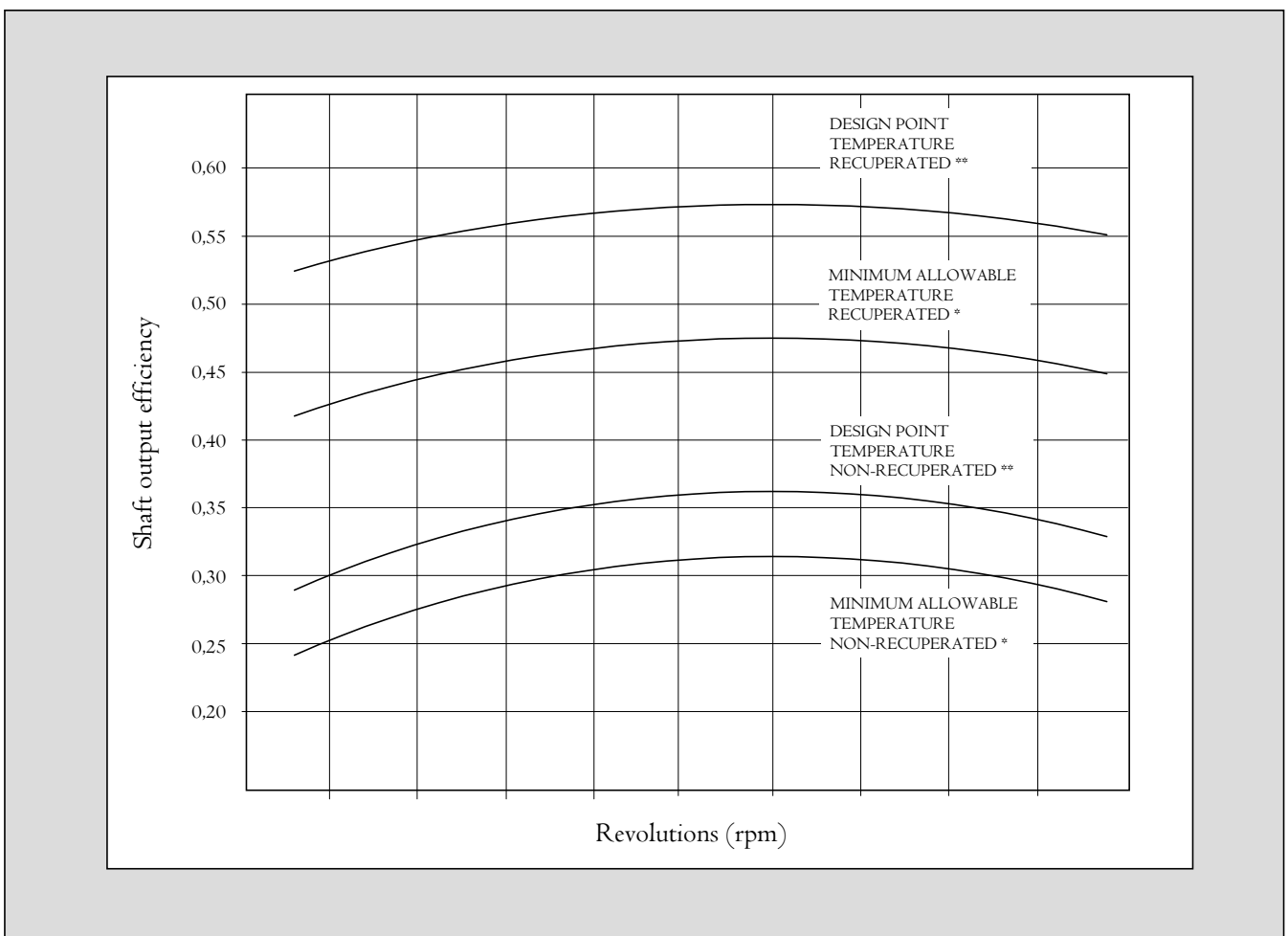
at the end, we achieved our objectives finding an engine design that is lighter, cleaner, smaller and more efficient than any other air breathing engine around today. We aimed high and focused on eliminating some of the limitations that conventional engines such as reciprocating engines and turbomachinery have, by using the philosophy, that major breakthroughs can only be achieved through changing the thermodynamical cycle that is applied to such engines. One

rugged. We have designed it to fit already existing standards used on the gen-set market for mobile and stationary power generation applications. You simply just replace your current reciprocating engine with the Fence Jumper and plug it into your existing interfaces. We guarantee that your customers can look forward to a completely new era of ultimate fuel efficiency, smooth operation, environmental improvement and a major reduction in fuel costs.

Ultimate Efficiency

One advantage that the Fence Jumper has is that incoming air is not compressed which is conventionally the case for air breathing engines. The internal energy exchange taking place under the isochoric combustion process, is converted into a steady pressure. Only with some minor fluctuation, pressure remains practically constant to the expander, giving stable continuous torque output over the whole operational envelope. The advantage of this method is that energy is saved by not compressing and that output remains pulsation free. Another important feature that the Fence Jumper has, is that

waste heat is immediately converted into pressure over the recuperator, contributing to a raise of the total efficiency. That is to be so understood, that if the recuperator is designed to capture a specific amount of energy at the maximum power setting, heat capture at a much lower setting, can similar be done without influencing the energy balance. As long as energy is continuously returned back into the system, the total cycle efficiency can be kept high no matter what the revolution setting is and nomatter if the combustion temperature is high or low.



the pressure gradient laying over the engine is markedly lower than for other air breathing engines. Not surprisingly, pressure in the Fence Jumper is regulated by temperature just as is the case in reciprocating engines. When applying a recuperator to the Fence Jumper, the heat capture can be markedly increased due to the lack of compression pressure - excluding what comes from the isochoric combustion. As part of the recuperator for the Fence Jumper operates under isochoric conditions similar to that of the combustion process,

Another feature for maintaining the high efficiency is the so called APC (Ambient Pressure Compensation) system that prevents vacuum generation in the expander when pressure nears the outside ambient condition. Ports open and suck in air to prevent the vacuum. This clever system has the advantage that when going off the design point temperature, efficiency only drops a few points nomatter where you are on the operational envelope. Therefore, it could be said, that the Fence Jumper easily adapts to its applications.

Technology milestones

We use components that are well tested from the automotive and aerospace business. This is by the way also the businesses from where we come. Though a lot of components have to be design ourselves we try to use as many off-shelf components as possible. A thing that we recognized under our market studies for the Fence Jumper, was that your greatest concern by switching to a new engine technology, lays mostly by the engines sealing system. One recognizes the early days of Wankel engines. From the beginning, we spend a lot of time focusing on solving those issues before proceeding with anything else. Therefore, in order to verify the theoretical basis for the Fence Jumper engine, a lot of test benches and stuff like that has been built. Within a period of 3 years, two engines have been designed and used as research base, where add-on technology has continuously been developed to improve them. At the end, the idea is naturally to end up with a saleable product for you. The first engine, the CM01, was completed in 2005. This engine has given valuable information about the LSTE design concept as such and its strengths/weaknesses. One weakness showed to be sealing. The engine never ran successfully though several attempts were made to solve the sealing issue. Unfortunately, the size of the engine did not show flexible enough for such drastic modifications. What the engine did contribute to, was important information about the so called leveling (levelling) effect. Leveling is the backflow of exhaust gas from the combustion chamber back into the inlet zone of the engine. Much has been learned about the parameters required for achieving a stabile combustion and how such a combustion chamber has to be designed. Based on this knowledge, a combustion chamber was designed, the ST00 that the Fence Jumper uses, and works rather different from those found in gasturbines as the control of the air injection through the combustor lining in the primary zone and swirl area, can be done at different velocity. If the air jet injection speeds is 90 m/s over the lining holes, the injection

speed through the swirl can be as high as 125 m/s before vortex breakdown in the primary zone. This contributes to a steady flame under leveling and better control of air flow to the primary, secondary and dilution zones. Plotting of the combustion chamber was done in 2007 with a multiple number of injection nozzles possessing different spray patterns, showing steady operation over practically any airflow. The EIT (Expander Inlet Temperature) varies between 1.440 K (tops 1.473 K) and 450 K before flameout. At maximum air massflow and low fuel flow, a stable pilot flame appears. Though, due to practical purposes and pressure altitude considerations, the minimum allowable operating temperature has been set to 723 K. The test combustion chamber for the Fence Jumper, operates stable inside an air massflow envelope of 0,020 - 0,162 Kg/s (2 -150 hp) with stoichiometric relationships between 2,1:1 and 16:1 (tops 25:1 for some injection nozzles). The combustion chamber is designed for gas fuels such as propane/methane but burns also benzine, diesel and lamp oil (and vodka, but that was meant as a joke). The selected fuel for tests trials has been propane/methane where emission values were measured to lay between 6 to 48 ppm for NO_x, 7 to 257 ppm for CO_x and 0,77 to 6,39 g/m³ for CO₂ before emission treatment. That is approximately 2 g NO_x per kWh on average.

The CM02 concept engine was completed in 2008 and has undergone many tests. First hot tests were performed in the beginning of 2009 but showed that some modification had to be done to the rotating system. With this engine, the design concept has been frozen and changes are now adapted to fit a saleable product. The CM02 engine has proven, that with more effort and money, the Fence Jumper product will be a superior engine product in the competition with its native technologies. The current development stage has recently been raised to CM03 out of 5 stages.

* Minimum allowable combustion temperature: 723 Kelvin [For more information on the Fence Jumper you can contact us.](#)

** Design point combustion temperature: 1.073 Kelvin

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The listed efficiencies is a combination of theoretical and practical results and from a recuperator efficiency of 0,84.

Combustion completeness: 0,99
Expander efficiency: 0,97
Mechanical efficiency: 0,91 - 0,95

EngineWorks is located in Itzehoe 65 kilometers from Hamburg some 45 minutes away from Hamburg airport. Public transportation takes approximately one hour and 30 minutes.