KAWASAKI ANNOUNCES NEW CHENG CYCLE MODEL BASED ON IMPROVED GAS TURBINE

Kawasaki Heavy Industries (KHI) of Kobe, Japan has announced it will begin marketing its new Cheng Cycle system, using KHI's new M1A-13CC gas turbine engine as prime mover. The M1A-13CC is based upon the new, uprated M1A-13 gas turbine. Fully steam injected, the M1A-13CC system is capable of producing 2.4 MW of power (ISO) at a generating efficiency of 32.7%. KHI is the exclusive worldwide licensee of International Power Technology (IPT) for Cheng Cycle products based on gas turbines rated between 500 and 2000 kilowatts. The Cheng Cycle is IPT's patented steam-injected gas turbine technology which improves turbine efficiency and power output. Over 130,000 hours of operation have been accumulated on Cheng Cycle units supplied by IPT.

KHI has been applying the Cheng Cycle concept to its own gas turbine at a demonstration facility which was installed after extensive bench testing had been performed. This demonstration plant has been operating at KHI's Akashi Works since April 1988 and consists of a Kawasaki gas turbine as prime mover, a waste heat recovery boiler with supplementary firing, system controls and balance of plant equipment. The demonstration plant, in addition to supplying the Akashi Works with steam and electricity, provides KHI with a facility for developing and testing product improvements. Kawasaki's experience at this demonstration facility helps to ensure that products sold to end users will be highly reliable and will meet all performance expectations.

The operating regime of the M1A-13CC system, net of inlet and exhaust duct losses, is shown in Figure 1. A heat balance for the system is shown in Figure 2 for operation with full steam injection, and in Figure 3 for operation with no steam injection. The system is capable of producing up to 2,370 kilowatts and up to 8.58 tons/hour of process steam. The wide operating flexibility of the Cheng Cycle makes the M1A-13CC system ideal for small cogeneration applications, because the system is capable of following variable steam and electric loads economically. In addition, the intrinsic NOx suppression inherent in Cheng Cycle steam injection makes the M1A-13CC very attractive from an environmental standpoint.

Potential customers for cogeneration systems frequently have electrical and thermal requirements that vary considerably over time. This variability is especially common in locations where much of the energy requirements are for facility heating and cooling. Hospitals, universities, large hotels, and large mixed-use complexes characteristically have steam and electricity requirements which change significantly both daily and seasonally. In addition, small to medium-sized industrial plants usually have processes which operate intermittently, which can also cause large swings in the requirements for process steam.

Traditional gas turbine cogeneration systems often cannot provide adequate economic benefits in small cogeneration applications due to the variability of the host's steam and electric loads. When the process steam demand falls below the steam production of the gas turbine at its rated output, either excess thermal energy must be wasted or the turbine must be derated. Neither of these options is desirable. In contrast, the M1A-13CC Cheng Cycle system avoids these shortcomings, since it is capable of operating over the wide range depicted in Figure 1. Steam not needed for process requirements is simply injected into the gas turbine, thereby increasing the power output and generating efficiency of the engine. In addition, during periods when electric power is particularly valuable, the M1A-13CC can be fully steam injected to maximize electric power production, while the supplementary burner supplies the customer's process steam requirements. Economically optimum operating points are automatically selected by the control system and the cogeneration system requires no manual intervention whatsoever.

The operating flexibility of the M1A-13CC Cheng Cycle system allows the system design to be standardized to a much greater extent than the design of a conventional cogeneration system. Of course, different customers will have different requirements in certain areas, such as generating voltage and fuel supply systems, but much of the system will not need to be redesigned for different customers. This standardization provides at least two significant advantages: 1) The installed cost of the system is reduced due to decreased site-specific engineering and component costs, and 2) System reliability is enhanced because there is less likelihood of unexpected problems arising due to design changes and installation mistakes.

The turnkey price to the end user of the M1A-13CC system will be approximately $2.0-2.2 Million, or approximately $840-930 per installed kilowatt. A typical customer, for example a 600-bed hospital in the Northeast United States, could expect to realize a simple payback of from 2 to 3 years with the M1A-13CC. Each customer's economic benefit will vary depending on a variety of factors, including retail electric prices and utility buyback rates, fuel prices, and process steam and electricity requirements, but Kawasaki expects that most potential customers in the United States should realize benefits that result in simple paybacks of from 2 to 3 years.

The M1A-13CC engine is based upon the M1A-13 gas turbine. The M1A-13 gas turbine can, of course, also be configured for cogeneration applications. In contrast to the M1A-13CC, the M1A-13 is most suitable for customers that do not have much variability in their steam or electric requirements, or for customers who have little or no incentive to increase their electric power production during certain periods. In addition, the M1A-13 is well-suited for industrial processes which have a direct use for the hot exhaust gas, such as dryers. Providing for inlet and exhaust losses, the M1A-13 will produce approximately 1420 kilowatts (ISO) at a generating efficiency of nearly 24%. In a baseload cogeneration application, the M1A-13 will deliver an overall thermal efficiency of approximately 80%, or higher in the case that the exhaust gas is used directly.

The turnkey price of the M1A-13 cogeneration system will be $1.7-1.8 Million. The choice of whether to apply an M1A-13 or an M1A-13CC system for a particular application will depend upon the individual requirements of the customer and the economics of each application. With the M1A-13 and the M1A-13CC customers have an opportunity to pick cogeneration systems ideally suited to their needs. In addition, the M1A-13 is available in a twin version, the M1T-13, which is two M1A-13 engines connected to a single gearbox and produces approximately 2.8 MW at the generator terminals.

The M1A-13 family of engines, that is, the M1A-13, the M1A-13CC, and the M1T-13, is based on the M1A-03 engine, which has been installed in cogeneration applications worldwide. The M1A-13 engine incorporates a number of improvements to the M1A-03 which enhance the engine's efficiency as well as its ease of maintenance and reliability. A list of improvements which have been incorporated in the M1A-13 engine is given in Table 1.

The M1A-13CC incorporates all the performance improvements of the M1A-13, and has the following design differences to adapt to the Cheng Cycle application: 1) The throat area of the first and second stage turbine nozzles has been increased to accomodate the increased mass flow due to steam injection; 2) The spline-strength of the torque transfer shaft has been increased to allow for the significant increase in power output with the Cheng Cycle; 3) The combustion case and liner have been modified to allow the steam to be injected; and 4) The main reduction gearbox has been changed from 2200 horsepower to 4000 horsepower.

The first delivery of the M1A-13 engine will be in July 1989. The first M1A-13CC system will be delivered in December 1989. The products will be available through Kawasaki's worldwide distributor network. In North America, the KHI distributors are U.S. Turbine Corporation of Maineville, Ohio, and Cullen Detroit Diesel of Burnaby, British Columbia.

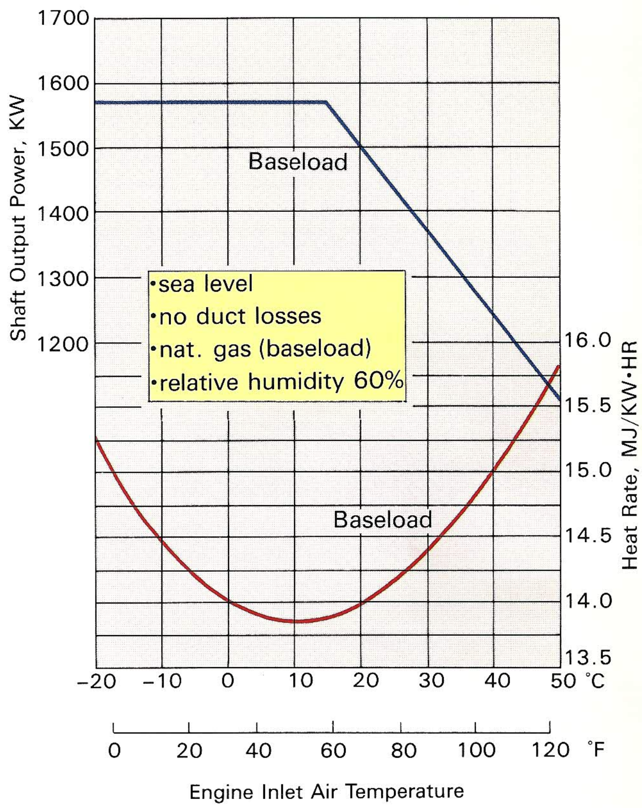
KAWASAKI HEAVY INDUSTRIES, LTD.

KAWASAKI

M1A-13

GAS TURBINE

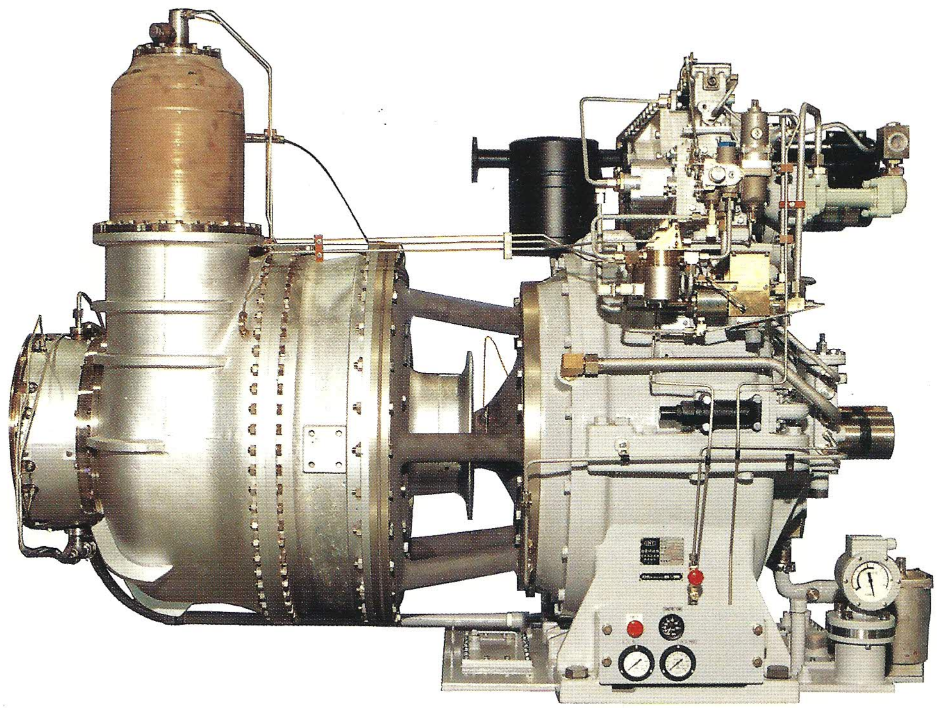
NOMINAL PERFORMANCE CURVE



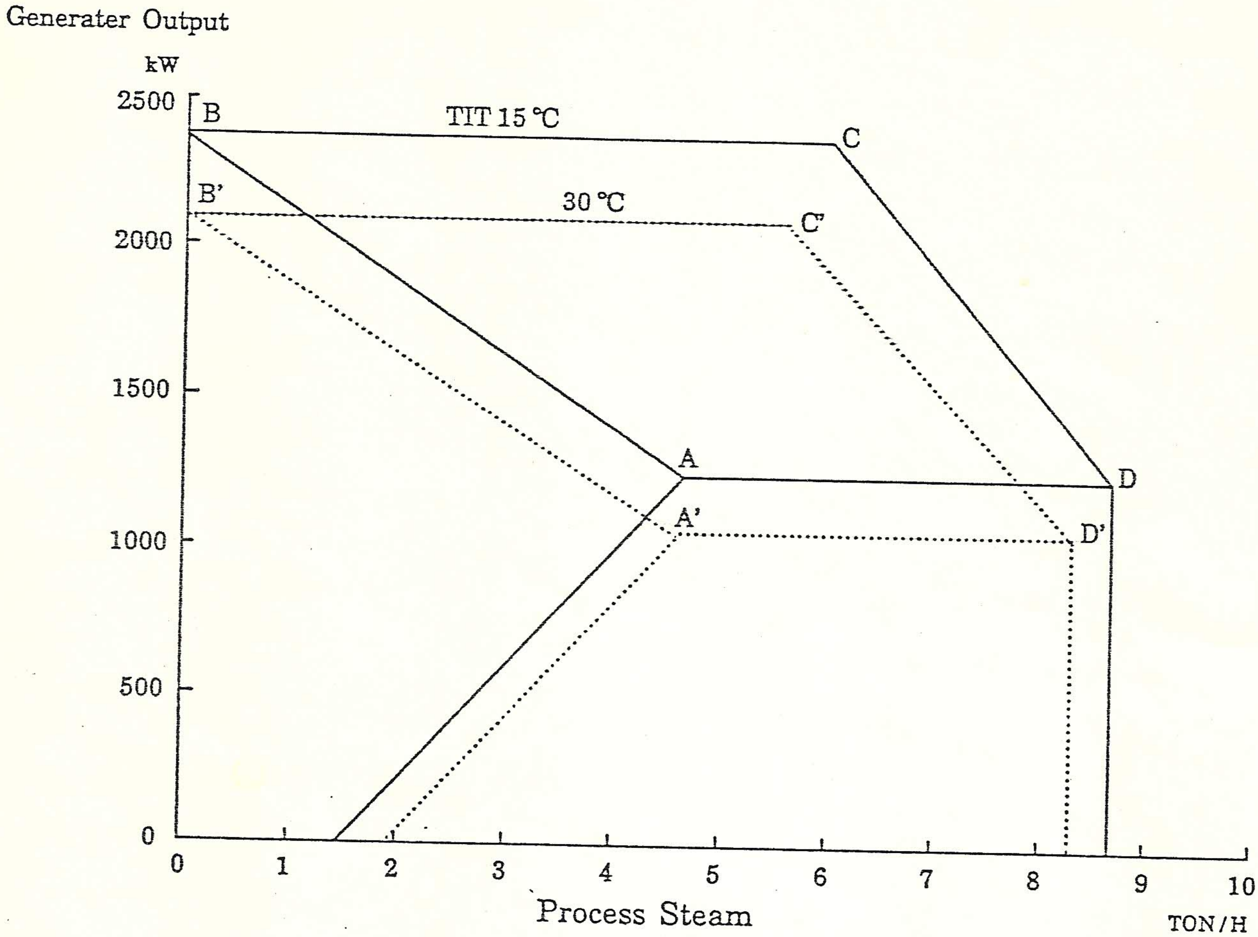
BASIC PERFORMANCE ISO Conditions

	baseload, natural gas
Shaft Output	1,570 KW
Heat Rate	13.9 MJ/KW·Hr
Efficiency	26.0%
Turb. Inlet Temp.	1,030 °C
Mass Flow	7.3 Kg/sec
Pressure Ratio	9.0
Exh. Gas Temp.	555 °C

KEY NOTES First Production : 1989



M1A - 13 Cheng Cycle Performance



TIT		15 ℃				30 ℃			
Operation Point		A	B	C	D	A'	B'	C'	D'
Generater Output	kW	1,240	2,370	2,370	1,240	1,060	2,130	2,130	1,060
Injected Steam	TON/H	0	4.71	4.71	0	0	4.46	4.46	0
Process Steam	TON/H	4.72	0	6.00	8.60	4.72	0	5.75	8.30
G/T Fuel	$\times 10^6$Kcal/H	5.31	6.27	6.27	5.31	4.91	5.72	5.72	4.91
Supplementary Fuel	$\times 10^6$Kcal/H	0	0	3.98	2.58	0	0	373	2.38
Generater Efficiency	%	20.1	32.5	32.5	20.1	18.6	32.0	32.0	18.6
Thermal Efficiency	%	77.8	32.5	58.0	84.5	81.1	32.0	59.1	86.6

Intake Duct Loss	100 mmAq	Steam Pressure	15.5 kg/cm^{2}a (Saturated Steam)
Exhaust Duct Loss	400 mmAq		
Generater Efficency	95%	Boiler Inlet Water Temp.	15 ℃
Fuel	Gas (LHV = 9940 Kcal/Nm^3)		