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Advances in Gas Turbines For Power Generation

by

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#1 - TITLE SLIDE

I would like to thank you this opportunity to talk to you about the role of gas turbines in power generation.

My name is Keith Johnson and I am the gas turbine product manager for Westinghouse Power Generation based in Orlando Florida. For the past few years I have spent a lot time talking to members of your insurance industry about gas turbines for power generation. So this is a very appropriate subject for this meeting.

I am going to review the role that gas turbines play in the global power generation market for the next 10 years or so and then review briefly some of the design features which Westinghouse as a major designer and manufacturer of gas turbines employees. The role that the insurance industry plays in this will be discussed. I

will also show two examples of where major equipment failures have occurred and show that with adequate spare parts and technical support available the actual downtime of the equipment can be minimized, thus reducing the impact on the insurance industry.

#2 - 1995 GENERATION

Looking first at the current, 1995 , world power generation market, the total installed capacity is about 3,075 GW. The major form of generation is the traditional steam turbine - generator which accounts for about 53.5% of this total. Hydro power represents about 23% and gas turbines are currently at about 11.5% of the current capacity, or 345 GW.

#3 - GT FORECAST

Moving to the forecasted new additions for the next ten years, out to the year 2005, the total additions are about 1,000 GW of power, or about a 30 % increase over todays installed capacity. These additions will be dominated by steam turbines and gas turbine based power plants. The added gas turbine power plants represent about 35 % of the new additions or about 350 GW. A very significant part of the market.

#4 - REGIONS OF WORLD

The overall rate of additional power from gas turbines is almost 5 % per year, compound annual growth. This chart shows the principle regions of the world where the major markets will be. The largest single region is Asia with the Americas both North and South being the second largest market. Europe and the Mid-East and Africa are the smallest regions for gas turbine power generation growth.

#5 - TYPES OF GENERATION

The characteristic of these new additions is interesting. If we look at the type of purchaser of the new power plants we see that in addition to the traditional utility type of customer, the non-utility customers, or IPP - Independent Power Producers - are globally becoming a very significant player. About 37 % of new additions will be from these IPP customers. This means that as they are private concerns, the ability to obtain insurance coverage, particularly for Business Interruption or loss of earnings, is becoming of major importance. This is not the case with traditional utility customers.

The major fuel source for the future is going to be gas, either natural or LNG, being almost 50% of new generation.

The type of power plant is also changing to utilize the high efficiency of the gas turbine based power plants. About 54 % of all new power generation will involve the gas turbine, either as a peaking or simple cycle plant or a base load combined cycle type of plant.

#6 - ECONOPAC PLAN

To show you a few examples of these different types of power plants lets first look at the basic layout of a simple cycle, open cycle gas turbine power plant which would be used mainly in peaking applications, that is for up to about 2,000 hours per year of operation.

The plant consists of the basic gas turbine which drives an electrical generator for the production of the electrical power. The plant has an inlet air system drawing air from the atmosphere where it is compressed before it is mixed with the fuel supply and combustion takes place. The high temperature products of combustion expand through a power turbine and the hot exhaust gases are discharged into the atmosphere.

#7 - SIMPLE CYCLE - CAPEX 3 ARGENTINA

This photo shows a typical simple cycle power plant where you can see the turbine generator, inlet air system and exhaust stack. This is a 125 MW power plant, and as you can see is far more compact than a steam turbine plant of similar output. This plant is a 50 Hertz located in Argentina.

#8 - COMBINED CYCLE PROCESS

I have mentioned combined cycles, which are the most efficient way to use the energy source. This diagram shows the combined cycle process where the hot exhaust gases instead of being discharged to the atmosphere are fed into a boiler where the exhaust energy is recovered to make steam. This steam then drives a steam turbine - generator. Thus the efficiencies of both the gas turbine cycle and the steam turbine cycle are combined.

#9 - AUBURNDALE, FLORIDA

This photo shows a typical combined cycle plant of about 150 MW output at the Auburndale site in Florida. It consists of one gas turbine and one steam turbine. Many variations of combined cycle configurations are available today by combining multiple gas turbines with multiple steam turbine generators. Plants can be any size with examples of up to 2,000 MW electrical power in operation.

#10 - BARGE

Another interesting application is the barge mounted power plant. Here the actual equipment both the gas turbine and steam turbine- generator are installed on a barge in a controlled environment of a shipyard. The power plant is then transported, in this case by a special heavy lift cargo ship, to the customer site where it is installed either a floating barge or is grounded.

#11 - CURVE OF POWER & HEAT RATE

I would now like to address the actual gas turbine technologies - where they have been and where we see them going in the future. It is the gas turbine technology levels that are mainly of interest to the insurers of such equipment. Over the past 25 years the technology has advanced in areas of materials, cooling designs and basic design analytical techniques. This has produced an ever increasing output size of power plant with ever increasing efficiencies. This trend will continue into the future.

#12 - RATE OF NEW PRODUCTS

It is interesting to look at the rate that the gas turbine industry has been introducing new products with new technologies over the recent past. As this chart shows for period of the 1980s, the average rate of introduction by the industry has been about 2 new products per year. However over the past 5 or 6 years there has been a dramatic increase in the industry for the introduction of new products in many cases with advancing technologies. We have all participated in this, the power generation market has demanded it with the need for larger and more efficient forms of power generation. This has also been reflected strongly in your industry as you are asked to provide the coverage for these new products and technologies.

#13 - TECHNOLOGY CURVES

The main technologies which are associated with these new products include the ever increasing firing temperature of the turbines. This trend is continuing as new products such as the US Government sponsored development program called ATS - Advanced Turbine Systems- progresses. Firing temperatures have increased from about 1260 C in 1990 to 1510 C by the year 2000. These increased firing temperatures are required for the continued increase in gas turbine efficiency. Ever more stringent emission requirements such as NOx - oxides of nitrogen is a continuing trend throughout the world.

#14 - DESIGN PROCESS

In order to achieve these advances in technology it is essential that the total design process be based upon a strong foundation and that you as an industry are familiar and comfortable with it. The process starts with a totally integrated process based upon well proven design philosophies. This includes not only the codes but must also include design verification and risk analysis, operator training and the continues follow of the power plants once they enter commercial operation.

#15 - 45 YEARS EXPERIENCE

Using my company, Westinghouse, as an example, fundamental design features of our turbines have been proven through over 45 years of operating experience. These basic features are included in all of our designs including the previously mentioned new ATS turbine which will take us into the 21st century. We strongly follow the philosophy of evolution rather than revolution.

#16 - MAINTAINABILITY

To highlight a few of these philosophies, especially those which have a direct bearing on the insurability of equipment, features such as designing for maintainability is important. We always consider the end user and the fact that he must have easy maintenance of his equipment if he is have a efficient operation.

#17 - DOWNTIME

Maintenance is required and from time to time unforeseen incidents do happen with rotating equipment. Therefore designing to minimize that actual downtime - or time the equipment is out of service for whatever reason is essential. As an example in our turbines we can remove and replace any individual blade in either the compressor section or the turbine section without having to remove the rotor from the casing. This reduces the time and costs by not having to bring in cranes etc.

#18 - CONTAINMENT

We all know that accidents do happen from time to time, however through careful and conservative design practices it is possible with a ruggedized and integrated design to contain any consequential damages that may occur. I will show you shortly examples of how this is realized in actual cases.

#19 - 501F EXPERIENCE

The latest technologies gas turbines that have now been in service for several years by the major manufacturers. The technology has generally been referred to in the industry as F technology - which actually is the designation given to specific firing temperature class of gas turbines. There has been much publicity in the press and within you industry of some of the operating experiences around the world with some of these class of turbines. It is important to state that non of the problems experienced has been related to this so called F firing temperature. The Westinghouse experience with this class of equipment is clearly demonstrated here with real world class records of availability of 94 % and reliability of 99 %.

The very recent incident with a MHI 701F in Thailand which you may have heard about is currently undergoing the engineering root cause analysis including the design parameters, manufacturing process and operational details. This will be concluded shortly.

#20 - DESIGN REVIEWS

We utilize in our design process the fully available experience from industry experts , including the insurance industry, to make sure that we are integrating everyones possible experience. The lessons learned concept from our own experience and that of customers and the insurers we consider to be of paramount importance.

I mentioned earlier that I would give a couple of examples of the containment of damage and with the optimum organization and planning the customer down time and as such the insurance liabilities can be minimized.

#21 - ROW 4 BLADE PHOTO

This first example is one of our turbines which suffered a row 4 turbine blade failure. This is a fairly significant failure and was the first time it had been experienced on this type of turbine.

#22- ROW 4 WORDS

The ruggedized design of the total plant including the rotor dynamics, bearing support structures, casings etc. together with a strongly dedicated engineering support organization, this machine had the root cause diagnosed and modified components reinstalled quickly. The total downtime that the machine was out of service was about 14 days.

#23 - ROW 1 PHOTO

A further dramatic example was failure initiating upstream of the turbine flow path causing a Row 1 turbine blade failure where further downstream consequential damage to the flow path components is inevitable.

As the photo clearly shows there was considerable damage throughout the entire turbine flowpath.

#24 -ROW 1 WORDS

I do not intend to discuss the details of How or Why this failure occurred , but use it as another example of minimizing downtime by having spare parts available, this time it was a total rotor assembly, together with the necessary support from the manufacturers organization this turbine was back in service in a remarkable 23 days.

#25 - HIGH AVAILABILITY

The messages from this discussion and these examples are clear, the market demands for more advanced products must be realistic, the manufacturers must complete thorough component verification before entering commercial service, operators must be well trained and users must have the required spares parts available to maintain a high availability. Here the insurance companies can provide a valuable input by insisting that their customers protect both their own investment and that of the insurance companies.

#26 - TRENT JET ENGINE

Before concluding I would just like to change the product slightly from the heavy duty industrial turbine to the aeroderivative gas turbines. These are fully proven in themselves and an accepted part of the power industry. The latest aeroderivative turbine is the Rolls-Royce Trent engine which is derived from the aero jet engine in airline service for just over one year on the Airbus A330 and the Boeing 777 aircraft. This aero engine is rated at over 90,000 pounds thrust. The industrial aeroderivative version is rated at over 51 MW for both 50 Hertz and 60 Hertz applications with simple cycle efficiency of 42 %.

#27 - TRENT AERO v INDUSTRIAL

This shows the modifications required in going from the flying jet engine at the upper half, to the industrial version shown at the lower section. The Trent is a 3 - shaft

design, that is three concentric shafts not connected together mechanically, but only aerodynamically. The slow speed or low pressure shaft rotates at either 3,000 rpm or 3,600 rpm for 50 or 60 Hertz applications. The major changes are the removal of the large fan at the front of the engine and replacing it with a new two stage compressor, so that all of the airflow now passes through the turbine section. The other major change is a new combustion system to satisfy the fuel and emission requirements of land based turbines. Virtually all other components are common with the jet engine.

#28 - TRENT ENGINE

The first of these Trent turbines will be shipping from the factory within the next few days and will be in commercial operation by November of this year. With this being the largest and most efficient power generation turbine in service we are entering a new and exciting market.

#29 - CONCLUSIONS

Finally then to summarize everything that I have talked about is the fact the market - your customers and the manufacturers customers will continue to drive advancing technologies which the manufacturers will introduce. You as insurers are required to get a comfort level with these new technologies. In order to achieve this comfort level it is necessary for the turbine designers and the insurers, as well as our mutual customers to maintain an improved level of communication. At Westinghouse we have been attempting to do this more in the past few years than maybe in earlier times.

#30 - BALANCE

Through this improved communications it is going to allow a realistic balance to be achieved between the advancing technologies and the need to maintain reliability and thus good insurability.

Thank you for your attention.