**High Efficiency Power Generation**

1. **Sayma, Y. Li**

Comments from the PB meeting

M. Ruggiero:

* (already discussed in AGM 2018 Bucharest) What is the importance of a good efficiency if a CO2-neutral and cheap fuel is used ?

G. Terzer:

* The title is not clear whether we look at a single turbine, or the complete cycle. Electrical efficiency is not always the target, e.g. CHP which rather looks at the global efficiency.
* Edit the graph

P. Kutne:

* Mention high efficiency for baseload, cheaper GT for peak or decentralized.

Y. Li:

* Variable-geometry GT efficiency should appear

Energy efficiency is very important from the supply side as well as the demand side. The IEA estimates that of all efforts required to deliver a 50% reduction in global CO2 emissions by 2050, 7% will need to come from power generation efficiency. Current European combined cycle gas turbine power plants operate at an average efficiency of 52%, while best available technology operates at above 60% efficiency. General measures to improve gas turbine efficiency are increasing Turbine Inlet Temperature (TIT) and compressor pressure ratio in parallel with cooling air reduction, more advanced aerodynamic concepts to improve component efficiencies and reduce leakeges in addition to cycle innovations. Other measure also include other components of the plant such as the steam turbine, waste heat recovery heat exchanger as well as electrical equipment. The above measures imply the need for development of new materials for improved component life at high part-load efficiency.

One of the implications of future flexible operation in power generation is the requirement for high part-load efficiency. Conventional power plants designed for base load have high design point efficiency, while part-load efficiency is comparatively low. Flexibly operating power plants should be developed to have higher average efficiency over the operating cycle, with higher part-load efficiency possibly being achieved at the expense of some reduction in design point efficiency as shown in Figure 3 (unless some innovative concepts become commercially viable). With the future scenario of CO2 neutral fuels, it would be still important to achieve high average efficiency to maintain commercial competitiveness of the plants.

To enable efficiency improvements to meet the required targets, research and development is needed in the following areas:

* Investigation of novel and/or variable thermodynamic cycles to achieve high power generation system efficiencies at both design and off-design operating conditions. Novel combined cycles should be investigated to achieve high global efficiency of power generation systems instead of gas turbines alone.
* Variable geometry gas turbines and combined cycle power systems should be investigated to achieve high thermal efficiencies at high part-load operating conditions.
* Advancements in design both for the primary and secondary flow paths. This requires adjusted axial and radial load distributions, new aerodynamic blade shape technologies, improved sealing and active tip gap control. It may also be possible to introduce end wall profiling or features that can disrupt secondary and leakage flows to improve efficiency particularly at part load.
* Reduction in cooling air requirements through advanced cooling system concepts as well as adjustable cooling air mass flow. This requires advancement in both modelling and testing methodologies.
* Design optimisation to achieve high efficiency over a wide range of operating conditions. This requires advancement in modelling and design tools to reduce the lead time for new designs. Ultimately, it may also be possible to achieve higher design point and off-design efficiencies through more variable pitch blading and using further improvements in aerodynamic and mechanical designs.
* New thermodynamic performance simulation tools should be developed to assist the design and optimisation of gas turbine power generation systems to achieve high thermal efficiencies.
* Improvements in material technology and thermal barrier coatings to withstand the higher turbine thermal loads resulting from elevated turbine inlet temperatures. This requires the development of tools to quantify material life under real operating conditions and improved material testing techniques.
* Optimisation of system efficiency should consider the combination of the gas turbine and the bottoming cycle at the same time, and thus R&D should take into account the performance of the Heat Recovery Steam Generator (HRSG) and the steam turbine. It should also consider the overall efficiency of the plant when used in CHP mode.
* New combustor technologies to enable low emissions and stable operation at part-load. This requires improvements in both modelling and experimental technologies in the field of combustion and issues of flame instability/lean blow-out and pressure pulsations.

**Ultimate Technology**

**Desired**

**Technology**

**Current**

**Technology**

Efficiency

Load