



130 kW / 200 kVA STARTER – GENERATOR AND ASSOCIATED POWER ELECTRONICS

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ABSTRACT

In the frame of MOET, THALES AES (TAES) realized and tested a high power starter – generator (S/G) able to generate a 200 kVA permanent power and to deliver a 130 kW mechanical power in starting mode. The S/G system was tested on the AIRBUS 100m test rig where it operated connected at an Electrical Power Center and high power converters delivered also by TAES, like an ATRU and a motor inverter.

INTRODUCTION

The mechanical – electrical conversion on board aircraft has changed for few years:

- Its power is increasing a lot to supply new loads,
- Its output electrical power characteristics are becoming different from the most usual ones (400 Hz / 115V constant frequency voltage),
- The conversion is going to contribute to the electrical main engine start,

- The electrical generation is often associated to power static conversion.

This change is explained by the fact that an electrical power increase is expected to reduce non-propulsive power consumption and so reduce fuel consumption.

This article presents an important item of this new electromechanical conversion: the S/G. Firstly, the S/G system architecture is presented, then technical characteristics and test results are described.

S/G SYSTEM ARCHITECTURE

The system is composed by a rotating machine, a generator control unit (GCU) and a power converter. The GCU provides the appropriate excitation current to control the generator output voltage and the power converter provides AC currents to develop the appropriate torque to start the main engine.

ROTATING MACHINE

It is a wound rotor synchronous machine composed by four main items:

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PMG (Permanent Magnet Generator): included auxiliary alternator, which supplies the GCU in generating mode;

ME (Main Exciter): included auxiliary wound field alternator supplied by the GCU in generating mode and supplied by an inverter in starting mode;

RR (Rotating Rectifier): supplied by the rotating ME winding, it supplies the MSG (Main Starter Generator) field winding;

MSG (Main Starter Generator): wound field alternator which provides voltage controlled electrical power in generating mode and which is supplied by a current controlled power inverter in starting mode.

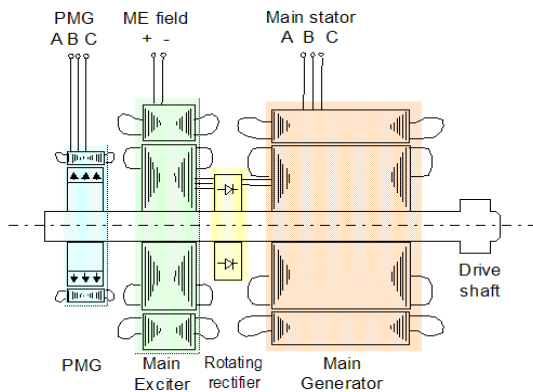


fig.1 - rotating machine scheme



fig.2 - rotating machine on TAES rig

POWER CONVERTER

It includes an input filter stage, an output filter stage and three inverters. Two of them are paralleled to supply the MSG winding. Their switching frequencies are interleaved to decrease the DC input filter size and AC

current ripples inside the MSG winding. The third one supplies the ME winding. It is only used in starting mode.

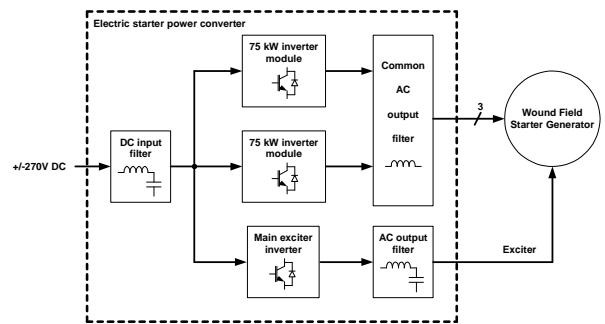


fig.3 - power converter scheme



fig.4 - power converter during TAES tests

MAIN CHARACTERISTICS

ROTATING MACHINE

- Starter power: 130 kW,
- Starter maximum torque: 300 N.m,
- Rated generator power: 200 kVA,
- Output voltage: 230 VAC,
- Generator speed range: 7600–16000rpm,
- Frequency range: 380-800 Hz,
- Cooling: oil circulation and oil spray.

POWER CONVERTER

- Input voltage: 540 VDC,
- Output power: 150 kW,
- Output current: 300 ARMS,
- Cooling: oil circulation.

TEST RESULTS

STARTING MODE

Different torque-speed characteristics were tested. Fig.5 shows one of them:

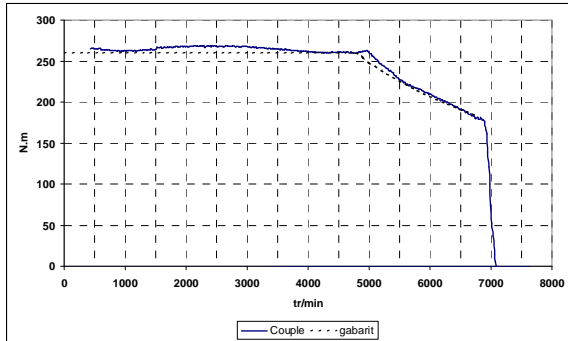


fig.5 - measured torque versus speed compared to expected curve

Three successive starts were performed at low cooling oil flow, to check the maximum temperature inside the machine at the end of the test. End winding temperatures remained at a low level (150°C like fig.6 indicates it).

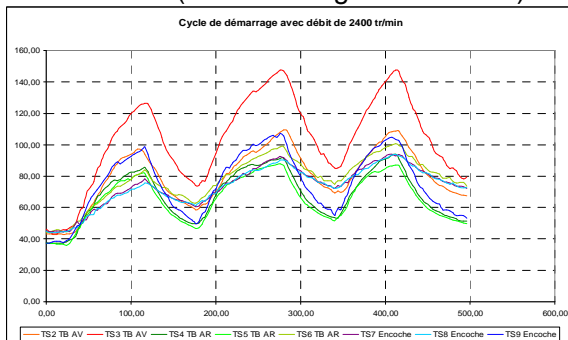


fig.6 - winding temperatures measured during three successive starts at low oil flow

In addition temperatures were measured inside the power converter during six successive starts. IGBT base plate temperatures remained below 70°C.

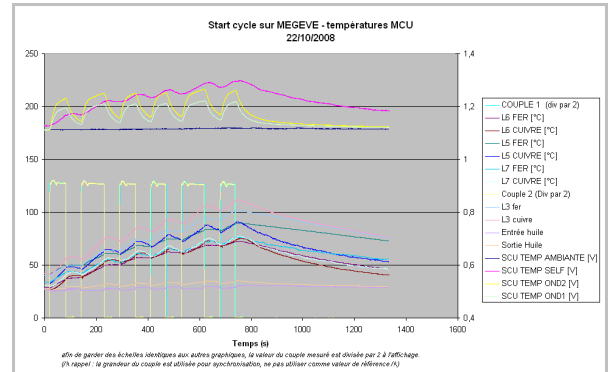


fig.7 - converter temperatures measured during six successive starts

GENERATING MODE

The S/G was associated to the GCU. The S/G delivered the expected power at the controlled 230VAC voltage. Main characteristics measured in generating mode are summarized hereafter:

- Speed range: 7600 to 16000 rpm,
- Permanent output power: 200 kVA,
- 5 min output power: 240 kVA,
- 5 sec output power: 320 kVA,
- Power factor: 0.75 to 1,
- Three phase phase to neutral voltage: 230 VRMS.

Power transients were tested. Transients no load / 200 kVA and 200 kVA / no load are shown in fig.8:

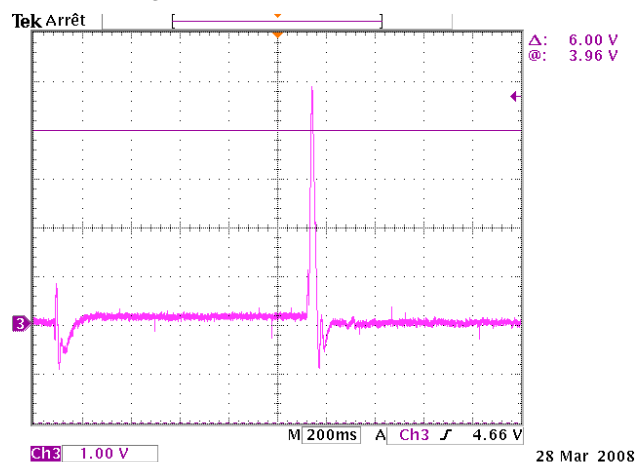


fig.8 - output voltage variation during no load/load and load/no load transients

CONCLUSION

The 130 kW / 200 kVA starter – generator was tested successfully on TAES rig. Then it was integrated on the AIRBUS test bench and connected to several power converters via an AC Power Center and a DC Power Center. Tests were conducted to estimate the network stability and the power quality. In general, test results showed the system functionality. It will be the basis for the further starter – generator developments during which mass, efficiency and compatibility with the new electrical networks will be optimized.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

- **GCU** : *Generator Control Unit*
- **IGBT** : *Insulated Gate Bipolar Transistor*
- **ME** : *Main Exciter*
- **MSG** : *Main Starter Generator*
- **PMG** : *Permanent Magnet Generator*
- **RR** : *Rotating Rectifier*
- **S/G** : *Starter - generator*
- **TAES** : *THALES AES*