HSG-System

Hybrid Shaft Generator

Electric system for shaft generators
(Patent number: NO 332138)

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The HSG-System

- drive system that controls the frequency from the shaft generator

Power range 100 – 5,000kW
Voltage 440V or 690V.

• Shaft generator (SG) can function either as a generator or as a motor (M)
• HSG drive supplies fixed frequency to switchboard even when engine rpm varies
• HSG drives allows shaft generator to operate in parallel with auxiliary gen sets
• Allows propulsion system to be optimised
• Reduced fuel consumption in all modes
• Reduced emissions of CO2, NOx, Sox
The HSG-System
Boost Mode

- Engine: 8500 kW, 750 rpm
- Generator: 6000 kW, 60 Hz
- Other consumers: 500 kW
- Two additional units: 1500 kW each
The HSG-System
Diesel Electric Mode
The HSG-System
Combinator Mode
The HSG-System
Transit Mode

- Pitch: 70%
- $P_n = 8500\,\text{kW}$
- $P_n = 2500\,\text{kW}$
- $P_n = 2500\,\text{kW}$
- $P_n = 6000\,\text{kW}, n_n = 750\,\text{rpm}$
- $P_n = 3500\,\text{kW}, 700\,\text{rpm}$
- $P_n = 1500\,\text{kW}$
- $P_n = 1500\,\text{kW}$
- $P_n = 600\,\text{kW}$
- $P_n = 400\,\text{kW}$

- Frequency: 58 Hz
- Frequency: 60 Hz
The HSG-System
Shore Connection Mode
Manual Mode Shift - Complexity

Manual Mode Shift:
Mode shift is based on several manual operations by crew: Start of auxiliaries, clutch operation, chose adequate PMS mode, etc.

Parallel Mode

Transit Mode

Diesel/Gas Electric Mode

Boost Mode
Rolls-Royce Automatic Mode Shift, Smart and seamless automatic mode shift:
- automatic transfer from one vessel mode to another vessel mode.
- controlling auxiliaries, connect/disconnect, clutches, synchronizing, pitch and rpm, and mechanical and electrical power demand in combination.
Rolls-Royce data-strictly private
HSG-System advantages

• Engines/propellers can be under full combinator control over entire speed range
  - optimised propulsion efficiency, minimised emissions

• HSG Drive supplies fixed frequency to the Switchboard

• HSG Drive output can be in parallel with auxiliary gensets

• Slow steaming in parallel mode and lower propeller rpm reduces propeller losses

• PTI Boost Mode using HSG and Shaft Generator running as motor

• Reduces running hours on auxiliary gensets

• Easy Mode selection

• Lower noise and vibration with reduced engine/propeller rpm

• Shore connection mode give fixed frequency from switchboard
HSG-System advantages

- Engines/propellers can be under full combinator control over entire speed range
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- HSG Drive supplies fixed frequency to the Switchboard
- HSG Drive output can be in parallel with auxiliary gensets
- Slow steaming in parallel mode and lower propeller rpm reduces propeller losses
- PTI Boost Mode using HSG and Shaft Generator running as motor
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- Easy Mode selection
- Lower noise and vibration with reduced engine/propeller rpm
- Shore connection mode give fixed frequency from switchboard
Variable speed benefits

- **Example:** Torghattens Landegode
- **One B35:40V12PG, one shaft**
  - 750rpm → 240 propeller rpm
  - 5250kW
P/D-N diagram

- Curves of shaft power vs prop speed at constant propeller pitch
- Free running speed indicated
- Minimum indicate maximum propulsion efficiency → low vibrations
- Add engine operation limits
- Add reserve for acceleration, weather and electrical power consumers
- Then choose where to operate by designing the combinator curve
Modified P/D-N

• Take into account gearbox losses
• And engine efficiency

• Then picture becomes even clearer
Field measurements
Conclusions – variable speed

- Lower speed improve fuel efficiency due to both propeller and engine effects
- Immediate lower fuel consumption benefits
- Lower vibrations from both engine and propeller
- Greatest benefit in vessels with extended part-speed operation
- Further improvements possible with automatic adaptation of engine operation limit and combinator curve
End

Thank you for your attention