Hybrid Ready Transmissions and Hybrid Systems

2020-10-08 | Marine Online Seminar
 Agenda

1. Hybrid Ready Transmissions
2. Hybrid Systems (and Strategy)
3. E-Motors
4. Single Line Description
5. Explanation of the Hybrid operating modes
6. Checklist for Hybrid Drive
7. References
01
Hybrid Ready Transmissions
# Hybrid Ready Transmissions

<table>
<thead>
<tr>
<th>Shaft</th>
<th>Type</th>
<th>Ratio range</th>
<th>FPP</th>
<th>CPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forth shaft</td>
<td>ZF 33XX</td>
<td>2.647-5.000</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>ZF 52XX A/V</td>
<td>1.882-4.250</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>ZF 53XX</td>
<td>2.587-5.040</td>
<td>x</td>
<td>x</td>
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<tr>
<td></td>
<td>ZF 83XX</td>
<td>2.576-4.708</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>ZF 93XX</td>
<td>2.471-5.185</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Intermediate shaft</td>
<td>ZF W10XX0/ ZF 10X00</td>
<td>1.683-7.900</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>pinion</td>
<td>ZF W11XX0/ ZF 11X00</td>
<td>1.683-8.700</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>ZF 24X00</td>
<td>0.790-8.060</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Input shaft pinion</td>
<td>ZF W43X00/ ZF 43X00</td>
<td>2.536-5.950</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZF 837X0 (right/ left)</td>
<td>2.867-5.591</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
Additional Shaft (4th shaft) on “smaller” gears – why?

- **Vessels of comparable smaller sizes look for compact solution**
  - The 4th shaft doesn’t need additional installation space (same footprint like the standard gears)
  - No prolongation of the shaft line (like e.g. with “inline” or “sandwich” solution)
  - Smaller electric engines can be mounted directly to the gearbox (no additional foundation)

- **Fits ZF’s philosophy: Light products with high power density**
  - Due to the additional shaft, we are not limited by the torque capacity on the input clutch

- **ZF looks for highest flexibility**
  - Various additional ratios on the input side of the 4th are available

- **Driving modes (Diesel- / Electric- / Boost- / Generator – Modes) are handled by one control station**
  - Main clutches and PTI clutches for diesel and electric mode are all operated by one hydraulic system
Latest version of hybrid ready transmission – ZF5200 A PTI
Example of Installation in a Yacht
02

Hybrid Systems (and Strategy)
Hybrid System – ZF scope of supply
ZF scope of supply

1. Maneuvering system

2. Power Converter incl. Cooling

3. Hybrid-ready gearboxes (incl. fixture, PTI brake, clutch, stand-by pump, elastic coupling etc.)

4. E-Motors ➔ 150 kW | 300 kW | 450 kW | 600kW | 750kW

Not ZF scope of supply: Battery, Generator, Main engine (diesel), Power Management
Standard System Solutions – why?

- Hybrid is still a niche product
  - Standardization will help to bring initial costs down
  - With further increased market penetration volume effects will bring cost down
  - Faster engineering and shorter lead times
  - Simplified management of service support (training on field personal, parts storage, handling, documentation)
03
E-Motors
### E-Motors

#### Asynchronous machine
- **Operating modes**
  - PTO
  - PTI-Boost
  - PTI-TMH
  - Normal Motor Control Mode with INU
- **Advantages**
  - No voltage on generator terminals
  - Without output breaker possible
  - High system efficiency at higher power
- **Disadvantages**
  - Blackout Start not possible
  - Bigger motor inverter unit (reactive power)
  - Encoder needed

#### Permanent Magnet machine
- **Operating modes**
  - PTO
  - PTI-Boost
  - PTI-TMH
  - PTO/PTI-Boost
- **Advantages**
  - Blackout Start possible
  - No Anti Voltage Regulator needed
  - High system efficiency at lower power
  - Smaller motor inverter unit (less reactive power)
- **Disadvantages**
  - Output breaker recommended (because of propeller drive)

#### Synchronous machine (separately excited)
- **Operating modes**
  - PTI
  - TMH
  - PTO
  - PTI-Boost
- **Advantages**
  - Blackout Start possible
  - Smaller motor inverter unit (less reactive power)
  - High system efficiency
- **Disadvantages**
  - Output breaker recommended (because of propeller drive)
  - External Anti Voltage Regulator needed
### E-Motors (Permanent Magnet machine)

<table>
<thead>
<tr>
<th></th>
<th>150 KW</th>
<th>300 KW</th>
<th>450 KW</th>
<th>600 KW</th>
<th>750 KW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating speed</strong></td>
<td>2700 rpm</td>
<td>2900 rpm</td>
<td>2100 rpm</td>
<td>1600 rpm</td>
<td>1600 rpm</td>
</tr>
<tr>
<td><strong>Cooling method</strong></td>
<td>Liquid cooled</td>
<td>Liquid cooled</td>
<td>Liquid cooled</td>
<td>Liquid cooled</td>
<td>Liquid cooled</td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>450 mm</td>
<td>450 mm</td>
<td>648 mm</td>
<td>665 mm</td>
<td>665 mm</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>368 mm</td>
<td>548 mm</td>
<td>598 mm</td>
<td>1040 mm</td>
<td>1040 mm</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>172 Kg</td>
<td>295 Kg</td>
<td>490 Kg</td>
<td>950 Kg</td>
<td>950 Kg</td>
</tr>
<tr>
<td><strong>Protection degree</strong></td>
<td>IP65</td>
<td>IP65</td>
<td>IP65</td>
<td>IP65</td>
<td>IP65</td>
</tr>
</tbody>
</table>
04

Single Line Description
**Single Line Description**

- **Liquid Cooled Frequency Converter Cabinet**
- **Diesel-Engine**
- **Transmission**
- **Simplified Gear-Box**
- **Permanent Magnet Machine (reversible)**
- **Opt-BC**
- **Opt-D7**
- **Opt-BC and Opt-D7**
- **Grid Inverter (INU)**
- **AFE – Grid Inverter**
- **Sine-wave Filter**
- **Air Cooled Isolation Transformer**

**Dimensions:**
- Length: 2170 mm
- Width: 1660 – 2060 mm
- Depth: 640 – 840 mm

**Weight:** depending on the scope of delivery
Explanation of the Hybrid operating modes
**Electric drive mode (PTI Power-Take-In)**

- Main engine (diesel) off
- Propulsion by E-motor
- Powered by main generator or battery*
- Hotel load by main generator or battery*

*if battery available
Power Management and battery not ZF scope of supply*
Boost mode

- Main engine (diesel) on
- Main generator on
- Propulsion by E-motor and main engine (diesel)
- Powered by generator or battery*
- Hotel load by main generator or battery*

* if battery available
Power Management and battery not ZF scope of supply
Generator mode (PTO Power-Take-Out)

- Main engine (diesel) on
- Main generator supply only on demand
- Propulsion by main engine (diesel)
- E-motor as generator driven by main engine to load battery* or to supply hotel load

* if battery available
Power Management and battery not ZF scope of supply)
06

Checklist for Hybrid Drive
### Checklist for Hybrid Drive

#### 1. Project Information
- **Vessel/Project Name:**
- **Model Number:**
- **Application Type:**
- **Designer:**
- **Shipyard:**
- **Owner:**
- **Number of propulsion systems:**
- **Commissioning Data:**
- **Expected Delivery Date:**
- **Classification Requirements:**

#### 2. Basic System Information
- **Motor Drive/Drive:**
  - **Type:**
  - **Power:**
  - **Control:**
  - **Rotation:**
  - **Voltage:**
  - **Parameters:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation</td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td></td>
</tr>
<tr>
<td>Parameters</td>
<td></td>
</tr>
</tbody>
</table>

#### 3. Expected Performance of the Electrical System
- **Power of E-Motor:**
- **Speed of E-Motor:**
- **Voltage and Opp.:**
- **Input Current:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td></td>
</tr>
</tbody>
</table>

#### 4. Expected Operation Modes

**Diesel Mode:**
- **E-Motor off, PTO disconnected**
- **Propulsion by main engine (diesel)**
- **Hoist load by main generator or battery**

*Expected speed in knots: Please extend*

**Generator-electric drive mode:**
- **Main engine (diesel) off**
- **Propulsion by E-motor**
- **Hoist load by main generator**

*Expected speed in knots: Please extend*

**Battery-electric drive mode:**
- **Main engine (diesel) off**
- **Main generator off**
- **Propulsion by E-motor (diesel)**
- **Hoist load by battery**

*Expected speed in knots: Please extend*

**Deactivation mode (Battery supplied):**
- **Main engine (diesel) off**
- **Main generator off**
- **Propulsion by rail**
- **Propeller turning**
- **E-motor or generator driven by main engine plus main generator to load battery**
- **or to supply total load**

*Generator mode:**
- **Main engine (diesel) on**
- **Main generator on**
- **Propulsion by main engine (diesel)**
- **E-motor or generator driven by main engine plus main generator to load battery**
- **or to supply total load**

*Battery available (not ZF scope of supply)*

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**Checkliste Hybrid Drive**

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References
Hybrid Reference
Vision of the Fjords

Vessel details

- Name: Vision of the Fjords (Norway)
- Shipyard: Brødrene Aa
- Application: Passenger Ferry (450 pax.)
- Commissioning: 2016
- ZF Gearbox: 2x ZF 2050
- Main-Engine: 2x MAN D2862 LE422
- E-Motor: 2x Oswald 150 kw each in E-Motor mode

Parallel Hybrid Catamaran with up to 3 hours full electric mode
Hybrid Reference

Home

Vessel details

- Name: HOME (Year 2017)
- Shipyard: Heesen
- Application: Fast Displacement Yacht (50m)
- ZF Gearbox: 2x ZF 3310 PTI
  1x ZF TT 1001 FP ALU
  (90kW@1500rpm)
- Main Engine: 2x MTU 12V 2000 M61 (power)
- E-Motor: 2x Visedo 237 kW
- Sister vessel in project phase (Heesen 18650, Year 2019)
Hybrid Reference
Incat Crowther

Vessel details
- Name: Incat Crowther (Design IC15171), under construction
- Shipyard: RDM Australia
- Application: Fast Ferry
- ZF Gearbox: 2x ZF 3311 PTI
- Main Engine: 2x MTU 10V 2000 M72
- E-Motor: 2x Visedo 237 kW

An innovative new eco tour vessel on Tasmania’s World Heritage listed Macquarie Harbour
Hybrid Reference
Rainbow Warrior II

Vessel details

- Name: Rainbow Warrior II
- Shipyard: Fassmer
- Application: Motorsailer
- ZF Gearbox: 1x ZF W7610 (PTO/PTI)
- Main Engine: 1x CAT 3512 (1425 kW at 1600 rpm)
- E-Motor: 1x electric motor 300 kW (used in generator mode "wind milling")
Hybrid Reference
Silver Wind

Vessel details
- Name: Silver Wind
- Shipyard: ISA, Ancona
- Application: Fast Displacement Yacht (50m)
- ZF Gearbox: 2x ZF 9350 PTI
- Main Engine: 2x MTU 16V 4000 M93 L (3440 kW at 2100 rpm)
- E-Motor: 2x SIEMENS electric motor 150 kW
Hybrid Reference
Aviva

Vessel details
- Name: Aviva (Year 2017)
- Shipyard: Abeking & Rasmussen
- Application: 98,3 m Yacht
- ZF Gearbox: 2x ZF 24360 PTI
- Main-Engine: 2x MTU 16v4000 M73L
- E-Motor: 2x SER Schorch 600kW
- Video of the Vessel: LINK
Hybrid Reference
MS Diamant

Vessel details

- Name: MS Diamant
- Shipyard: Shiptec AG
- Application: Ferry
- ZF Gearbox: 2x ZF 3000 V
- Main Engine: 2x Scania DI13, 405kW
- E-Motor: 2 x Siemens e-motor 180 kW
Hybrid Reference
EuroTug 3515

Vessel details

- Name: EuroTug 3515 Hybrid
- Shipyard: Neptune
- Application: Tug
- ZF Gearbox: 2x ZF W5350 PTI
- Main Engine: Caterpillar C32
  (2910 kW at 1800 rpm)
- E-Motor: Caterpillar
Thank you for your attention