MOL Rotating Equipment Consultant

ING. A.(ARIE) MOL
EUROPA-RING 67
7641 DJ WIERDEN
THE NETHERLANDS

PHONE +.31.(0)546.573643
FAX +.31.(0)546.573643
MOBILE +.31.(0)6.53166719
E-MAIL molrec@hotmail.com

ABNAMRO BANK 45.45.62.314
Kvk (CoC) 060.76445
BTW (VAT) NL080312792B01
WEBSITE www.ariemol.nl

MACHINERY VIBRATION ANALYSIS
ROTATING EQUIPMENT ENGINEERING

AN INTRODUCTION TO THE

'DYNAMIC MARINE POWER' CONCEPT

A NOVEL APPROACH TO FUEL EFFICIENCY

Arie Mol, Rotating Equipment Consultant
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The 'Dynamic Marine Power' concept represents the most advanced diesel-electric marine power supply system serving large power consumers on board.
At almost any kW power demand the diesel engines are operated at their minimum specific fuel consumption rate BSFC [lb/hp-h], [grams/kWh] thus significantly saving on fuel.
The 'Dynamic Marine Power' concept features electric power supply delivered by variable frequency dieselgenerator sets, induction motor drives and the use of electronic variable frequency converters in between them.
The 'Dynamic Marine Power' concept adresses two basic problems for long time waiting very patiently to be tackled:

a) diesel engine inefficient fuel consumption at partload
b) energy losses caused by the natural mismatch of torque-speed characteristics of diesel engine and axial/radial flow machines like propellers, bowthrusters, centrifugal pumps, etc.

Savings in space and weight thus investment costs, reduced pollutant emissions, low maintenance costs, low noise and vibration and the use of conventional rotating equipment add to overall economy and reliability. The simplicity of the concept allows the shipyard to reduce installation and commissioning time on board.

This concept was presented for the first time at Europort Maritime 2007 in Rotterdam.
www.ahoy.nl/docs/europortmaritime/persberichten/pb_pieterdrives.pdf

2007: more than € 700,00 per ton?

The steadily increasing price of fuel is a powerfull drive towards a search for innovative solutions in the field of energy generation and distribution on board. Are significant savings on fuel feasible today? In recent years much have been done by manufacturers to achieve best efficiency for components like diesel engines and propulsion impellers. Major leaps forward regarding efficiency are not expected in the near future. Efficient route planning and logistics along with a fuel-conscious attitude may help to win a few percent. Could a more conceptual approach focussing on the entire power 'system' rather than focussing on a single 'component' add to more efficiency?
The answer is yes provided classic ideas are thrown overboard.

The basics behind Dynamic Marine Power concept.

As mentioned earlier there are two basic problems responsible for poor energy efficiency on board. Two solutions that tackle these two shortcomings are presented in this paper.

Firstly, there is the problem of a diesel engine's inability to run efficient at partload. At constant speed and reduced power demand the engine becomes inefficient very soon because the specific fuel consumption rate (BSFC) increases rapidly at reduced torque and fuel injection levels. In the past a diesel engine also lost efficiency once deviating from a nominal speed or from a confined speed range. Today, modern state-of-the-art diesel engines are capable of producing a high torque and low BSFC at a wide operating speed range (WOSR) thanks to common rail injection technology.
Therefore, it is more efficient to respond to variations in kW (HP) demand by changing speed rather than by throttling back the fuel rack. As an example, it is more fuel efficient to respond to variation in kW demand from 100 % to 65 % by changing speed from 1800 rpm to 1170 rpm at constant torque rather than by changing the fuel rack position back to 65 % at constant speed.
Secondly, the problem of hugh natural mismatch between supply and demand need to be solved. In other words, between the torque-speed characteristic of diesel engine and the torque-speed characteristic of axial or radial flow machines like a propeller, bowthruster or centrifugal pump. This mismatch inevitably leads to energy losses. For some applications the WOSR characteristic may be helpfull to overcome such a mismatch. In general however an electronic frequency converter is an ideal 'transformer' to eliminate the mismatch.

Dynamic Marine Power concept lay out.

Figure 1 shows the basic schematics of the Dynamic Marine Power concept. It is basically the set up of the classic diesel – electric power supply system. However a fundamental difference is that the main power supply switchboard has a variable frequency. The induction motor driving the load is connected to the generator through a cable (electrical shaft) and in this power line the variable frequency converter is inserted.
Each variable frequency converter supplies the load with the required frequency, speed and required kVA power. The variable speed dieselgenerators choose a frequency and excitation level that meets the total kW and kVAr demand of all consumers.
The Dynamic Marine Power concept is best suited for applications featuring several heavy duty consumers that have a varying kW power demand over varying time-scales. As an example, a dredging vessel may need 5 MW for a dredge pump whilst propulsion demand is reduced to 2 MW. When speeding to sea and going back 5 MW propulsion is needed. A conventional design needs 10 MW installed diesel engine power although a total of 7 MW is required. On the contrary, when 99 % of the time the power scenario is constant, other designs may be fuel efficient as well. This may apply to a long haul container ship.

To achieve minimum BSFC over a wide power range the dieselgenerators are running in parallel.
For example, for a single unit BSFC can be minimum for a speed range from 1850 rpm / 62 hz to 1450 rpm / 48 hz covering a 100 % - 78 % kW power demand. With the fuel rack position back to 75 % where BSFC is still minimum a kW power demand of 100 % - 58 % can be covered. Choosing two or three units in parallel covers 100 % to 29 % resp. 19 % kW power demand. At almost any kW power demand the diesel engines are operated at their minimum specific fuel rate resulting in minimum fuel consumption.

The basic advantages that come with the Dynamic Marine Power concept are:

- The maximum frequency at maximum kW power rating can be higher than the classic 50 hz or 60 hz. A higher frequency at same kW power level means lower torque level, hence lower size and weight of all rotating equipment in the entire power string. Price of rotating equipment is proportional to weight so a significant investment reduction can be achieved.
- Standard design dieselgenerators can be located anywhere on board, leaving room for more payload. Containerised version provides low-noise and low-vibration adding comfort to the crew on board.
- 'Oil-free' transmissions: no gearboxes, no bi-directional couplings.
- Reduced torsional vibrations, compact drives, no need for long baseframes that are susceptible to torsional vibrations.
- Built-in redundancy.
- Standard 'proven design' components and technology, normal delivery times.
- Reduced commissioning time-line, a significant part of commissioning work can take place on land.
- Compact electrical drives saving weight and space. Reduced dimensions using water-cooled motors or motors with permanent magnet technology.
- There is no limit to power rating using medium kV electrical machines and 690 V variable frequency converters with step-down / step-up transformers.

Design evaluation.

When considering the Dynamic Marine Power concept, or any other concept, it is crucial to evaluate the fuel consumption profile. Such a profile shows running times versus load and fuel consumption. On existing ships an advanced engine management system can provide these data. On new-built ships a profile can be modelled. Once a fuel consumption profile is known a fair comparison can be made between various concepts regarding fuel savings.
For example, a comparison can be made based on a 1000 kW (1350 HP) engine, 4000 running hours over a one year time span (46 % of a total of 8760 hrs), at an arbitrary chosen operational schedule:

>> Classic concept:

hours	load	BSFC	fuel	consumption	
[hrs]	[%]	[gr/kWh]	[tons]	[kWh]	
1000	100	200	200	1000000	P = max.
2000	42	240	202	840000	P = (3/4)^3
1000	13	300	39	130000	P = (1/2)^3
-------+			-----+	------------+	
4000			441	1970000	(average 224 gr/kWh)

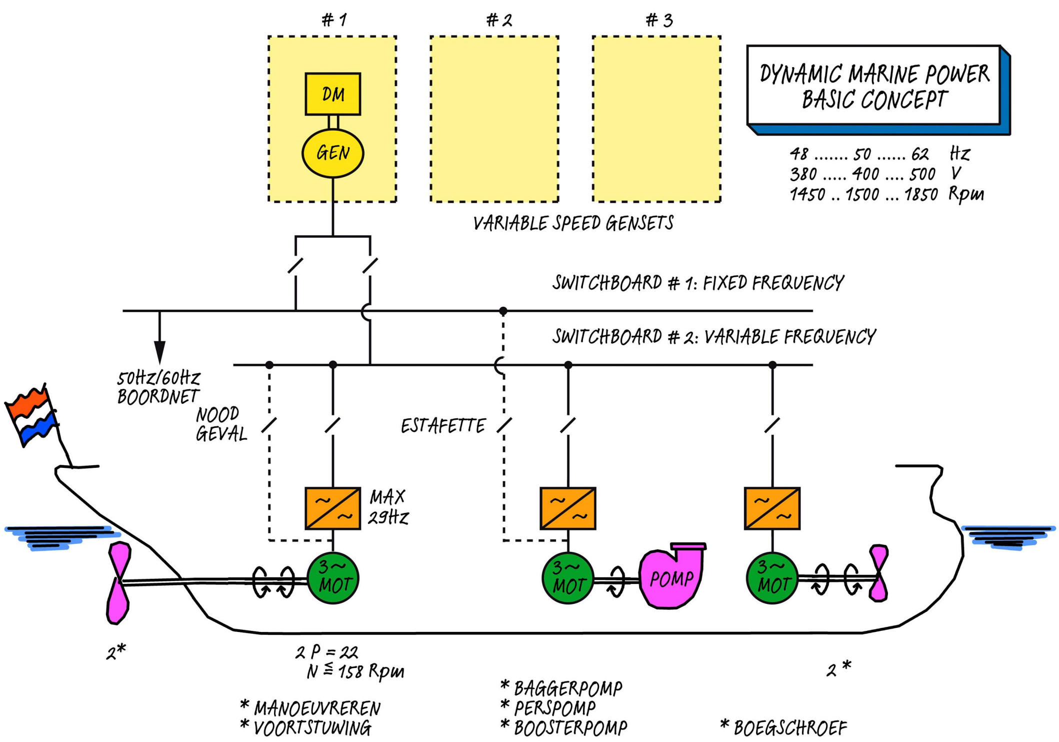
>> Dynamic Marine Power concept:

hours	load	BSFC	fuel	consumption	
[hrs]	[%]	[gr/kWh]	[tons]	[kWh]	
1000	100	200	200	1000000	P = max.
2000	42	200	168	840000	P = (3/4)^3
1000	13	200	26	130000	P = (1/2)^3
-------+			-----+	------------+	
4000			394	1970000	(average 200 gr/kWh)

Savings on fuel are 11 %. And 47 tons diesel fuel at a € 700,00 per ton price level saves € 32.900,00 per 1000 kW installed shaft power rating.

The autor:
Arie Mol is self-employed independent Rotating Equipment Consultant, Wierden, Netherlands.
Website: www.ariemol.nl
Contact mobile: +.31.6.53166719

ENERGIEZUINIGE AANDRIJVING VOOR SCHEPEN



PIETER DRIVES

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Fig. 1 : ‘an artists impression’ of the ‘Dynamic Marine Power’ concept.