Analysis of transient behavior during starter compensated of asynchronous motors propellant in low-powered electric boats

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Abstract: - They are known operational limitations that cause the electrical system of a ship, the starter of electrical bow thrusters. Normally during this operation has appealed to generator dedicated exclusively to such motors, for this purpose, or dispose of any of the auxiliary power plant off the bar bus and thus limiting the consumption of power available inside the ship.

This way of design or operating the electric system during operations in port, is conditioned by the high starting current that need asynchronous electric motors and their strong reactive, which leads, temporarily, significant voltage droops and changes in the frequency in the transient response of the generator. These variations can be accepted by the electrical bow thrusters, increasing his start cycle, or for any resistive load, but are unacceptable for the good functioning of any other kind of dynamic or electronic load.

The same problem is transferable to electric propulsion in small boats, with the aggravating circumstance that space constraints and that conditions leading to a single generator for all services. This study shows the improvements offered in these cases, the starting offset by kinetic accumulator, reducing voltage drop and the star cycle.

Key-Words: - Asynchronous motor, electric generators, synchronous compensator, thrusters, power plant.

1 Introduction

The present work is summarized in three parts: introduction, development and presentation of experimental work and finally the first conclusions that we obtained. Which allow a forecast of possible developments and applications of the research that we hope in the future, based on research conducted to date [1-6].

We have tested two propellers powered by an engine generator and the connection is made directly through contactors [3,4]. The direct control of contactors, allow the stop and reversing the direction of rotation of the propeller without electronics, for example direct control all or nothing.

The synchronous generator is limited to short-circuit current 3 In. Excitation control, enables fast control of reactive power put into play during the transient start up and reversal of rotation. It has also been used with a synchronous compensator regulation similar to the electromagnetic generator

[7-9], to strengthen the instantaneous reactive power of the generator, increasing the total available, no significant increase in consumption by the engine.

Propellants react in less than 1000 ms, much lower than in the transient start up and reversal of rotation with electronic control, which opens an interesting range of possibilities in the field of dynamic stabilization of heel and pitch. This structure of electric thrusters allows orient vertical component of force on both sides and / or fore or aft. Has not yet studied the influence on thermal thrusters working on this scheme, depending on the timing of the work cycle and allowed to study it later.

The fact that the generators have a short-circuit current limited to 3 times the nominal (3In), unlike other equipment such as transformers that can lead to short circuits in the order of 20 [10], becomes a serious limitation, since a board, where is generated by rotating machine.

The current limited by definition on-board can be increased with the use of synchronous compensators. This allows coping with transient start up and reversal of rotation of large induction motors, not oversize the engine carried by the diesel generator.

2 Experimental development

Equipment used in the experimental part, were essentially:

- A power of 13 hp engine and alternator 6.5 kVA and 400 V.
- A synchronous compensator 5.5 kVA - 400 V
- Two induction motors of 2.2 kW, III 400V, 50 Hz, IP 68, submersible pump.
- Transformers measuring intensity 5/5
- Shunt measuring 60 mV/5A (power synchronous compensator)
- Shunts measuring 80 mV/5A (engine power)
- Yokogawa Oscilloscope 4 channels.

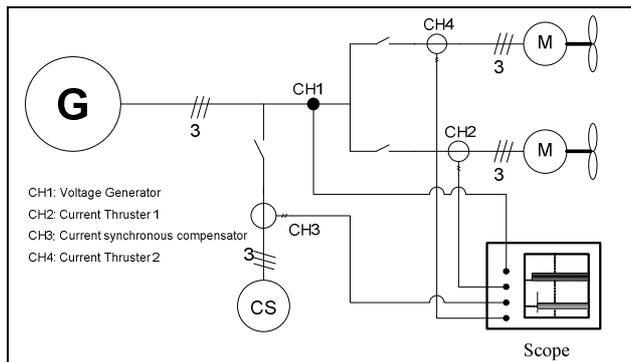In figure 1 represents the outline of the single channel.

Fig.1, Schematic single connection

The starter control circuit, through contactors, and measurement is illustrated in figure 2. The team carried out the experimental tests that had previously looked on paper. The results [4] and the particular experience are summarized below.

The first test performed and recorded with the corresponding starting synchronous compensator can be observed in the graph of figure 3, the pendulum swings (channel 1), due to reactive power flow between the electrical machines. It is random and depends on the relative position of the rotor and stator. The first peak is observed on channel number 3 is the initial activation of the synchronous compensator as an asynchronous machine, the second peak of the entry in sync, and working as synchronous compensator.
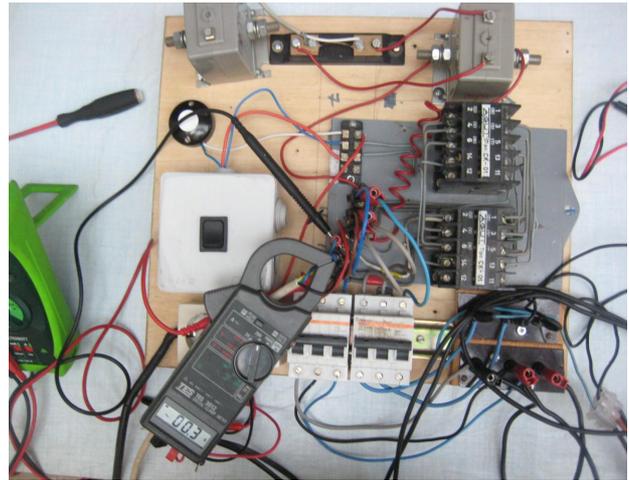

Fig.2, Assembly the starter control circuit and measurement

The angular frequency is measured in the tank was 3180rpm, which means it is above the 50Hz, specifically applying the formula (f = P·N/60) provides the frequency generated by a synchronous machine, this gives a frequency of 53Hz.

As shown in the graphs of figure 3 (Channel 3), the peak intensity at the start as an asynchronous machine up to 16A. In the second peak is observed that the intensity rises to about 8.5 A. After the intensity values down to 4.2A; as soon as you connect a synchronous compensator (synchronous machine) the intensity goes up to 14A. From neither here nor stress intensity stabilized and it is necessary to disconnect. The tension rms, varies between 340V and 460V.
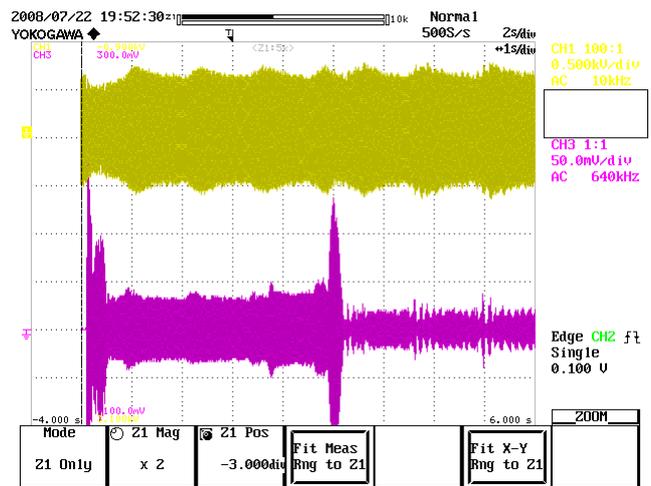

Fig. 3, Starting synchronous compensator - Pendulum swings

The second test has been done has been to repeat the first experiment, by introducing some

modifications, for example, this time synchronous compensator has been synchronized correctly with the generator of the generator, this would have avoided the pendulum swings. We remember that is an oscillating movement of the rotor around an equilibrium point, which overlaps with the spinning speed of synchronism.

Based on the schedules prepared and analyzed, we are connected directly to the synchronous compensator as a synchronous machine, the experimental results can be seen in figure 4, and we see that the peak intensity is much more pronounced (Channel 3). As measured by the image obtained with the oscilloscope, one can observe that the peak voltage reaches 4 divisions, them the voltage rise to 0.2 V.
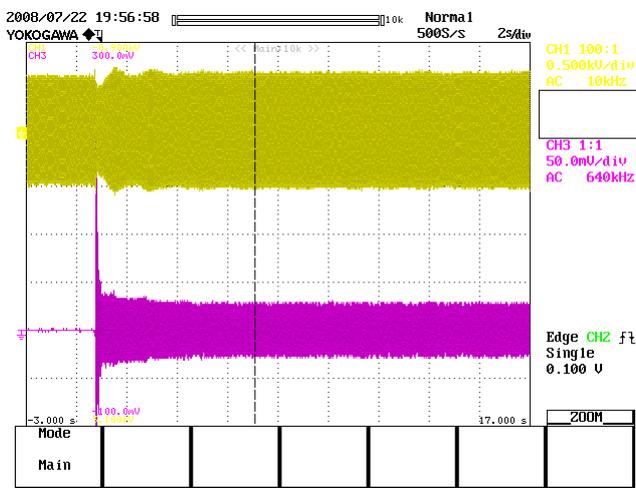

Fig.4, Starting the synchronous compensator with generator of 13 CV

Since the measure is carried out through a shunt, the peak of the boot reaches 16.66 A. They also noted that the transition is fast starting, being less than 0.5 seconds. The time scale is 2 seconds per division. One can see that the large peak lasts less than half a second and that the system is fully booted and stabilized from 2 seconds. Consumed by the intensity kinetic accumulator stabilizes around 2.5 A. The voltage drop at the time of starting up the 100V and quickly stabilizes at 400 V.

The intensity measured by the ammeter in the battery was again Kinetic 2.9 A and current flowing through the power of 1.4 A. The rotational speed of the machine was 3075rpm, which means that the frequency generated by the machine was 51.25 Hz.

The third test that was conducted was the start of an engine without kinetic accumulator. The peak intensity in the boot when connecting the motor reaches 0.4 V, through the shunt, so the intensity at boot time is 25A. Then the intensity is stabilized

around 0.1 V around on the screen of the oscilloscope, ie stabilizes around 6.25 A. Channel 2 of figure 5.
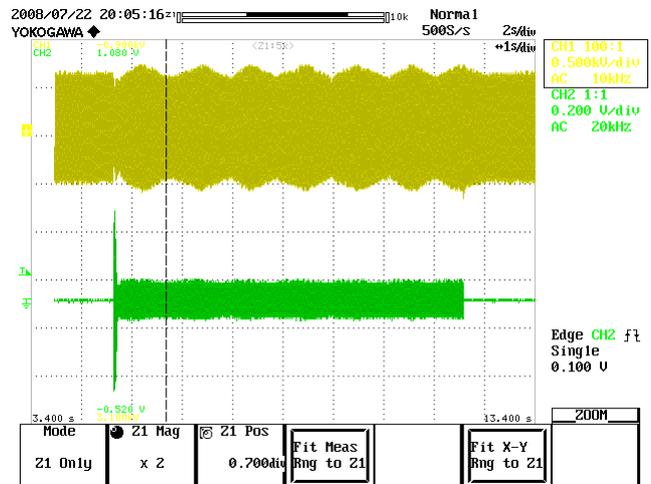

Fig.5, Starting of one motor without compensation.

The voltage is not stable and varies between about 440V and 360V (channel 1), it makes the engine also swing and not to reach the rated speed, thus consuming more intensity. The oscillatory behaviour is maintained over the 4 seconds it takes to connect.

The fourth test is connected first kinetic accumulator and then one of the engines started, and the image captured with the oscilloscope, shown in figure 6.
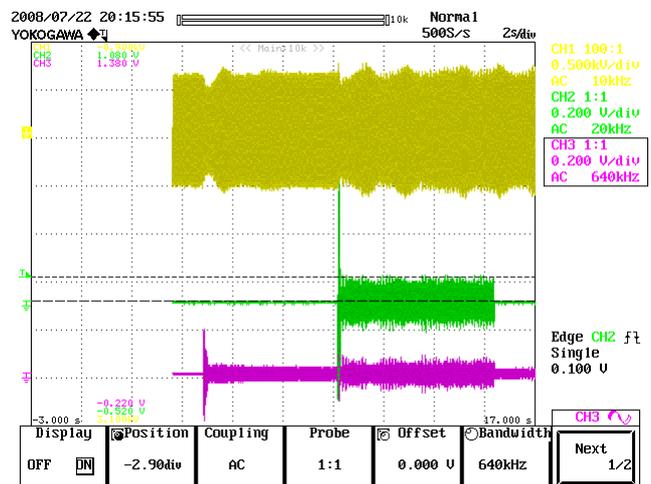

Fig.6, Starting the synchronous compensator and one motor. Generator of 13 CV

The synchronous compensator has a peak intensity of 25A boot, and then levelled off at 6.25 A (Channel 3), stabilizes the voltage at 400 V in less than 2 seconds (channel 1). At the time of starting the engine, compensating intensity increases, but the

engine shows current oscillations (channel 2), but the voltage swings are not as pronounced, with peak overvoltage, but minimize voltage drops. The oscillatory behaviour is maintained for the 6 seconds of connection, but the voltages below 400 V during about 2 seconds.

3   Conclusion

Of the test include the problems of synchronizing with pendulum swing between the two synchronous machines. Difficulty can be resolved, by means two machines with greater compatibility in regulatory systems of excitation.

Connecting the motor propellant, where the generation with the help of the synchronous compensator, causes an increase in intensity in the compensator and voltage drop in the generator is minimized, but not peak overvoltage.

These remarks, let imagine that resolving the problems of oscillation between synchronous machines (generator and compensator), can they maintain the generator voltage drops to minimum during the first motor start, and allow the early connection of the second motor.

While previous observations and conclusions of a study not conclusive, was a possible way forward for the small electric motor boats.

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