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ANALYSIS PROBLEMS OF THE SHORT CIRCUIT CURRENTS THAT APPEAR ON BOARD A VESSEL

Serghei RADU[1]
Gheorghe SAMOILESCU[2]
Adelina BORDIANU[3]
[1]Marine Chief Engineer, PhD candidate, BARKLAV Ag., Constanta
[2]Captain Professor Engineer, PhD, Naval Academy “Mircea cel Batran”, Constanta
[3]University Assistant, PhD, Polytechnics University, Bucharest

1. INTRODUCTION

Availability of electrical power on board is get from the equipment on board, so on board should be an independent power plant capable of generating all the power needed to support the whole load. Naval power plants meet certain general and specific design specifications that differ from those of terrestrial plants in all aspects of operating environment characteristics. These features should be considered in the construction of marine equipment and machinery. The main elements in achieving a maximum operating time of the vessel are high availability of electrical and propulsion as well as safety systems. Automation and safety systems needed for monitoring, protection and control of power system has a major role in the optimal and safe use of facilities. The particularity of naval power systems is the fact that it is an isolated system, with short distances between generators and consumers. Electrical installations on board ships must have increased operating safety due to climatic and technical conditions on board during the voyage. The energy control (management) has the role of checking of the generation facility to ensure availability of electricity, avoiding its disruption. Short circuits in marine electromagnetic installations are complex phenomena that due to the small length affect all electrical circuits on board. For quantitative assessment of the possible effects of short circuit currents on electrical installations and to establish measures to ensure the proper functioning of protections aimed at preventing dangerous effects of short circuit currents is necessary in design of power systems to determine different values which characterize the short circuit currents. [1, 2, 3]

2. GENERATING ELECTRICITY ON BOARD

Voltage generation on board is via a motor-generator group, comprising of an electric generator coupled to a diesel engine, a gas turbine, steam or nuclear plant. An alternative ways of generating set is represented by the coaxial generator system and driven by ME shaft, so some of the mechanical energy produced by the combustion engine serves to generate electricity. This version has some great features, such as the need for an independent motor-generator power plant to power the ship, when the rotational speed of the propeller is not enough. In addition, the system raises issues of management of propulsion engine speed and simultaneous management of electricity generation by the two systems. Medium voltage distribution starts from the main switchboard, consisting of two sections, each connected to a motor-generator group. Busbars are connected by a transverse coupling allowing power control as needed, aiming at all times to maintain efficiency continuously to ensure a certain level of ship safety and stability. In fact, on-board electrical network is an independent system characterized by short distances between the power source and loads. The total installed capacity can be very high, with values of short and large electrodynamics forces that require special attention to the operation and design of systems. Division of useful power supply must allow starting of larger motors with a minimum number of generators in operation and without causing a voltage drop to disturb the distribution system. Mains medium voltage distribution generally consists of a three-wire three-phase system without neutral wire. Such a system is kept under control with neutral point star isolated from earth or connected to it through a resistance or Petersen coil, thereby reducing dispersion current values and short circuit. So first loss with insulation failure is not a danger and allows the system to remain in service without interference of protection systems. [4, 5, 6, 7]

In marine power system analysis must take into account the role of energy control system that verifies installation and ensure the availability of energy generation, avoiding its disruption (blackout). Depending on the type and size of electrical network (auxiliary supply or the ME energy), the system can be independent or be integrated in the automation system of the ship. The system has different control options: fully automatic control, remote control or local control. A complex system of energy control generally has the following functions: Start / Stop of diesel generator (DG); DG Safety System; auto-synchronization of generators and control switches; On / Off depending on load; load distribution, when control the speed reducing; control of load growth; electricity interruption monitoring; energy reservation for large energy consumers; load shedding; frequency control; selection of vessel’s operating mode and the start program; load transfer of the shaft generator. For electricity transmission from sources to consumers are used marine cables and conductors. In practice of the design for naval electrical installations the naval conductor sections are chosen for heating reasons and then being checked the voltage drop. Short circuits in marine electromagnetic installations are complex phenomena that due to the grid small length affects all electrical circuits on board. Usually a short circuit duration does not exceed one second, however, in this period may appear several phenomena that follow: fire in place of short-circuit due to arcing, equipment damage by electric arc where short-circuit occurs, damage of electrical equipment (machinery, electrical appliances, cables, switchboards, etc..) due to thermal and electrodynamic effects of short circuit currents, damaging of electrical contacts, which interrupt currents exceeding the maximum switching appliances; sudden power failure; instability in parallel operation of generators etc. For quantitative assessment of the possible effects of short circuit currents on electrical installations and also to establish measures to ensure the proper functioning of protections aimed at preventing dangerous effects of short circuit currents it is necessary that in the design of power plant to determine various values that characterize the short circuit currents. Among the particularities of naval power plants affecting short-circuit currents are: relatively small nominal voltages, high power synchronous generators and their parallel operation. Due to these features, in the naval networks are large rated current and the short circuit currents may have also high values; low circuit impedances, primarily because of their short lengths. This leads to increased ratio of currents under the influence of asynchronous motors; circuit resistances are high compared to reactance. These resistors have a great influence on the time constants of short circuit processes and through them also on current values at certain times; variations in different regimes of generators power and corresponding large variations of short circuit currents related to the system regime initially taken by calculation; differences between time constants of excitation coils of synchronous generators operating in parallel; strong cable heating and a corresponding increase in cable resistance.

3. ELECTRICAL CURRENTS ANALYSIS INTO THE NAVAL ELECTRICAL GRID

Knowing the possible values of short circuit current is an essential component in the marine electrical network analysis, which allows the choice of electricity distribution scheme on the ship, setting the maximum permissible sum of power of synchronous generators, which operate in parallel under long-term regime based on the switching capacity of the circuit-breakers available, choosing current limiting devices and system protection. [7, 8, 9,10]

Knowing the values of short circuit currents is particularly important in the design and selection (checking) of used electrical apparatus in the system. This can be done by calculation. Electrical installations are equipped with short-circuit protections where there are gaps in the network. These are usually the points where the cross section changes. Short-circuit current must be determined for each level in the system to determine the characteristics of the equipment to withstand appropriate stresses. Reducing short-circuit current and implicitly requirements determined by those, determine the choice of circuit elements less oversized compared to the normal mode operation. Effectiveness of practical methods to reduce short circuit current result from the difference between reducing investment in primary circuit elements due to lower short-circuit current and investment caused by the elements which are inserted after current reduction.

Calculation of short-circuit currents performs to determine if components are able to withstand short circuit and allow choosing appropriate protective equipment as a means of optimizing the ship's entire electrical network.

In this sense, short circuit currents were analyzed within the electrical grid of bulk carrier vessel optimized by computer algorithm in a computer applications. Calculation algorithm used in the software tool is based on IEC standard 61363-1. This standard applies to naval electrical installations and the procedures for calculating A.C. symmetric three phase short-circuit currents. However, this standard does not deal with asymmetric short-circuit conditions, which can give high levels of aperiodic components, so must be found new procedures for calculating short-circuit currents, to explore all the possibilities of their occurrence.

4. HYPOTHESES OF SHORT-CIRCUIT CURRENT CALCULATION

Knowing the values of short circuit current is particularly important in the design and selection (checking) of apparatus used in naval electrical plant. This can be done by calculation. Experimental determination of short circuit currents is usual done on the model. There are still many cases where experimental determination can be made directly on the network. Taking into account the usefulness of short-circuits current calculations and the fact that, often, they are not known with much precision (except calculations for adjusting of protection or automation; for apparatus choice because it is built on great steps, it is not required a rigorous calculation), are introduced some general assumptions, it is particularly difficult, especially in complex systems.

Therefore, in the calculation of short circuit currents following simplifying assumptions are made: initial e.m.f. phase difference is considered zero; all electric voltages are in phase; thereby, resulting short-circuit current value increased compared to their fair value; loads are considered constant; in reality, due to changes in the short-circuit voltage, some consumers and, especially, electric motors change their parameters; but these changes are non-essential, and often lead to lower loads, therefore are not to be taken into account, we neglect the loads contribution to the place of short circuit supply; in reality, motors and synchronous compensators (especially those with high power levels over 1 MW) contribute as additional sources to obtain short circuit current, if sufficiently close to short-circuit the resistances are neglected, so the circuit is formed only from the reaction (exception, small cross section cable networks), as a result, all resulting short circuit currents are in the phase (and voltages are in phase, however, in determining the time constants, it is necessary to take into account the resistances); because the resulting short-circuit currents are in phase is obtained an important practical conclusion that those may be determined on DC models, arc resistances are neglected, the occurrence of short-circuit between two phases or between phase and earth, between the shorted elements is interposed one variable resistance formed by the arc resistance and resistance of other elements interposed at short circuit, whereas arc resistance varies depending on many parameters (short circuit current value, arc length, nominal voltage), it is practically difficult to determine it; on the other hand, in the most cases these can be very small resistance that could be neglected. In this case, the short circuit is said to be metallic, the metallic short-circuit calculation determines short-circuit currents higher than in the non-metallic ones, so the calculation remains covering, are neglected transverse components of the network, those introduce very little current compared to short-circuit current, are neglected magnetic circuit saturation, which allows equations linearization, it is considered a three-phase grid perfectly symmetrical, this condition is almost always satisfied for all system elements; power generators oscillation are neglected during the short-circuit, this will cause obtaining a short-circuit currents higher than the real ones, the assumption is valid when short circuit duration is small, and the system is considered strong enough; if short circuit occurs in weaker systems, where question of stability is considered may occur important generators oscillations or even leaving their synchronism, therefore, in these situations, in the calculation of short circuit currents must be taken into account and the oscillation of generators. Existing experimental material shows that differences between actual results and simplified practical calculations are not large. Initial values of currents and voltages, calculated by practical methods; differ with $\pm(5-10\%)$from the values recorded on oscillograms. If generators have not large oscillations can be calculated the values of voltages and currents of undamaged branch with $\pm(5-10\%)$errors. [1, 3, 7]

5. CONCLUSIONS

Occurring large currents in the case of a short circuit have adverse effects on installations that go through, loading those thermal and dynamic; these effects can be mitigated by quick disconnecting the damaged circuit. Calculation of short circuit currents in the worst situations must be carried out when designing an installation because according to their values are done choosing of appliances, bars etc. Value of sequence currents at short circuit place depends on reactance of all sequence schemes. The way this depends is done may vary from short circuit to another. So the three phase short circuit that determines the highest value of current in the networks and therefore it depends on the choice of protective gear.

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