The issues of philosophy in relay protection

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Philosophy beginning with the ancient Greeks is literally "a love of wisdom" and deals with the most general issues of reality. The Wikipedia dictionary determines philosophy as a science, which studies everything. Logic and critical analysis are the pillars of philosophic thinking. So, why don't we use these attributes of philosophy to analyse the situation around relay protection. It appears that such analysis may result in counterintuitive findings.

The life of a modern person is closely related to the use of complex and inter-connected systems such as cellular communication, television, radio, electric systems and others. All these systems can be visualised as a so called "consumer chain", which consists of series of links. The last link in this chain i.e. the one that directly interacts with a person, would be a certain apparatus: cellular phone, TV, radio receiver, refrigerator, washing machine, etc. The aspiration to improve the last link (in other words the one that actually interacts with a person) and make it perfect, even though all other links may be far away from perfection is clear and justified.

A special design TV-set, its user-friendliness, special functions (such as, record and playback telecasts according to a specific schedule; playback CDs; split screen that allows having a main screen and a series of auxiliary screens, making it possible to watch several channels simultaneously, etc.) adds significant value to such a TV-set from the stand point of the consumer, regardless of the fact that this TV-set is only a final link in a long chain called television.

It does not mean that the quality of TV programs or the quality of broadcasting will be of the same quality as the final link.

However, this doesn't prevent a consumer from investing in an expensive final link. Likewise, other consumers do not stop dreaming about this perfect final link. Thus, the final link in different consumer chains has a special status, and certain requirements and attention are accorded to it by both consumers and manufacturers. On the other hand, regardless of the perfection of the final link, it cannot influence the quality or reliability of the chain in general. Indeed, a broken TV-set in one of the rooms in the consumer's house will not influence the operation of TV-sets in other rooms, or the neighbours' TV-sets.

Another feature of the final link of the above mentioned consumer chains is the applying of customer requirements to functionality and design beyond requirements of reliability and longevity. This is conditioned by modern trends, when substitution of one final link with another has not much to do with malfunctioning or breakage, but with technological obsolescence and the emergence on the market of new models with better functions and improved design.

Now, let us compare this situation with what happens in relay protection (RP), which is a most important component of a consumer power supply circuit that consists of a series of links called production, transmission and distribution of electric energy. Where is the place of relay protection in this circuit? Surprisingly, there is no such link in this chain! Indeed, relay protection neither participates nor influences the operation of the circuit under the normal mode of chain operation. RP does not influence the amount of produced energy. Nor does it influence the capacity of energy transmitting lines or the process of energy distribution. Relay protection can even be disconnected from the energy supply circuit and there will be no effect on the circuit's operation. So, what is relay protection, and where is its place in energy transmission and distribution circuit? Visually, relay protection can be depicted in this chain as a set of separate auxiliary links installed in the places of connection of main links of the energy supply circuit i.e. production, transmission and distribution of electric energy (Fig. 2).

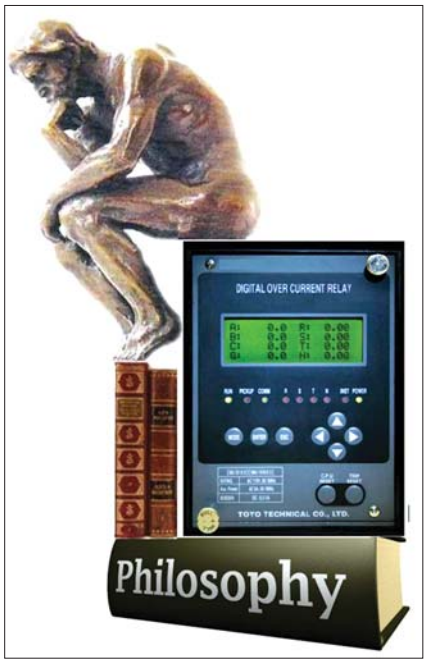

Fig. 1: Philosophy of relay protection.

Visualisation of a consumer chain of power supply equipped with relay protection (RP)

Functionally, these places of connection are formed by high-voltage switches, the condition of which is determined by relay protection. In other words, even though relay protection is not a series link in the power supply circuit, it can influence the connectors between the links (by circuit breakers) by cutting the ties between all the links of this chain. This is a fundamental difference of relay protection from other links in consumer chains.

If relay protection does not influence

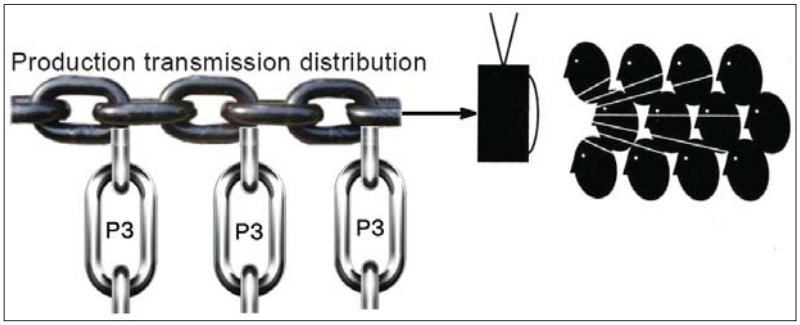

Fig. 2: Consumer power supply consists of a series of links.

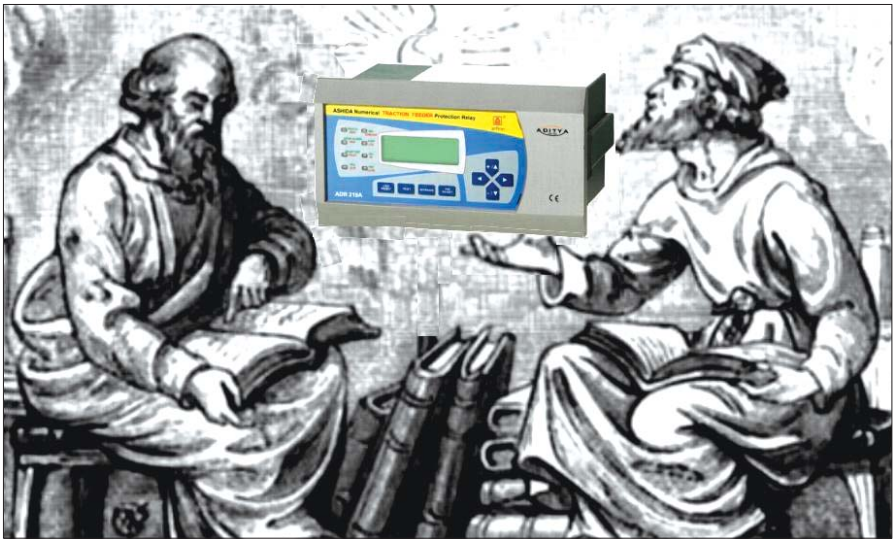

Fig. 3: Philosophy is a love of wisdom.

the power supply circuit under its normal mode of operation, does it have any effect under the emergency mode? It is widely perceived that this influence consists of the prevention of emergency modes in the power supply circuit. Is this really so? To answer this question we need to understand what relay protection is and what its functions are.

A protective relay is a device, the purpose of which is to detect the emergency mode of the object being protected and send a command to a control power element, which eliminates this mode. A system of relay protection is an aggregate of related devices, which ensure detection of the emergency mode in the operation of electric equipment, and its elimination. These definitions show that regardless of the widespread opinion that relay proction cannot prevent the emergency mode in a power supply circuit, it can limit the scale of its effect on the circuit in time and space, in other words, limit the material damage from the break-down, and nothing more.

Everything said above relates to a properly functioning relay protection and its correct operation. But as with many other complex technical devices, relay protection can also malfunction. This creates an absolutely different situation, where a malfunctioning relay protection due to a so called "unnecessary protection operation" can send a faulty command to open a circuit breaker (in other words, break ties between the links of a power supply circuit), thus creating an unnecessary prevention of normal functioning of a power supply circuit i.e. its switching to an abnormal, emergency mode, leading to the disconnection of thousands of consumers and great damage.

This makes us conclude that relay protection cannot prevent an emergency mode of operation of a power supply circuit, but it can cause this mode. Recently significant qualitative changes have happened in the field of relay protection. Single function electro-mechanical protection relays have been replaced by multi-functional digital protective relays (DPR) with much higher qualitative characteristics and easily programmable logic. How does perfection of characteristics and improved functional capabilities of the new protection relays influence the operation of the power supply circuit? As mentioned above, there is no influence under the normal mode of operation. However in the case of the emergency mode of the circuit, the DPR can efficiently limit its effect in time and space due to their improved characteristics. In other words they are more effective in limiting the material damage than electro-mechanical protection relays.

At the same time it is known that DPRs are less reliable than electro-mechanical protection relays (we are talking about the best electro-mechanical relays manufactured by the leading Western companies). Their lifetime does not exceed 15 to 20 years. They are more susceptible to destructive external impacts, such as cyber attacks or intentional electro-magnetic impact. A lot of extra functions, with some functions not specific to relay protection, are built into a single DPR. Mistakes by staff during programming of logic reduce reliability of relay protection even further, and increase the probability of malfunctioning, resulting in impacts on the power supply circuit that lead to deterioration of its operation (emergency modes).

Thus, transition from electro-mechanical protection relays to DPRs results in reduction of material damage from accidental emergencies in the power supply circuits, but at the same time it leads to an increase in the number of accidents (due to additional accidents caused by the malfunctioning of relay protection device itself) in the power system.

In Russia, conventional electro-mechanical relay protection, like all domestic low-voltage equipment, is reliable and long-lasting. It is noteworthy that the unique power plant of Russia has been working without major system outages for 50 years. However, major system outages are regular in the power industry of many countries where equipment of companies sharing the Russian market has been used and is used now.

Unlike the trouble-free operation of the unified electric power system of Russia, which is protected by electro-mechanical relays, there were 13 major accidents abroad during the last two decades, and eight of them were in the USA. The power supply failures covered large territories, whereas Russian equipment continues functioning faultlessly in Egypt, Iran and Africa. There were neither breakdowns nor failures at power plants.

Taking the above into consideration, we come to the conclusion that unlike consumer chains mentioned in the beginning of this article, reliability and longevity of relay protection in the power supply circuits should prevail over improved characteristics, expanded capacity and design. Specifically we come to the following conclusions:

- The promoted advantages of DPR compared with electro-mechanical protection relays are insignificant, and have little influence on general efficiency of a power supply circuit.
- The efforts of DPR developers and manufacturers should be mostly concentrated on improving reliability of devices and their resistance to intentional external impacts, and not to increasing the number of functions, perfection of characteristics and design. When comparing and evaluating DPR quality and selecting a certain type of DPR, reliability and resistance to external impacts should prevail over the number of functions and quality of their characteristics.
- It is necessary to develop simple, clear and efficient methods of evaluation of DPR reliability and arrange collection of real data about failures.

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