УДК 621.311 : 621.317.613 : 621.316.935.5 **doi: 10.20998/2079-3944.2023.2.02**

***V.P. KALINCHYK, V.A. POBIGAYLO, O.V. BORYCHENKO, S.B. KUZOVKIN***

## RELEASERS WITH ELECTRO-HYDRAULIC RETARDERS AS AN EFFECTIVE ALTERNATIVE FOR SHORT CIRCUIT AND OVERCURRENT PROTECTION

It is known that circuit breakers (CBs) installed in distribution cabinets (DCs), better known as “enclosed circuit breakers”, depending on the execution, are designed for: protection against emergency states of grids: overvoltage and short circuit (s/c) or voltage drop below the permissible level (circuit breakers installed on the grid do not always provide protection against voltage reduction); protection of AC motors, as well as for combined installation with other electric devices (CBs can service by grid sections as well as separate motors if CBs are used to operate the wound-rotor motor or starting devices, they must include voltage drop protection); to be used as disconnectors for supply and trunk networks. Overcurrent protection is done by a bimetallic plate, while an electromagnetic releaser provides s/c protection. The main features inherent in this technical solution of overcurrent protection include: relative dependence on ambient temperature; inability to quickly switch on again after the CB is triggered; unstable time-current characteristics of the CB. National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute” and «E.NEXT Ukraine» offers an alternative solution for the design of CB protection elements, which is an integrated overcurrent and short circuit protection at the same time in the form of a releaser with an electro – hydraulic retarder. A releaser with an electro-hydraulic retarder triggers the CB actuator, which breaks the contact group of the CB when the current exceeding the set maximum permissible value (s/c or overcurrent) is passing through electrical equipment. The main part of this releaser is an electromagnet, whose coil is connected in series with working contacts in the circuit of the operating current.

**Keywords:** circuit breakers, heating, hydraulic release, bimetallic plate, switching efficiency, network process research, switching equipment.

***В.П. КАЛІНЧИК, В.А. ПОБІГАЙЛО, О.В.БОРИЧЕНКО, С.Б. КУЗОВКІН***

## РОЗЧЕПЛЮВАЧІ З ЕЛЕКТРОГІДРАВЛІЧНИМ СПОВІЛЬНЮВАЧЕМ ЯК ЕФЕКТИВНА АЛЬТЕРНАТИВА ПРИ ЗАХИСТІ ВІД СТРУМІВ КОРОТКОГО ЗАМИКАННЯ ТА ПЕРЕВАНТАЖЕННЯ

Відомо, що автоматичні вимикачі (АВ), які встановлюються в розподільних шафах (РШ), більш відомі як «вимикачі закритого типу», залежно від виконання, призначені для: захист від аварійних процесів мереж: перенапруги та короткого замикання (КЗ) або падіння напруги нижче допустимого рівня (як правило, встановлені в мережі вимикачі не завжди забезпечують захист від зниження напруги); захист двигунів змінного струму, а також при комбінованому монтажі з іншими електричними пристроями (АВ можуть обслуговувати секції електромережі, а також окремі двигуни, якщо АВ використовуються для захисту двигуна з фазним ротором або пускових пристроїв, вони повинні включати захист від падіння напруги); для використання в якості роз'єднувачів магістральних мереж та мереж живлення. Захист від струму перевантаження виконується завдяки біметалевої пластини, а електромагнітний розчіплювач забезпечує захист від КЗ. Основні недоліки, що властиві цьому технічному рішенню захисту від струмів перевантаження, включають: відносна залежність від температури навколишнього середовища; неможливість швидкого повторного включення після спрацьовування АВ; нестабільні часово-струмові характеристики КП. Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського» та «E.NEXT Україна» пропонують альтернативне рішення для конструкції елементів захисту АВ, що є інтегрованим захистом від перевантаження та короткого замикання одночасно у вигляді роз’єднувача з електрогідравлічним сповільнювачем. Розчіплювач з електрогідравлічним сповільнювачем призводить до спрацювання механізму приводу АВ, який розмикає контактну групу АВ при проходженні через електрообладнання струму, що перевищує встановлене максимально допустиме значення (струми короткого замикання або перевантаження). Основна частина цього розчеплювача – електромагніт, котушка якого включається послідовно робочим контактам в коло робочого струму.

**Ключові слова**: автоматичні вимикачі, нагрів, гідравлічні розчіплювачі, біметалева пластина, ефективність комутації, дослідження процесів мережі, комутаційне обладнання.

**Introduction**. It is known that circuit breakers (CBs) installed in distribution cabinets (DCs), better known as “enclosed circuit breakers”, Fig. 1, depending on the execution, are designed for [1, 2, 3]:

– protection against emergency states of grids: overvoltage and short circuit (s/c) or voltage drop below the permissible level (circuit breakers installed on the grid do not always provide protection against voltage reduction);

– protection of AC motors, as well as for combined installation with other electric devices (CBs can service by grid sections as well as separate motors if CBs are used to operate the wound-rotor motor or starting devices, they must include voltage drop protection);

– to be used as disconnectors for supply and trunk networks.


Fig. 1. General image of the CB

Traditional design of overcurrent and short circuit protection in the form of enclosed CBs [2] is shown in Fig. 2. Overcurrent protection is done by a bimetallic plate, while an electromagnetic releaser provides s/c protection.

© V.P. Kalinchyk, V.A. Pobigaylo, O.V. Borychenko, S.B. Kuzovkin, 2023

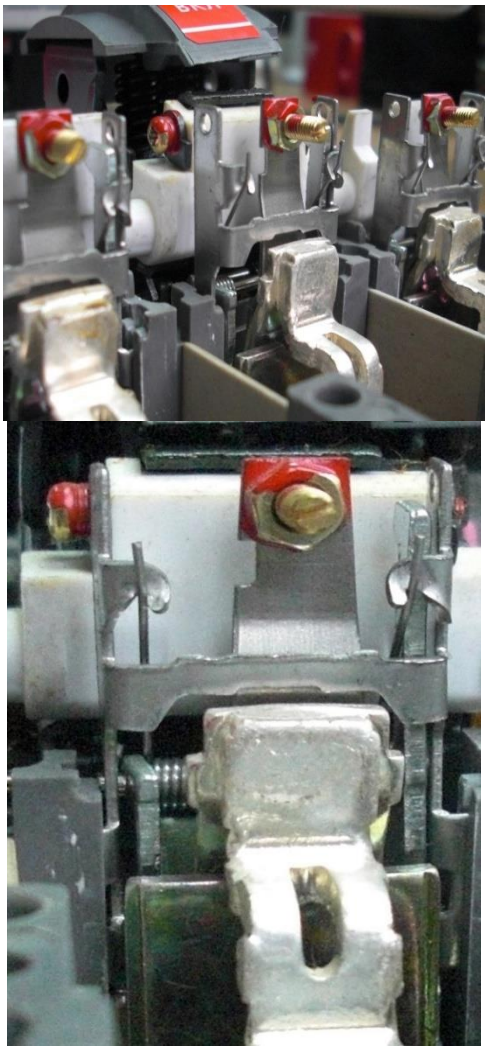


Fig. 2. General image of the CB releasers

The main features inherent in this technical solution of overcurrent protection include:

- relative dependence on ambient temperature;
- inability to quickly switch on again after the CB is triggered;
- unstable time-current characteristics of the CB.

E.NEXT-Ukraine offers an alternative solution for the dseign of CB protection elements [4], which is an integrated overcurrent and short circuit protection at the same time in the form of a releaser with an electro – hydraulic retarder. The design of the CB releaser is shown in Fig. 3.

A releaser with an electro-hydraulic retarder triggers the CB actuator, which breaks the contact group of the CB when the current exceeding the set maximum permissible value (s/c or overcurrent) is passing through electrical equipment. The main part of this releaser is an electromagnet, whose coil is connected in series with working contacts in the circuit of the operating current. Schematic design of the releaser with electro-hydraulic retarder is shown in Fig. 4. Let us consider the operating principle of an electromagnetic releaser with hydraulic retardation, which provides an inverse-time delay of the releaser in the overload zone, Fig. 5. The releaser automatically disconnects the CB at overload currents and short-circuit currents, regardless of whether the control lever “on / off” is on. The releaser consists of a relay, a rocker arm, a rail and a free-release mechanism.

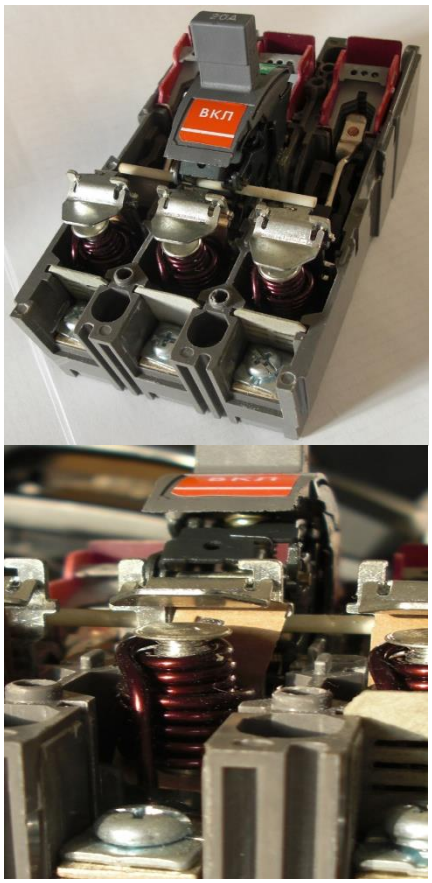
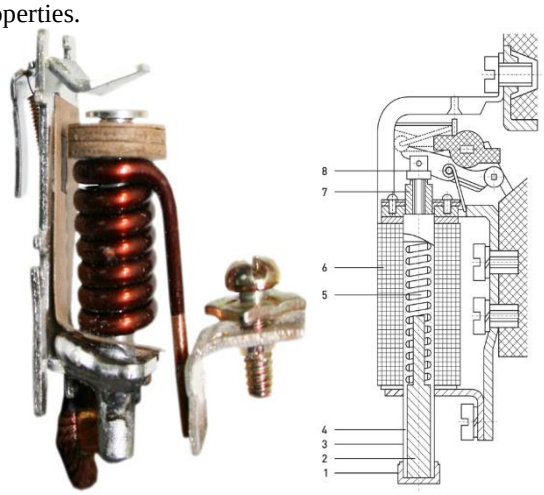



Fig. 3. Releaser with electro-hydraulic retardation

The relay of a hydraulic retardation releaser is an electromagnetic system with two moving parts: the armature and the plunger. The armature and the plunger are part of the magnetic circuit. The plunger and spring are moved inside the tube. The tube is placed inside the coil of the electromagnet. The tube is filled with silicone fluid, slowing down the movement of the plunger due to its chemical properties.



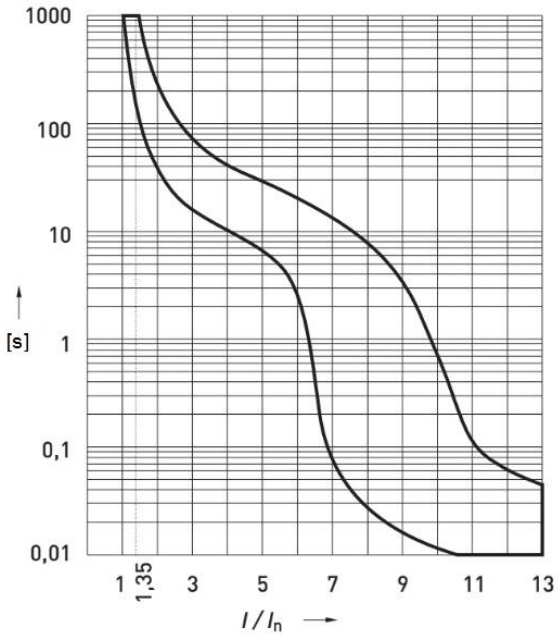

1 - non-magnetic cover; 2 – plunger; 3 - a cylindrical glass; 4 - cavity filled with organosilicon liquid; 5 - rotational spring; 6 - the coil; 7 - pole tip; 8 – armature

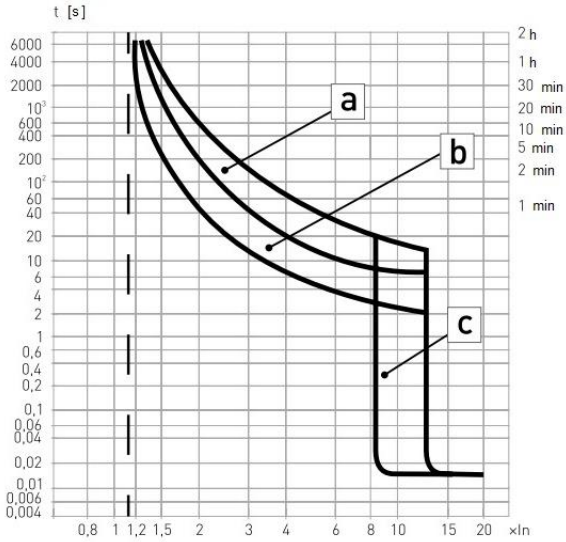
Fig. 4. A sketch of the CB releaser with hydraulic retardation

During overcurrents, the electromagnetic force of the release coil increases and becomes sufficient to overcome the counteracting force of the rotational spring, so the plunger begins to move to the pole of the core. The armature, in turn, is attracted to the pole of the core at the overload current, in the instant, when the plunger, reducing the resistance of the magnetic circuit when moving inside the core, affects the value of magnetic induction in the air gap required to draw the armature to the pole of the core. At s/c currents, the plunger does not move, in the event of short circuit the value of magnetic induction in the air gap is sufficient to retract the anchor without delay. The force of the releaser armature is transmitted through the rocker arm to the rail, which is a link in the free – release mechanism. The armature and the rail return to the original position by means of rotational springs.

As the retarder of the CB releaser, organosilicon fluid used has small loss tangent (at 25° C<0.0001), besides organosilicon liquid is more resistant to mold and has relatively low hygroscopic quality and higher heat resistance.

Organosilicon fluid is characterised by low dependence of viscosity from temperature. Little magnitude of intermolecular interaction forces determines their low viscosity and, consequently, negligible compared with others liquid dielectrics change in viscosity due to lower temperature. For instance, when the temperature goes down from 100ºC to -35ºC, the viscosity of organosilicon fluid increases only sevenfold, while for mineral oils this increase is 1800 times (at the same initial viscosity). The advantages of organosilicon fluid listed above make it an indispensable structural element in instrumentation, radio engineering and other industries electrical engineering.




a - release response from the “cold” state at overload currents;
b - release response from the “warm” state at overload currents;
c - release response at short circuit currents.
Fig. 5. Time – current characteristics of actuation with hydraulic retarder (a) and with bimetal plate (b)

Traditional design of overcurrent and short circuit protection in the form of enclosed CBs dependent on ambient temperature. This graphical dependence is shown in Fig. 5.

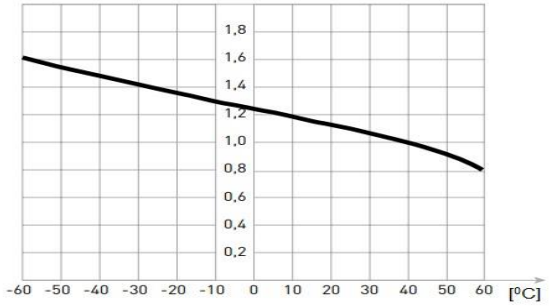



Fig. 5. The dependence of the rated current of automatic ambient temperature switch

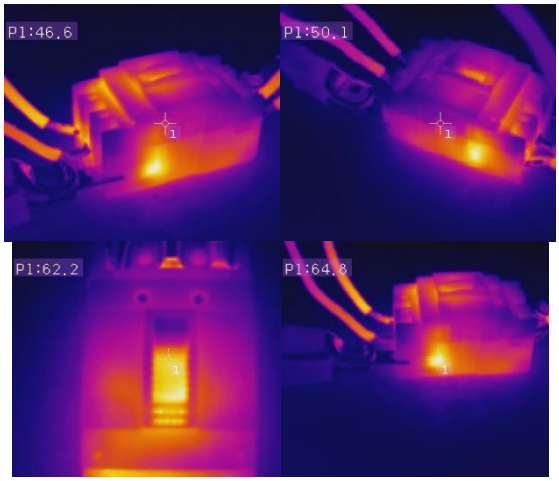



Fig. 6. The figure shows the thermal imaging of the circuit breaker heating, with a bimetallic plate, when operating in nominal mode (the maximum heating temperature is indicated in the upper left corner)

**Conclusions.** The scientific novelty of the work is in the comparison of two technical solutions for the implementation of overcurrent and short circuit protection, one can conclude that the use of a releaser with an electro – hydraulic retarder gives CBs certain advantages over the use of a traditional releaser – a bimetal plate:

- a relative independence of the releaser on the ambient temperature;
- fast re-activation after being triggered in case of an emergency mode;
- shorter actuation time in the event of an overload (decrease in the performance of the AV, confirmed by repeated practical studies);
- stability of time-current characteristics of the CB;
- instead of two functional elements we have one multifunctional, which leads to a constructive reduction of the internal volume of the structure and weight of the CB;
- resistance to vibration.

Considering the advantages of using a releaser with electrohydraulic retardation in CBs, it should be noted that an alternative technical solution to protection against overcurrents and short – circuit currents shows promise of development in this area of electrical technical engineering.

**References**


1 Rosen V.P., Pobigaylo V.A. Tool strumoobmezhennya as one of the effective ways of energy use. Proceedings of the National University "Lviv Polytechnic". Electricity and electromechanical systems. 2001. No 421. Pp. 181 - 188.

2 Rosen V.P., Taradai V.I., Nesen L.I., Pobigaylo V.A. Analysis approaches k Decision Problems restrictions currents in short zamykanyya proyzvodstvennyh and enerhetycheskyh systems. IEE "KPI". Kiev.: 1999. 18 p. Eng. - Dep. HNTB of Ukraine on 26.07.99, № 225 Uk99. anoth. in the same. VINITI RAS № 10 (333), 1999.

3 Rosen V.P., Solovey O.I., Momot D.E., Pobigaylo V.A. A mathematical model of the limiting current devices under the "reactor - fuse". Proceedings of the National Technical University of Ukraine "KPI". A series of mining. 2000. No 4. Pp. 82 - 90.

4 Patent of Ukraine № 2002021620 from 15.11.2002, the way to limit short-circuit currents and device for its implementation. Rosen V.P., Kalynchyk V.P., Momot D.E., Pobigaylo V.A.

5 Samusya, V., Oksen Y., Huk O. The choice of rational parameters of the heat pump installation for the utilization of low-potential heat of mine water. Metallurgical and mining industry. Science and Technology and production magazine. 2015. Vol. 1 (92). Pp. 126-131.

6 Vinoslavsky V.N., Prakhovnik A.V., Bondarenko A.F. Forecasting the power consumption of industrial facilities. Energy and electrification. 1974. No 5. Pp. 30-31.

7 Shumilova G.P., Gotman N.E., Startseva T.B. Prediction of electrical loads in the operational control of electric power systems based on neural network structures. Syktyvkar: RAS, 2008. 78 p.

8 Kalinchik V.P., Kokorina M.T Forecasting of indicators of energy consumption, generation and cost of the received energy. NTUU “KPI” N.-i. Institute of Automation and Power Engineering "Energy". Kiev, 2013. 14 p.: bibliographic illustrations: 7 – deposit in SSTLU Ukraine 22.07.13, No 35. Uk 2013.


*Надійшла (received) 20.06.2023*

*Відомості про авторів / About the authors*


***Калінчик Василь Прокопович*** (***Kalinchyk Vasyl Prokopovich***) – кандидат технічних наук, доцент, Національний технічний університет України КПІ ім. Ігоря Сікорського, доцент кафедри електропостачання; м. Київ, ORCID: https://orcid.org/0000-0003-4028-0185, e-mail: vkalin@i.ua.

***Побігайло Віталій Анатолійович*** (***Pobigaylo Vitaliy Anatolievich***) – кандидат технічних наук, доцент, Національний технічний університет України КПІ ім. Ігоря Сікорського, доцент кафедри електропостачання; м. Київ; ORCID: https://orcid.org/0000-0003-2673-7329, e-mail: pobigaylo@gmail.com.

***Бориченко Олена Володимирівна*** (***Borychenko Olena Volodimirivna***) – кандидат технічних наук, доцент, Національний технічний університет України КПІ ім. Ігоря Сікорського, доцент кафедри електропостачання; м. Київ; ORCID: https://orcid.org/0000-0002-6127-2945, e-mail: borichenko_olena@ukr.net.

***Кузовкін Сергій Борисович*** (***Kuzovkin Sergii Borisovich***) – комерційний директор «E.NEXT-Group» м. Київ.