Comparison of Different Air Flow Concepts for a Medium Voltage Load Break Switch

Nina Sasaki Støa-Aanensen, Erik Jonsson, and Magne Runde

***Abstract*—The research and development work towards a compact SF_6-free load break switch for the medium voltage range has led to several design proposals. The interruption capability of three different nozzle and gas flow concepts with atmospheric air as the interrupting medium is compared and assessed. The three test switches are installed in circuits corresponding to the mainly active load and switch-fuse test duties of the 24 kV / 630 A load break switch standard. A pressure tank is used to provide different air flow rates, and the interruption capabilities of the different flow concepts are compared with basis in the tank pressure required to give successful interruptions. 270 current interruption tests were carried out. Air flows directed radially onto the arc or swirling along the arc turn out to result in a substantially better interruption performance than when the air flows straight and parallel to the arc. Air flows corresponding to upstream over-pressures of a few tenths of a bar seem to be sufficient for an air-based load break switch rated for 24 kV / 630 A.**

***Index Terms*—Medium voltage (MV), switchgear, load break switch, SF_6-free switchgear, air-filled switches, thermal interruption.**

I. INTRODUCTION

IN the recent years, substantial efforts have gone into developing SF_6-free switchgear [1]- [4]. With its moderate ratings, a natural starting point has been the compact load break switch for medium voltage (MV) level. One solution, and perhaps the most straightforward one, is to replace SF_6 with air in an existing switchgear design. However, since air is poorer both as a dielectric and as a current interruption medium, such a switch will have to be substantially derated with respect to both current and voltage. A better approach is to develop new switch designs that are optimized for use with air.

An essential part of the design of power switching devices is the gas flow pattern and the associated arc cooling and arc quenching capabilities. Various nozzle designs and gas flow concepts are in use. These are usually described by the direction of the gas flow relative to the arc. Circuit-breakers for transmission voltage levels include axial blast, cross blast and radial blast designs, as well as combinations of these [5]. Successful design features of these large circuit-breakers are, however, not necessarily transferable to a MV load break switch. The latter employs gas pressure just slightly above atmospheric and subsonic gas velocities, whereas large circuit-breakers have supersonic gas flows, and typical pressures are in the range 5-20 bar.

In a previous study, a simple MV load break switch design where air is blown axially onto the arc was investigated with the objective of determining the influence of different design parameters on its current interrupting capability [6]- [9]. The present work compares the efficiency of such a straight axial flow design with two other flow concepts, namely a radial flow (also referred to as stagnation point flow) and a swirling axial flow, all by using simplified MV load break switch geometries in atmospheric, room temperature ambience. The different interruption capabilities are evaluated by determining the upstream over-pressure required to achieve an air flow sufficient to extinguish the arc and thereby interrupt the current.

Two different test circuits are applied for this purpose. Topology and parameters correspond to single-phase versions of the 24 kV / 630 A "mainly active load" and of the "switch-fuse" test duties, both of the IEC standards for MV switchgear [10], [11]. The latter test duty is considerably more challenging as the transient recovery voltage (TRV) is steeper and has a higher first peak voltage.

In commercial MV load break switches, the upstream over-pressure is typically generated by means of simplified versions of the "puffer principle", well-known from large gas circuit-breakers. Thus, the upstream over-pressure is time dependent and linked to the contact movement and affected by e.g., arc clogging in the nozzle. The tests reported on here instead make use of a pressure tank to provide the air flow. This ensures a steady upstream over-pressure that is de-coupled from the contact movement and thus more appropriate for comparing different air flow concepts.

Initially, the different flow principles and the test objects are presented. The two circuits and the test procedures are then described, followed by the results of a campaign comprising 270 interruption experiments.

II. TESTED SWITCH DESIGNS

Below is a short description of the three different switch geometries and air flow concepts that are compared in this work.

A. Straight Axial Flow

Fig. 1 shows the "straight axial flow" test object. The tulip contact and the polytetrafluoroethylene (PTFE) nozzle are fixed to the pressure tank. As the pin contact is pulled

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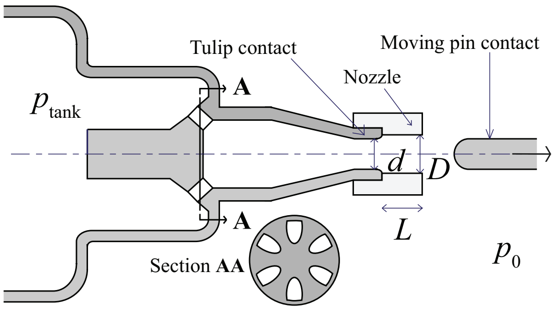

Fig. 1. The ”straight axial flow” design.

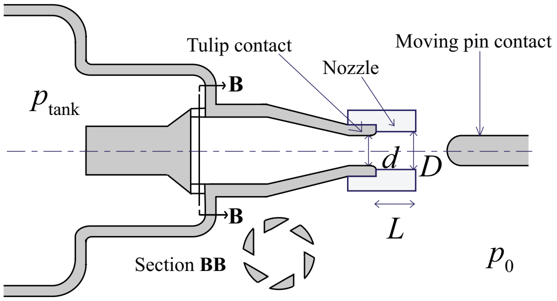

Fig. 2. The ”swirling axial flow” design.

out of the tulip contact, an over-pressure in the tank creates a flow of air through a disc with six outlets slanting towards the center axis with a 27.5° angle. The air is further guided by a low angle funnel and reaches the tulip contact and nozzle part of the switch as a more or less purely axial flow.

In general, axially blown arcs are efficiently cooled. However, such a flow pattern is poor in providing cooling if the flow channel diameter changes abruptly. In the present geometry, the nozzle inner diameter D is always somewhat larger than the tulip contact inner diameter d due to the space required for the pin contact to move easily in and out of the nozzle. Consequently, the tulip-to-nozzle joint creates a small inner corner or ”backwater” with low air velocity and poor cooling. The arc foot point, burning from the end of the tulip contact, may ”hide” in this corner, making the current interruption more difficult. Consequently, the interruption capability of a switch with straight flow is highly dependent on how this area is designed and on the D/d ratio [9].

B. Swirling Axial Flow

The ”swirl flow” design, shown in Fig. 2, has similarities to the axial straight flow principle; the air flows from the tank through the tulip contact and nozzle. An important difference, however, is the design of the disc located between the tank volume and the funnel. In the swirl design the disc has six tangentially directed holes, generating a swirling flow pattern. The air flows through the funnel, tulip contact and nozzle with a large tangential velocity component. Whereas the straight flow has its maximum velocity in the middle of the flow channel and lower velocity closer to the tulip contact and nozzle walls, the swirling flow pattern has its highest velocity close to the walls, and a lower velocity in the center.

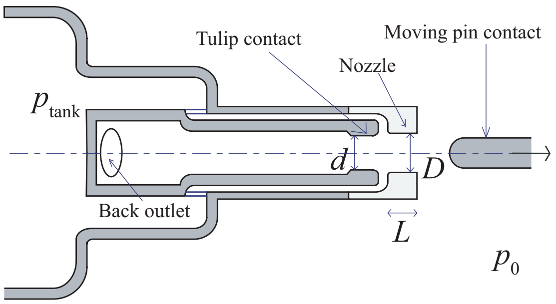

Fig. 3. The ”radial flow” design.

Consequently, the cooling of the arc foot point at the tulip-to-nozzle interface area becomes considerably better.

C. Radial Flow

The ”radial flow” or ”stagnation point” design is presented in Fig. 3. The air flows at the outside of the tulip contact before it makes a turn and enters the arcing zone radially between the tip of the tulip contact and the nozzle. A low-velocity, high static pressure region (a so-called ”stagnation point”), is formed where the air reaches the center axis. The air is then accelerated from the stagnation point in two directions: through the tulip contact towards the back outlet, and through the nozzle towards the arcing pin contact. Consequently, the arc is exposed to the air flow in two ways. The air that enters radially towards the stagnation point ensures that the arc or its foot point cannot hide in any corner or along the wall. Secondly, the air that flows from the stagnation point cools the arc axially.

Such a radial flow pattern is commonly applied in circuit-breakers for higher voltage ratings, and the upstream over-pressure is so high that the gas flow becomes supersonic. In the MV designs considered here, air velocities remain, in contrast, well below sonic.

D. Test Object Dimensions and Materials

To reduce the problem caused by low-velocity ”backwaters” in the straight flow case (and to some extent also in the swirl case), narrow nozzles are used. The nozzle-to-contact diameter ratio, D/d, is 1.05 for the straight and swirling axial flow designs. Furthermore, the nozzle length, L, is 13 mm. During the course of a test series arcing wear increases the nozzle inner diameter a little. The radial flow design has a slightly larger nozzle-to-contact diameter ratio of 1.11. Moreover, in the radial flow design there is a gap between the tulip contact tip and the nozzle wall to allow the cooling gas flow onto the arc. The nozzle length is thus reduced to ensure that in all three designs the pin contact moves 13 mm after contact separation before it is outside the nozzle.

The smallest flow area is through the tulip contact for both the straight and swirling axial flow designs, and equal to 85 mm^2. In the radial flow design the smallest flow area is where the air exits the channel between the tulip contact and the nozzle. This area is 110 mm^2. The minimum flow area influences the mass flow rate. In general, if the flow area is

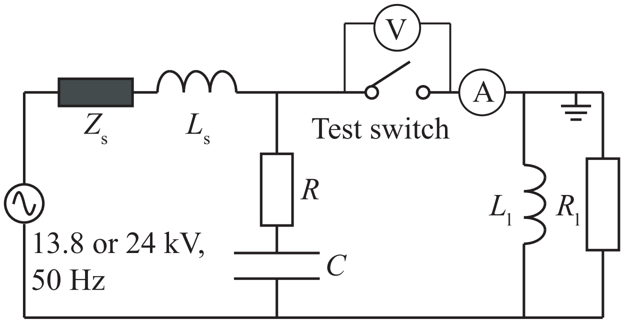

Fig. 4. The test circuit.

small, less mass flows and thus less cooling air flows towards the arc, given the same upstream over-pressure. However, to accurately estimate the air velocities and mass flow rates other factors than the area and pressures must be taken into account, such as wall effects and turbulence. This will probably affect the flow through the narrow channel in the radial design, reducing the ”effective” flow area somewhat. Consequently, the three designs are believed to have comparable mass flow rates given the same over-pressure.

Instead of using a pin contact with a split, which is common in commercial switches (the spring effect of the split generates the contact force in closed position), an axisymmetric pin contact without a split is applied. In the present setup, the pin contact plugs the pressure tank outlet before a test, and a split would cause air leaks and a poorer control of the experimental conditions. The pin and tulip contact members are made in a copper-tungsten composite, whereas the other metallic parts of the switches are copper or brass.

III. EXPERIMENTAL

A. Test Circuits and Procedures

Fig. 4 shows the directly powered single phase test circuit. The component values are set to give currents and TRVs corresponding to the ”mainly active load” (first pole to clear) and to the combined ”switch-fuse” test duties of the 24 kV rating of the IEC standards for load break switches [10], [11].

Table I lists the current, the rate of rise of recovery voltage (RRRV), and the first peak amplitude of the recovery voltage for these two circuit settings. The RRRV and the first voltage peak of the ”switch-fuse” duty are two to three times that of the ”mainly active load” case.

TABLE I
TEST CIRCUIT CHARACTERISTICS

Test duty	**Current [A]**	**RRRV [V/μs]**	**First voltage peak [kV]**
”Mainly active load”	640	79	7.6
”Switch-fuse”	680	143	24.6

An experiment is initiated by closing the laboratory circuit-breaker (not included in Fig. 4) on the primary side of the transformer, and current starts flowing through the closed test switch. An electromagnet is then triggered to release a spring that causes the pin contact to start moving. The switch is given up to around 20 ms of arcing or at least two current zero (CZ) crossings or interruption attempts. With a contact speed of approximately 3 m/s, this ensures at least one interruption attempt with the pin contact outside the nozzle, a condition which turns out to improve the interruption capability significantly, at least for the straight flow design. The test is considered successful if the switch interrupts the current at the first or second CZ crossing. In the cases where the test switch fails to interrupt, the laboratory circuit-breaker terminates the experiment. Further information on the laboratory circuit and setup, including photographs of the test rig and circuit components can be found elsewhere [6], [12].

The current, the voltage across the switch, the pin contact position, and the upstream over-pressure are recorded during each experiment. The pressure sensor (Kistler 4260A) is installed at a location where the air velocity is fairly low, so the pressure measured is nearly equal to the static pressure in the tank.

B. Test Program

The three switch designs and two test duties give a total of six cases. For each of these, the upstream over-pressure necessary to successfully interrupt is estimated by performing ten consecutive tests at each pressure level.

The initial tests for each of the six cases were carried out with an upstream over-pressure of 0.2 bar, i.e., with 1.2 bar in the tank. If all ten interruptions were successful, the over-pressure was reduced in 0.04 bar intervals down to 0.16 bar, 0.12 bar, etc., until less than four of the tests were successful. In the cases where a 0.2 bar over-pressure was insufficient to obtain ten out of ten successful interruptions, the over-pressure was increased to 0.24 bar, 0.28 bar, etc., until none of the ten tests failed, and then reduced in steps of 0.04 bar until the success rate dropped below four out of ten.

The 0.04 bar step was chosen based on the observed decline in upstream pressure from the time of contact separation to the time of current interruption. There is always some leakage from the pressure tank, especially in the radial flow design, where one of the outlets is through the tulip contact. Consequently, the tank pressure may drop 0.01–0.02 bar during the interruption test, especially when the switch fails to interrupt at the first CZ.

The nozzle was replaced when changing the test switch type or the test duty. The type tests require that a load break switch is able to successfully interrupt in 100 consecutive attempts. Considering this, and to save time and material, the nozzle was not replaced between each pressure level as long as the limit of 100 tests was not reached. Arcing contact wear was negligible, with virtually no change in the contact diameters.

IV. RESULTS

A. Current, Voltage and Pressure Curves

Figs. 5 and 6 show measurements from two typical interruption tests, one with the ”mainly active load” and one with the ”switch-fuse” test duty. The upstream pressure (i.e., the tank pressure) is in both cases fairly stable around 1.16 bar most

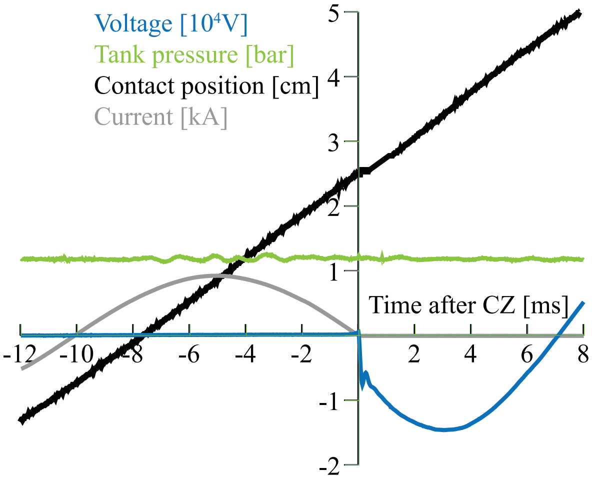

Fig. 5. Typical recordings from a successful interruption with the ”mainly active load” test duty.

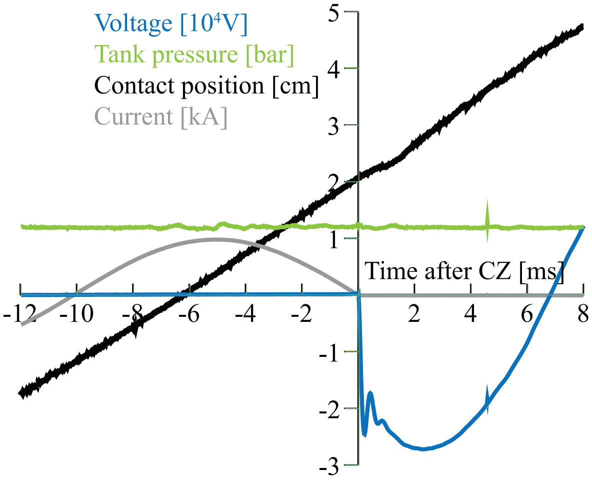

Fig. 6. Typical recordings from a successful interruption with the ”switch-fuse” test duty.

of the time, except in the milliseconds after contact separation (contact position equal to 0 cm) where the arc creates some pressure fluctuations. In both tests current is interrupted at the first CZ (time equal to 0 ms) after contact separation. Immediately after, the voltage across the contacts builds up and eventually reaches the source voltage. The main difference between the two experiments is the TRV, in particular the amplitude of the first peak. The ”spikes” on the voltage and pressure curves in Fig. 6 around 5 ms after current interruption are noise.

Fig. 7 shows typical examples of current and voltage traces of each of the three possible outcomes of an experiment: i) successful interruption, ii) thermal failure or re-ignition, and iii) dielectric failure or re-strike. In the successful interruption current ceases after CZ, and the TRV rises to around 25 kV within approximately 0.2 ms. In the dielectric failure case, a re-strike occurs near this point. A new arc is formed as the current changes polarity and starts a new half-cycle. The thermal failure takes place immediately after CZ, not causing any notable change in the current waveform. In this case a barely visible, temporary increase in the voltage across the switch occurs within the first tens of microseconds after CZ.

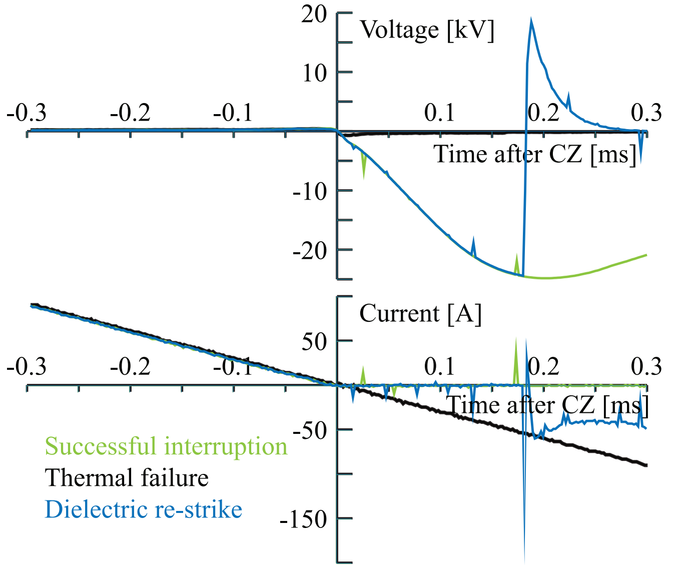

Fig. 7. Current and voltage measurements from a successful interruption, an interruption that failed due to thermal re-ignition, and an interruption that failed by a dielectric re-strike. (The ”spikes” are noise.)

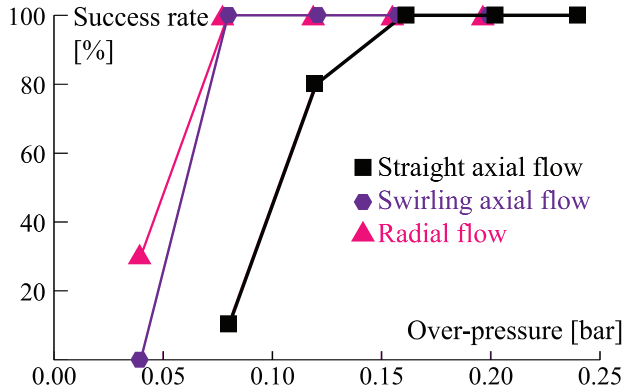

Fig. 8. Percentage of successful interruptions as a function of the upstream over-pressure for all three designs subjected to the ”mainly active load” test duty. Note that some symbols are overlapping.

There is nothing unusual in the current and voltage waveforms of Figs. 5-7. These are all typical examples of what can be observed when studying power switching devices, indicating that the behavior of the somewhat idealized test setup resembles that of commercial devices.

B. Interrupting Capability with ”Mainly Active Load” Test Duty

Fig. 8 summarizes the results of the ”mainly active load” test program for all three switch designs. Each symbol represents ten interruption tests. As can be seen, the radial and swirling flow designs were tested down to 0.04 bar upstream over-pressure, whereas the straight axial flow tests ended with only one successful and nine failed interruptions at 0.08 bar. Hence, the air flow patterns and the arc cooling efficiency of the two

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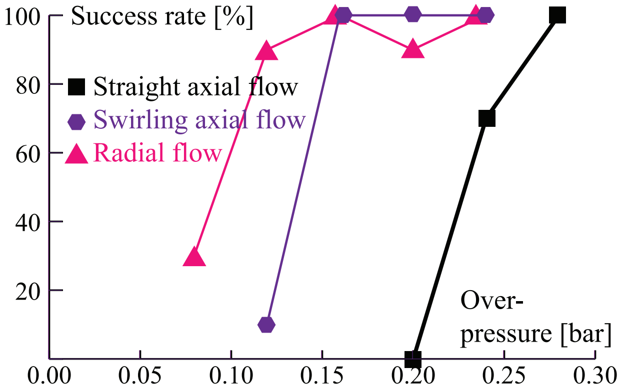

Fig. 9. Percentage of successful interruptions as a function of the upstream over-pressure for all three designs subjected to the ”switch-fuse” test duty. Note that some symbols are overlapping.

former designs appear to be considerably better than of the latter.

All but one of the 28 unsuccessful interruptions included in Fig. 8 were thermal re-ignitions. Moreover, the radial flow design seems to have a better interruption capability when the pin contact is still inside the nozzle than the other designs. The radial air flow concept had no failed interruption attempts inside the nozzle until the over-pressure was lowered to 0.04 bar. Here, the switch failed with the pin contact both inside and outside the nozzle. This is not the case for the two other designs, where attempts at current interruption often failed if the pin contact was still inside the nozzle.

C. Interupting Capability with ”Switch-Fuse” Test Duty

The results of the ”switch-fuse” test duty experiments – where the current is almost the same, but the TRV is more challenging – are presented in Fig. 9. Not surprising, all three designs need a higher upstream over-pressure to successfully interrupt. The largest difference is found with the straight axial flow design, where the required over-pressure increases from 0.15-0.20 bar to 0.25-0.30 bar. The radial flow comes out somewhat better than the swirl and substantially better than the straight flow concepts.

These test series saw no successful interruptions while the pin contact was inside the nozzle. (That is, all interruptions happened after the pin contact had been pulled out, and typically at the second CZ). This leads to similar arcing times, and thus similar contact and nozzle wear for all three designs. The probable reason for this difference in interruption capability inside the nozzle compared to what was observed in the ”mainly active load” tests, is that the more demanding TRV gives a higher dielectric stress on the contact gap immediately after CZ.

Moreover, as expected and for the same reason, dielectric restrikes are far more common. Whereas the radial flow design had only a single dielectric failure in the ”mainly active load” part of the campaign, half of the unsuccessful interruptions now experienced are dielectric re-strikes and half are thermal re-ignitions. Also the two other test switches had several dielectric failures.

V. DISCUSSION

Even though the number of tests carried out is limited and the outcome is associated with a certain statistical scatter, it is quite clear that the radial flow and swirl flow designs are significantly better than the straight axial flow geometry. Under the present test conditions the axial flow concept requires about twice as high upstream over-pressure to obtain a switching performance comparable with the other two.

In commercial load break switches, the energy needed to produce a sufficiently strong air flow comes from the operating mechanism; typically discharging a spring. The operating mechanism or the ”drive” with all its shafts, linkages, levers, springs and chargers constitutes a major portion of the manufacturing costs of a switchgear, and the costs are closely related to the energies and mechanical forces the drive provides. Consequently, identifying an air flow and arc cooling concept that uses the drive energy in an efficient way, translates into substantial cost savings.

In addition to the good overall interrupting performance, the radial flow design has a few advantageous properties. It is able to interrupt the current at almost any contact position, including the pin contact being inside the nozzle. This in contrast to the other two designs which have few successful interruptions with arcing times less than 4 ms, the time needed for the pin contact to move out of the nozzle. This is probably due to the outlet through the tulip contact that allows the cooling air to flow immediately after contact separation. In the other two designs, the only outlet is through the nozzle, which is closed as long as the pin contact is inside the nozzle.

Quenching the arc and interrupting current while the pin contact is inside the nozzle reduces arcing time and energy dissipation, and thereby nozzle and contact wear. Furthermore, little or no hot and ionized air from the arc is blown into the contact gap. It mainly flows out backwards through the tulip contact. This is favorable when considering a real load break switch which also has a pair of main contacts. Dielectric restrikes across the main contacts are less likely if the hot gas is removed from the contact gap.

The use of a pressure tank instead of some kind of a piston and cylinder arrangement generating the air flow onto the arc constitutes a considerable difference between the present experimental switches and commercial devices. In the tank setup the air volume at over-pressure is significantly larger than the volume being compressed in a ”puffer principle” based device, causing the upstream over-pressure to become independent of the contact movement and more stable than in a real switch.

In a puffer device, the first stage of the pressure build-up lasts from the starting position and until contact separation. The pin contact is essentially plugging both the tulip contact and the nozzle, and the air in the puffer volume is compressed with little leakage. The pressure rise as a function of contact position will be similar in all three designs considered.

The next stage of the pressure build-up lasts from the contacts separate and until the pin contact leaves the nozzle. In the radial flow case, air now starts flowing out from the puffer volume through the tulip contact and the back outlet. This reduces the contribution to the pressure increase per distance the contact moves compared to before contact separation. In the straight and swirl flow designs, the pin contact is still plugging the only outlet, even though some air escapes through the gap between the pin contact and the nozzle wall. (This cross-sectional area is less than one tenth of the radial flow design outlet area.) Thus, a higher over-pressure is expected as the pin contact moves through the nozzle in the straight and swirl flow cases than in the radial flow case. Arcing, clogging and nozzle ablation of course also contribute to the pressure rise.

Hence, a puffer design using a radial flow pattern will probably not build up as high pressure as puffer devices utilizing straight and swirl flow designs. When using a tank to provide air flow – as it is done in the present investigation – the interrupting capabilites for the radial flow concept may thus be somewhat overestimated. In any case, the interruption capabilities of the three air flow concepts in a puffer-type device can only be firmly established by testing a complete switch design.

A final observation is that in the past swirling flow patterns have been tested for circuit-breakers for transmission level voltages, but without much success. The reason for the far better outcome in the present study is most likely related to the straight nozzle geometry and the lower dielectric stresses associated with MV load break switching. For a conical nozzle geometry, as is used in high voltage circuit-breakers with supersonic gas flow, a swirling pattern creates a back-flow channel in the center of the flow. This causes a poor dielectric recovery in this area and a high risk for dielectric re-strikes. This effect is avoided with subsonic flow in a cylindrical nozzle, and the dielectric recovery seems to be sufficiently good for the MV application considered in this work.

VI. CONCLUSIONS

The most important conclusions that can be drawn from this work are that:

- Air flows directed radially onto the arc or swirling along the arc turn out to result in a substantially better interruption performance than when the air flows straight and parallel to the arc.
- For modest TRVs, a radial air flow seems to give a good interruption capability even before the pin contact has been pulled out of the nozzle, resulting in short arcing times and presumably less nozzle and contact wear.
- Air flows corresponding to upstream over-pressures of a few tenths of a bar seem to be sufficient for an air-based load break switch rated for 24 kV / 630 A.

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REFERENCES

[1] H. Okubo, and A. Beroual, ”Recent trend and future perspectives in electrical insulation techniques in relation to sulfur hexafluoride (SF_6) substitutes for high voltage electric power equipment”, *IEEE Electr. Insul. Mag.*, vol. 27, no. 2, pp. 34-42, 2011.

[2] P. C. Stoller, M. Seeger, A. A. Iordanidis, and G. V. Naidis, ”CO_2 as an arc interruption medium in gas circuit breakers”, *IEEE Trans. Plasma Science*, vol. 41, no. 8, pp. 2359-2369, 2013.

[3] R. R. Bjørtuft, A. Sitko, E. Attar, O. Granhaug, M. Saxegaard, and H. Landsverk, ”Dielectric and thermal challenges for next generation ring main units (RMU)”, *22nd Int. Conf. and Exhib. Electricity Distrib.*, 2013.

[4] Y. Kieffel, T. Irwin, P. Ponchon, and J. Owens, ”Green gas to replace SF_6 in electrical grids”, *IEEE Power and Energy Mag.*, vol. 14, no. 2, pp. 32–39, 2016.

[5] R. Garzon, *High Voltage Circuit Breakers - Design and Applications*, New York: Marcel Dekker, 1996.

[6] E. Jonsson, N. S. Aanensen, and M. Runde, ”Current interruption in air for a medium voltage load break switch”, *IEEE Trans. Power Del.*, vol. 29. no. 2, pp. 870-875, 2014.

[7] N. S. Aanensen, E. Jonsson, and M. Runde, ”Air flow investigation for a medium voltage load break switch”, *IEEE Trans. Power Del.*, vol. 30. no. 1, pp. 299-306, 2015.

[8] E. Jonsson, and M. Runde, ”Current interruption in air for medium voltage load break switch ratings”, *IEEE Trans. Power Del.*, vol. 30. no. 1, pp. 161-166, 2015.

[9] N. S. Støa-Aanensen, M. Runde, E. Jonsson, and A. D. Teigset, ”Empirical relationships between air load break switch parameters and interrupting performance”, *IEEE Trans. Power Del.*, vol. 31, no. 1, pp. 278-285, 2016.

[10] *High-Voltage Switchgear and Controlgear – Part 103: Switches for Rated Voltage Above 1 kV up to and Including 52 kV*, IEC International Standard no. 62271-103 ed. 1.0, 2011.

[11] *High-Voltage Switchgear and Controlgear – Part 105: Alternating current switch-fuse combinations for rated voltages above 1 kV up to and including 52 kV*, IEC International Standard no. 62271-105 ed. 2.0, 2012.

[12] E. Jonsson, and M. Runde, ”Medium voltage laboratory for load break switch development,” *Proc. Int. Conf. Power Systems Transients*, Vancouver, 2013.

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