Redesign of a spark gap switch assembly towards reduction of volume, weight and ease of assembly

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1. INTRODUCTION

There is always a need for products that are easy to assemble and quick to manufacture. This need in addition to the requirement of reduced volume and weight of the assemblies have been driving factors for designers. In this work, a spark gap switch assembly has been redesigned towards making it smaller, lighter and quicker to assemble. Spark gap switches are switches which start conducting at pre-set voltages (of the order of tens of kV). These switches are essential building blocks for high voltage impulse generators used for achieving very high voltages (hundreds of kV). The switch under consideration is required to conduct above 80 kV potential difference between its two electrodes when the gap between them is nearly 12 mm (Fig. 1). The switch is required to be filled with gas (nitrogen) to a pressure of 5 bar to have the flexibility of varying the voltage of conduction.

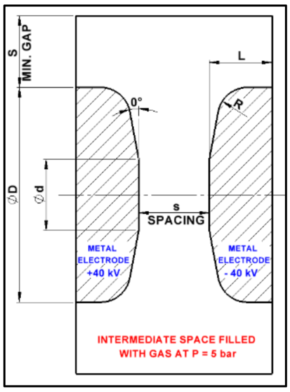

Fig. 1: Switch requirements

2. EXISTING DESIGN VS NEW DESIGN

In order to achieve the above mentioned goals of 80 kV operation under a gas pressure of 5 bar a switch was designed with a nylon enclosure for the gas. The flanges made of AISI 304 stainless steel, on the two ends of the nylon enclosure were machined with the integral electrodes. The sealing of the gas was ensured using the O-rings. The flanges were held by the 6 numbers of M6 bolts on either side (refer Fig. 3 and Fig. 5). The enclosure was provided with threaded holes fitted with helicoil inserts to receive the bolts.

To make the above assembly easier to assemble the flange on one side was removed by making the change in the enclosure shape. The electrodes were designed to be threaded on to the enclosure on one side and to an aluminium alloy (6061 T6) flange on the other side (refer Fig. 4 and Fig. 6). The change of flange material to aluminium was to make the assembly lighter. A backing ring of aluminium was provided to have a metallic base for the internal threads unlike the existing design were the internal threads are made on the nylon (with helicoil inserts). The nylon threads in the existing assembly were found to deteriorate thus making the assembly leak after few cycles of operation.

3. FE ANALYSIS

The new design was evaluated for strength and rigidity by estimating the stress and deflections using analytical expressions. To further make more accurate estimate, a finite element analysis was performed using ANSYS 2016 for the loading condition of 7.5 bar (1.5 times the working pressure) internal pressure. The maximum equivalent stress (occurring at the centre of the aluminium flange) was found to be 88 MPa which is lesser than the yield strength of aluminium alloy used. This resulted in the design having a factor of safety greater than 3. The maximum deflection of 0.02 mm was found to occur at the centre of the aluminum flange. The deflection of the flange from the enclosure decides the leakage of the gas (reduction of gas pressure). The estimated deflection was very much lower than the compression of the O-ring thus ensuring the leak tight operation of the assembly.

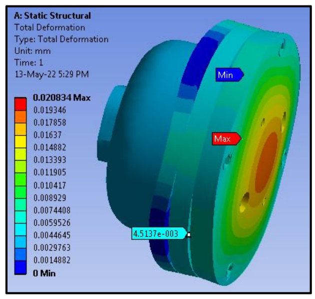

Fig. 2: Deformation - FE analysis

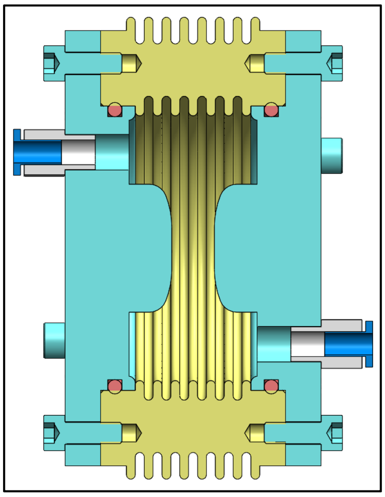

Fig. 3: Sectional view of the existing design

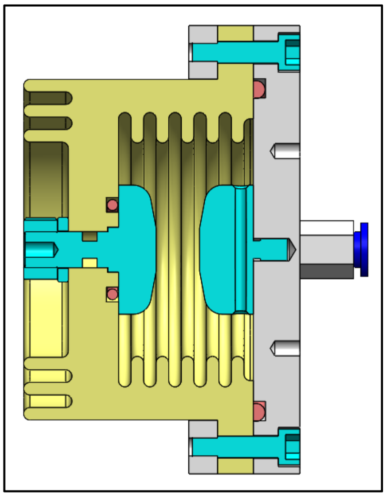

Fig. 4: Sectional view of the proposed design

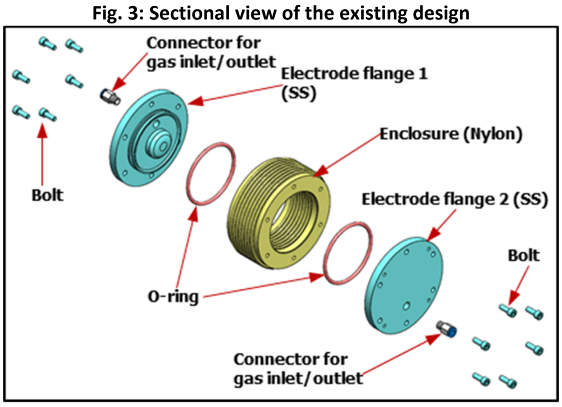

Fig. 5: Exploded view of the existing design

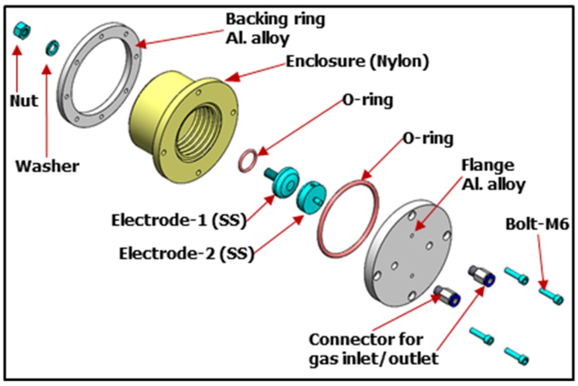

Fig. 6: Sectional view of the proposed design

4. CONCLUSION

A spark gap switch has been redesigned to reduce the number of parts. By suitable modifications in the shape and choice of material the assembly has been made lighter. The assembly has been made with provision of having metallic threads thus preventing deterioration of the seal. The number of bolts have been reduced to 4 from existing design to 12 numbers by change of shape and use of right materials. The new design has also provided higher creepage distance for the high voltage by virtue of corrugations on the outer side of the nylon enclosure.

Table 1: Comparison of schemes

Existing design	Proposed design	Remarks
3.2 kg	1.2 kg	Lighter than existing
19 parts (3 machined)	15 parts (5 machined)	Lesser number of parts
14 threaded joints	8 threaded joints	Lesser assembly time

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