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MONTE CARLO ESTIMATIVE OF ABSORBED DOSE IN ALUMINUM BASED EPOXY RESIN FOR UNDULATOR VACUUM CHAMBER APPLICATIONS IN SIRIUS

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Introduction: Epoxy based resins are commonly used composites in many devices present in particle accelerators. Due to their application in components inside the accelerators, they're submitted to high radiation doses, which could damage the resin's structure eventually causing malfunctions of the composite. One specific desired applicability of epoxy resin is on vacuum chambers of some undulators to be installed in the Brazilian Synchrotron Light Source, Sirius. The undulator is a device which uses magnets fields to generate consecutives oscillations in electron trajectory for synchrotron radiation production. During the operation, electron beam losses can occur, whose electrons could hit accelerators elements and produce a high amount of energy deposition around the loss region. This study was developed in Monte Carlo computational code FLUKA to examine the radiation dose to which epoxy resin could be exposed in undulators, in order to verify the viability of its long-term usage on those devices without effects on its physical properties, such as tensile strength, deformation and degradation temperature.

Material and method: The material analyzed in this study was an epoxy resin filled with aluminum metal Duralco-132 provided by COTRONICS CORP. Its density was 1.8 g/cm³ and the composition of the resin was a Diglycidyl ether of Bisphenol A mixed with aluminum metal at a ratio of 0.58 and 0.42 respectively, estimated based on each component material densities. Thereby, this composition was reproduced in the FLUKA code.

The undulator vacuum chamber geometry and its different material compositions, including the aluminum-based epoxy resin material, were implemented in the code. The electron beam of 3 GeV was inserted in such a way as to hit the wall of the vacuum chamber inside the undulator, representing a beam loss during operation. In this way, the absorbed radiation dose in the epoxy resin was estimated and compared with threshold values for radiation damage in similar epoxy resins found in literature [1, 2]. Based in these references, the threshold dose value for significant damage in epoxy resin's properties was assumed as 1 MGy.

Results: The absorbed dose per electron lost obtained by simulations was $(2.5252 \pm 0.0003) \cdot 10^{-12}$ Gy/electron, composed 98% by electrons with the other 2% being mostly positrons. An overestimated electron loss rate could be established to obtain a superior limit of absorbed dose. Considering $2 \cdot 10^{12}$ electron lost per day, the value for the total absorbed dose in the epoxy resin was (44.263 ± 0.004) kGy per year. Therefore, considering the threshold of 1 MGy, even in the worst scenario analyzed, it'll be needed over 20 years for the epoxy resin presents mensurable radiation damages in physical properties that would harm the resin's functions.

Conclusions: The epoxy resin filled with aluminum presented a low absorbed dose, comparing with other components, even considering an overestimated electron loss in the accelerator. The simulated value was 44.3 kGy/year, correspondent to more than 20 years of operating to reach the threshold based in literature of 1 MGy. This time of use is comparable to the maximum expected use period of a synchrotron component; thus, it wasn't expected that the epoxy will have important effects in its physical properties due its use in undulators vacuum chambers. It reinforces that this epoxy resin is a suitable material for this kind of application, widening the use of the epoxy in other applications beyond undulators vacuum chambers.

References:

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