Prediction of Temperature and Stress in a Multi-stage Depressed Collector under Different Enviornmental Conditions

Vishant Gahlaut[1] **and Sanjay Kumar Ghosh**[2]

[1]Department of Physics, Banasthali University, Banasthali, Rajasthan, India
[2]CSIR-Central Electronics Engineering Research Institute (CEERI), Pilani, Rajasthan, India

Abstract— Increasing requirement of traveling-wave tubes (TWTs) with high efficiency, high power, high gain in addition with weight and size reductiondemand proper thermal management. Specially, collectors in TWTs have to have very good heat dissipation as spent electron beam is dumped here. In high efficiency TWTs, the maximum power of the spent electron beam is recovered by collecting the electrons at different electrode potentials and remaining unrecovered power is waste as heat. The potentials of electrodes are essentially negative with respect to cathode, hence, coined as multi-stage depressed collector (MDC). With the increasing demand in size and weight reduction, complexity in thermal packaging enhances. This paper presents thermal and structural parameters, namely, temperature and stress distribution in different parts of a MDC using different software packages.

1. INTRODUCTION

With the modern innovative design concepts and with the state of the art of the technologies, high power wide band TWTs with reduced size and weight are being developed for long life and reliability applications. Efficient thermal management need proper thermal packaging, but a heavy packaging enhances the weight of the device. Thus, high efficiency, long life TWTs efficient thermal management [1–4].

MDC of a TWT is being heated up during operation due to dumping of spent electron beam and which is dissipated either through conduction and or radiation [5]. Here, source of heat is the electron beam and environment is the sink through base plate, thus, variation of environmental temperature conditions affects variation of temperature and stress in MDC. Hence, proper packaging and choice of material is very important for efficient heat dissipation at reduced size and weight of the TWT.

In this paper, authors have studied heat dissipation, expansion and stresses developed among the collector electrodes in a MDC under different environmental conditions and study has been made using COSMOS which provides one screen solution for thermal, stress, frequency and harmonic analysis. Three dimensional modeling of the complex geometry of MDC with symmetry is

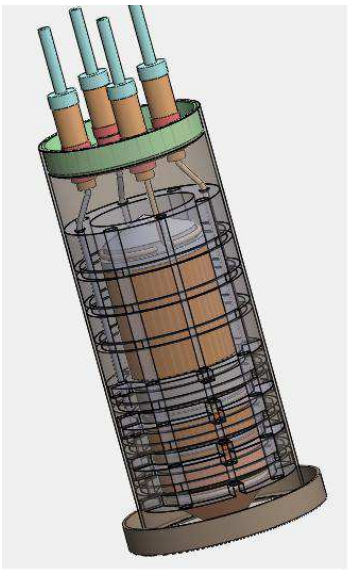

Figure 1: Thermal model of four-stage MDC.

constructed in Solid Works and imported in COSMOS finite element (FE) analysis. It has also mesh controller which enables to apply various mesh size in different zone as per requirement of level of accuracy. Range of element size can used in meshing of model with tolerance required to adjust the element size during meshing. Moreover, to validate the simulation in COSMOS, results have also been compared with different software packages, namely, ANSYS.

2. MODEL

Axially symmetric four stage MDC, under study (Figure 1), have been analyzed-using COSMOS, to predict both temperature distribution at ambient temperature (+25°C) as well as under different environmental conditions, typically, −25°C and +80°C. Moreover, expansion of electrodes and stress developed at different braze joints have also been studied under RF condition, that is, when RF power is extracted. Under RF condition amount of spent beam energy recovered or amount of energy dissipated among the collectors are different and, thus, expansion, temperature and stress developed among the electrodes are different.

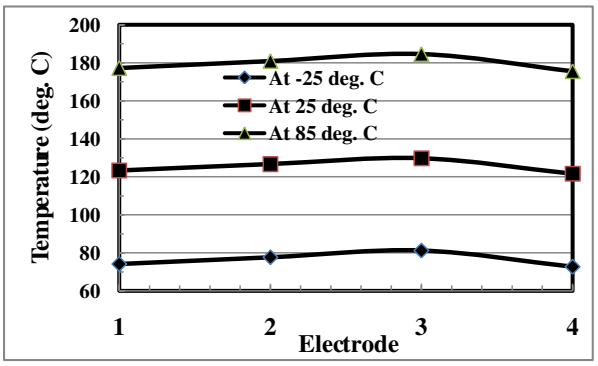

Figure 2: Electrode temperature under different temperature (environmental) conditions.

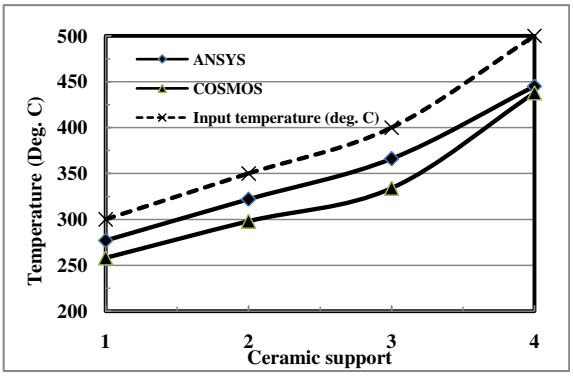

Figure 3: Comparison of temperature distribution without radiator obtained from ANSYS and COSMOS, taking temperature (broken line) as inputs.

3. RESULTS AND DISCUSSION

Boundary conditions are the Emissivity of the standard materials is given elsewhere. Thermal resistance 4.0e-5 K-m2/W at brazing joints. Figure 2 shows temperature distribution on collector electrodes under different environmental temperature conditions for same input conditions. Temperature distribution in electrodes is different when ambient temperature is different. At the extreme condition (80°C), the temperature in all the collector electrodes is much more compare to other two conditions.

A comparison of study has also been done using different software packages (Figure 3). To study the analysis under different software, generalized inputs have been applied in terms of temperature at the inner surface of collector. It is shown from the figure that the results obtained from different software are closely agreeing and hence further study have been made using COSMOS.

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