Support Geometries for Temperature Dissipation Through Helix Slow-Wave Structure in Space Traveling-Wave Tubes

Vishant Gahlaut[#], PA Alvi[*], RK Sharma[#], V Srivastava[#] and S Ghosh[#]

[#]*Microwave Tubes Division*
Central Electronics Engg. Res. Inst., Pilani, Rajasthan 333 031
vishantgahlaut17@gmail.com, ghoshsk@rediffmail.com
[*]*Department of Physics*
Banasthali University
Banasthali, Rajasthan, India

Abstract **-- In helix traveling-wave tubes (TWTs), average power is being restricted due to thermal management of helix. In increasing requirements of power and wideband miniature size TWTs, thermal issues are becoming rigorous problem. Moreover, if TWTs are to be used for space applications, where size and weight are being restricted, proper thermal analysis is necessary to enhance the life of TWT. In TWTs, the major portion of heat, generated in the helix, is conducted through support rod and some part may be radiated from the uncovered portion by support rods (neglected here) to the metal envelope. Thus the shape, size and property of the support material determine the amount of heat conduction from the helix. In this paper, authors have studied the effect of support rod geometries on heat dissipation from helical slow wave structure in space TWTs.**

Keywords-- **Thermal management, support rod, helix.**

I. Introduction

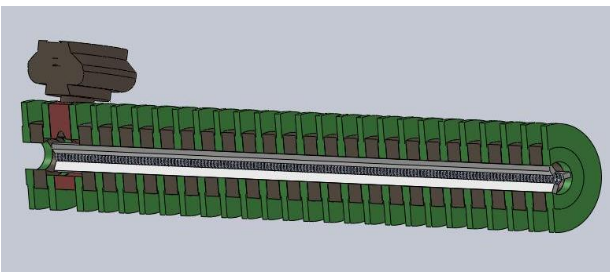
Thermal management problem of helix in a traveling-wave tube (TWT) restricts its average power handling capability. The helix, in a TWT, is supported with dielectric support rods, symmetrically arranged 120^0 apart each other around the helix and enclosed in a metal envelope (Fig. 1(a)). The geometry of the support structure plays an important role in heat dissipation from the helix[1]. Helix being a periodic structure, the contact between the helix and support geometry is non-uniform. Surface finish of helix and support rod enhances thermal contact resistance at the joint[2]. However, this problem becomes severe at higher frequencies, where transverse dimensions of the structure are reduced. In this paper, authors have studied thermal characteristics of helix, its support geometry and envelope for two different helix support geometries, namely 'T' type support geometry and 'rectangular' support geometry (Fig. 1(b)). In this paper, authors have studied the temperature distribution of helix, supported by three taper geometry APBN dielectric support rods 120^0 apart each other and its cross sectional view shown in (Fig.1) using commercially available software COSMOS[3]. Also studies have been made with different support rods of different geometry (Fig. 1(b) &1 (c))and results are shown in Fig. 2. It is observed from the results (Fig. 2) that drainage of heat from helix to rod is more in case of rectangular support structure (fig. 1C).

II. Results & Discussion

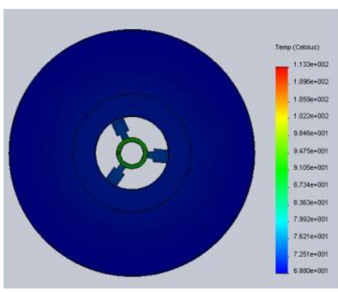
For simulation of the structure, properties of different materials, namely, periodic helical structure made of tungsten, anisotropic pyrolytic boron nitride (APBN) support rods and barrel envelope made of monel, have been used (Table-1). Modeling has been carried out in Solid Works and simulations using finite element method. For the simulation, the power loss in the helix has been taken as the helix interception power 12 W, corresponding to 2 mA interception current and helix voltage of 6 kV increases the temperature of the helix and which is being drained to the environment through the helix support geometry and metal envelope[4]. Temperature distribution at different structure regions have been shown in figure 1(b)&(c). It can be seen from the figure- 2 that heat dissipation from the helix with rectangular support geometry is better than the T-type support geometry. However, for design consideration for lowering the dielectric loading factor in the vicinity of helix, to enhance the performance, structure 1(b) is taken. Structural dimensions are shown in table-2.

Table 1: Material Properties

Material	Density (Kg/m^3)	Thermal Conductivity (W/m^{0}K)	Specific Heat (J/Kg^{0}K)	Emissi vity	Young's Modulus (N/ mm^2) *10^{11}	Thermal expansion (10^{-6}/^{0}C)	Poison's ratio
Tungsten	19300	173	133	0.25	411	4.5	0.28
APBN	2150	60	850	0.45	22	11.9	0.25
Monel	8900	19.5	400	0.43	162	13.5	0.30



(a)



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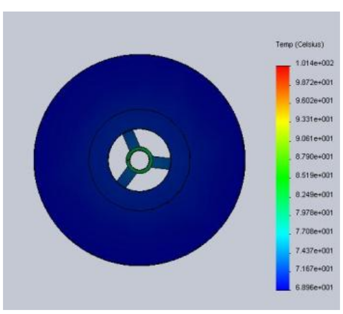

(c)

Fig.1. Thermal model helix SWS under evaluation, helix support geometry **(a)** cross-sectional view of T-type support Rods **(b)** and cross-sectional view of Rectangular support Rods **(c)**

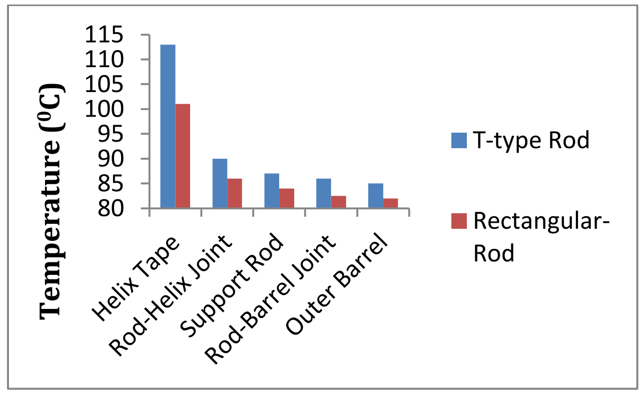

Fig.2. Maximum temperature distribution at different locations of SWS

Table: 2: Structural dimensions of SWS assembly parts

Parts	Dimension
Barrel radius (C)	1.70 mm
Helix radius (a)	0.55 mm
Helix thickness (t)	0.15 mm
Pitch	0.60 mm
Barrel length	100 mm
T - shape rod	Step Ist width = 0.30 mm height =0.30 mm Step IInd width = 0.60mm height =0.70 mm
Rectangular rod	width = 0.60 mm height =1.0 mm

III. Conclusion

For heat dissipation from helical slow wave structure in space TWTs, the effect of shape and size support rod geometries have studied. Rectangular shaped support rod and T-type support rod have been simulated. The heat drainage is better with the rectangular shaped APBN support rod from the helix comparative than the T-type support geometry.

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