Analysing Waveguide Flange for High Power Waveguide Systems by using Cavity Structure

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Abstract

In this paper, waveguide flange for high power waveguide systems are presented. To prevent breakdown problem due to the small groove for gasket, its location is changed to the outside of the groove for rubber O-ring. Rectangular cavity is fabricated and measured to prove the performance of the proposed flange. According to the measured results, the resonant frequency of the proposed flange is not changed, but return loss characteristic is degenerated.

Keywords : Rectangular waveguide Waveguide flange High power microwave

1. Introduction

A waveguide flange is a connector for joining sections of waveguide. The connecting face of the flange is either square, circular or rectangular. Key features of a waveguide join are; whether or not it is air-tight, allowing the waveguide to be pressurized, and whether it is a contact or a choke connection. This leads to three sorts of flange for each size of rectangular waveguide as shown in Fig. 1. First type is known as a *cover* or *plain* flange. This ungrooved type has a plain flat face. Second type is called as a *gasket* or *gasket/cover* flange. For electrical continuity, this type of flange uses waveguide gasket. If a gasket is a die-cut configuration, groove is not necessary. However, a ring type gasket including bal seal, which is a spring type seal [1], requires a groove as shown in Fig. 1. Final flange type is *chock* flange. It has only groove without sealing material. Since the chock forms a quarter-wave transformer, the high impedance at the top of the ditch is changed to a low (ideally zero) impedance at the broad wall of the waveguide [2].

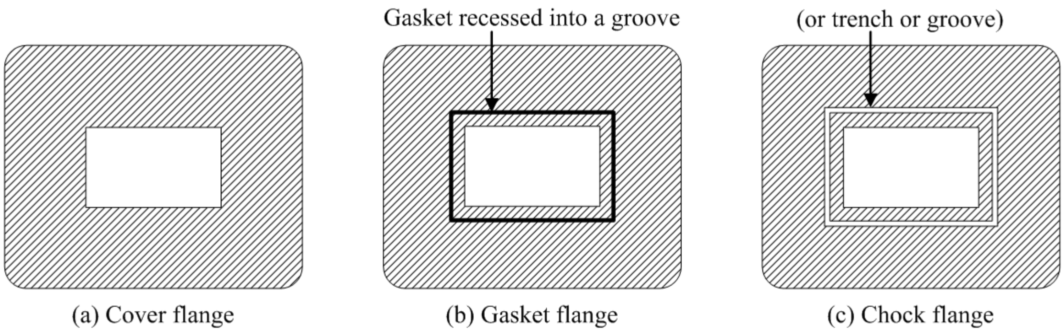


Figure 1: Three types of waveguide flange.

Additionally, the atmosphere within waveguide structures is often pressurized to raise its breakdown voltage and so increase the power that may be carried by the guide. Since this requires that all joins in the waveguide be airtight, rubber O-ring is recessed into a groove in the face of flanges. These various flanges should be tested to verify that their electrical property is suitable to transmit microwave because flange loss could degenerate system performance. However, since flange is not a waveguide component but a joint section, it is hard to test the performance of waveguide flange directly and additional test fixture is necessary [3]. Therefore, we use a method to simply analyse a performance of flange by using waveguide cavity.

2. Waveguide Flange for High Power Microwaves

The general rubber O-ring is located at outside of gasket or chock as shown in Fig. 2 (a). In this case, since RF contact is possible due to gasket, rubber O-ring could not theoretically affect the electrical characteristic in the waveguide. This structure is suitable for low vacuum condition under 10^{-4} Torr or using insulating gas. However, if the transmitting power becomes hundreds MW, high vacuum condition is required. In this case, since narrow space or gap such as small crack and groove could be a trap of molecules, they should be removed for high quality vacuum condition. Therefore, when transmitting hundreds MW power, the location of rubber O-ring is changed as shown in Fig. 2 (b). In this case, since RF contact is located at outside of rubber O-ring, it could be a cause for loss. However, this type of flange is more suitable for high power microwave applications because a small groove which could be a reason of breakdown is located at outside of rubber O-ring.

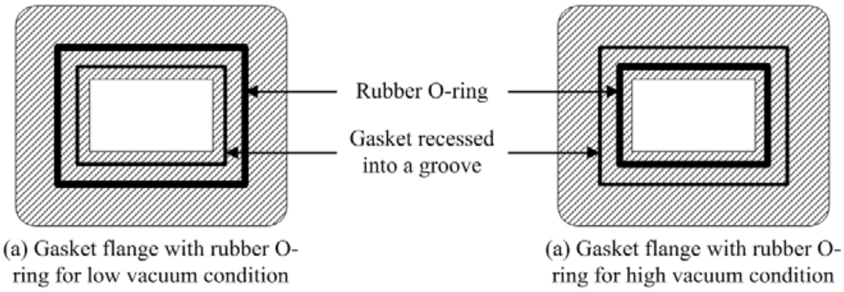


Figure 2: Two types of gasket flange with rubber O-ring.

3. Cavity Design

To verify the performance of modified gasket flange, rectangular waveguide cavity is designed. Since the operating frequency of the desired system is 2.856 GHz, WG-284 waveguide is considered and the cavity length is decided as half guided wavelength of 76.5 mm as shown in Fig. 3 [4]. This cavity is simulated by CST MWS, and its resonant frequencies are also listed in Fig. 3. As expected, it is observed that the first resonant frequency is 2.856 GHz.

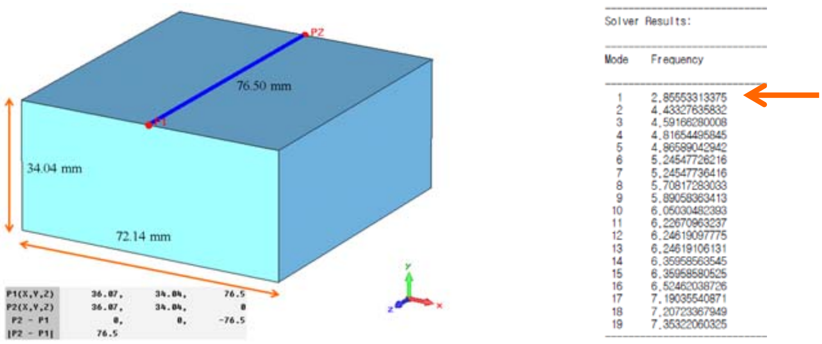
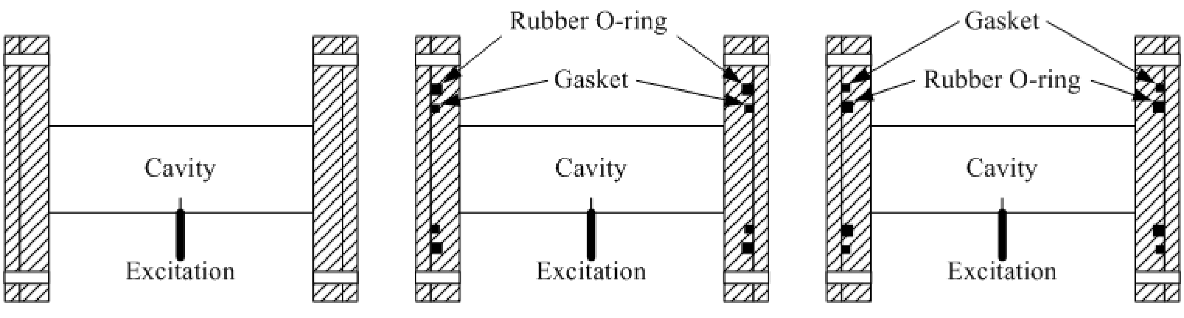


Figure 3: The designed cavity and its resonant frequencies.

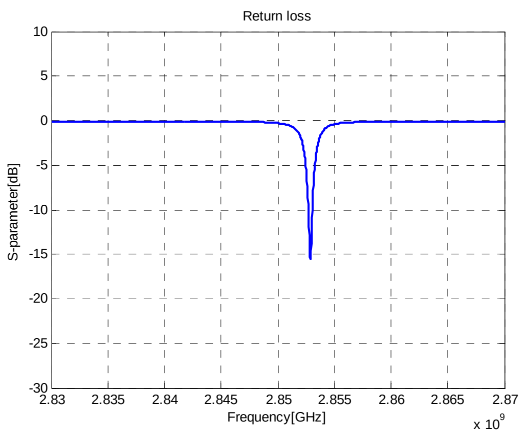
4. Measurement

The designed and simulated cavity is fabricated into three types as shown in Fig. 4. The first is a cavity using cover flange, and the second cavity uses conventional gasket flange. Finally, the third one is connected with modified gasket flange. They are same size cavities. However, since the flanges are different, their return losses are also difference as shown in Fig. 5.

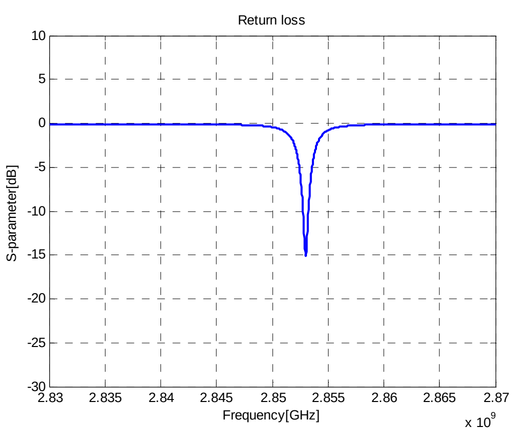


(a) Cover flange (b) Conventional gasket flange (c) Modified gasket flange

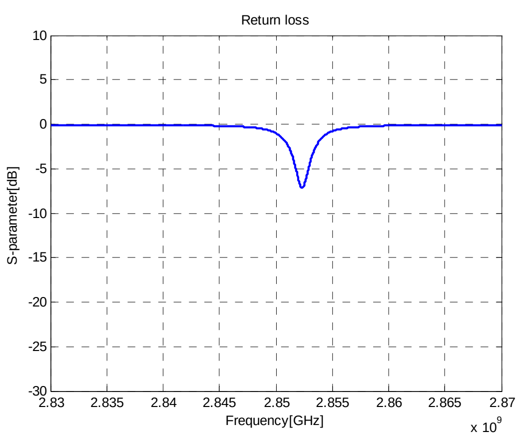
Figure 4: Three cavities using different types of flanges.



(a) Cover flange (1^{st} cavity)



(b) Conventional gasket flange (2^{nd} cavity)



(c) Modified gasket flange (3^{rd} cavity)

Figure 5: Return loss of three cavities using different types of flanges.

Electrical properties of three cavities are listed in the Table 1. Since there is no air gap between two flanges, the resonant frequencies of three cavities are almost same. In other words, it means that the gasket functions normally. However, return loss of 3rd cavity at operating frequency is different from the values of the others. Since robber O-ring is located in the inside of gasket as shown in Fig. 4 (c), it affects electrical properties of cavity.

Table 1: Electrical properties of three fabricated cavities

	1st cavity	2nd cavity	3rd cavity
Resonant frequency	2.853 GHz	2.853 GHz	2.852 GHz
Return loss at operating frequency	-15.54 dB	-15.08	-7.16

5. Conclusion

In this paper, we propose the waveguide flange for high power microwave applications. Since the small groove could a reason of breakdown problem, its location is changed to the outside of the groove for rubber O-ring. As a result, rubber O-ring which is located in the inside of gasket becomes a loss factor. However, resonant frequency of rectangular cavity using the modified gasket flange is not changed. Therefore, it is proved that the proposed flange could be applied to high power microwave application.

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