Comparative thermal analysis of the ITER VVTS panels with circular external pipes and extruded internal pipes

Objectives

The main objective of the performed thermal analysis is to compare a thermal performance of the different design of the VVTS panels: (a) panel with extruded internal pipes (Fig. 4.15); (b) panel with circular external pipes attached to the panel by 2 mm stainless steel brackets and (c) panel with circular external pipes attached to the panel by stainless steel brackets cladded with 0.5 mm copper (Fig. 4.16).

Initial data

A calculation cross section for a panel region with extruded and circular pipes are shown in Fig. 4.15 - 4.16 respectively.

The boundary conditions and surface emmisivities are taken the same as for the analysis of the joint regions (paragraph 4.2).

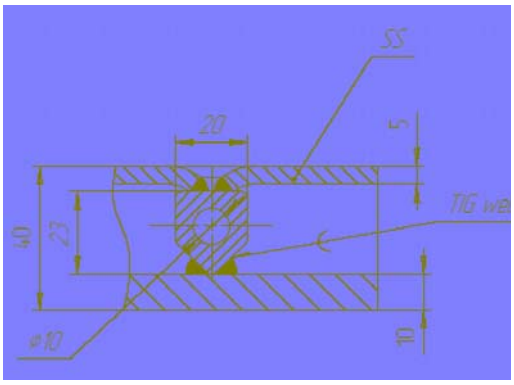

Fig. 4.15. VVTS fragment with extruded pipes

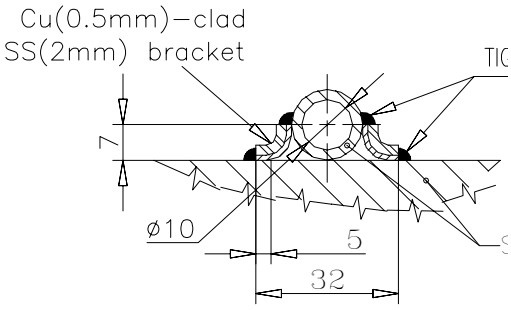

Fig. 4.16. VVTS fragment with circular pipes

Results of analysis

Temperature state for different type of panel design are presented for the 3 analyzed design options:
Case # 1 – for panel region with extruded pipes (Fig. 4.17);
Case # 2 – for panel region with circular pipes
attached by 2 mm SS (80% welding on length) brackets (Fig. 4.18);
Case # 3 – for panel region with circular pipes
attached by 2 mm SS brackets cladded by 0.5 mm copper (50% on length) (Fig. 4.19).

Temperature distribution in a thin fin for the analyzed cases are shown in Fig. 4.20 - 4.22 respectively, distribution of heat flux to the TFC along the thin fin - in Fig. 4.23 - 4.25. Averaged and max local heat fluxes to the TFC are summarized in Table 4.2.

Fig. 4.17. Temperature distribution. *Case #1*

Fig. 4.18. Temperature distribution. *Case #2*

Fig. 4.19. Temperature distribution. *Case #3*

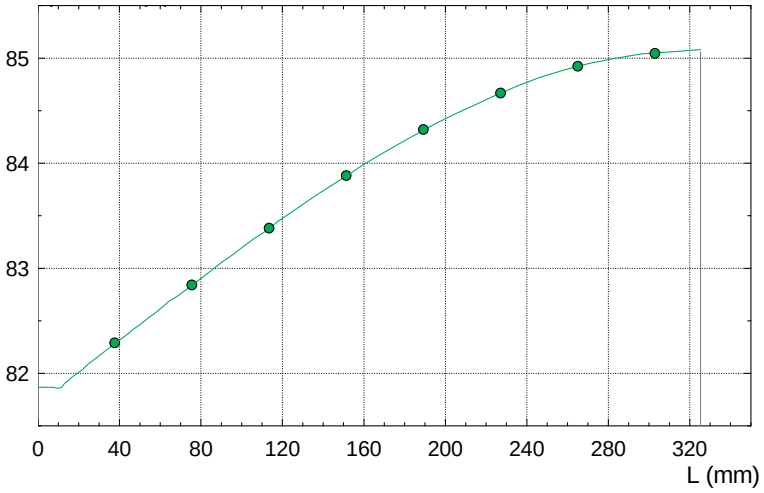

Fig. 4.20. Temperature distribution along thin fin. *Case #1*

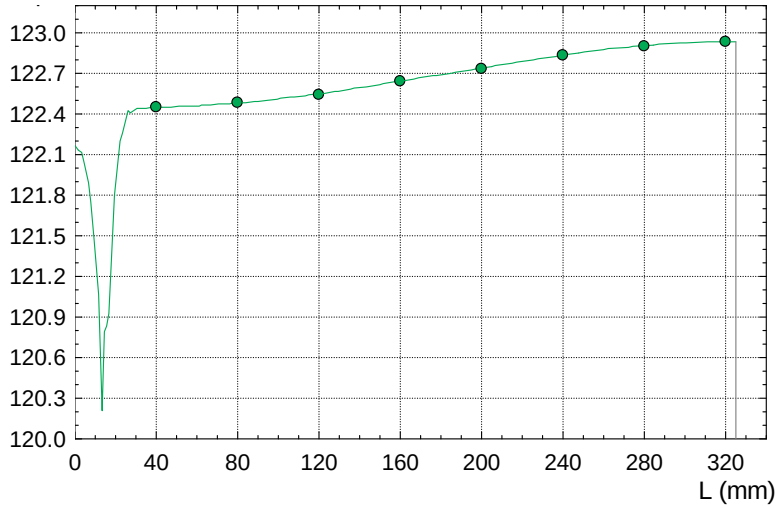

Fig. 4.21. Temperature distribution along thin fin. *Case #2*

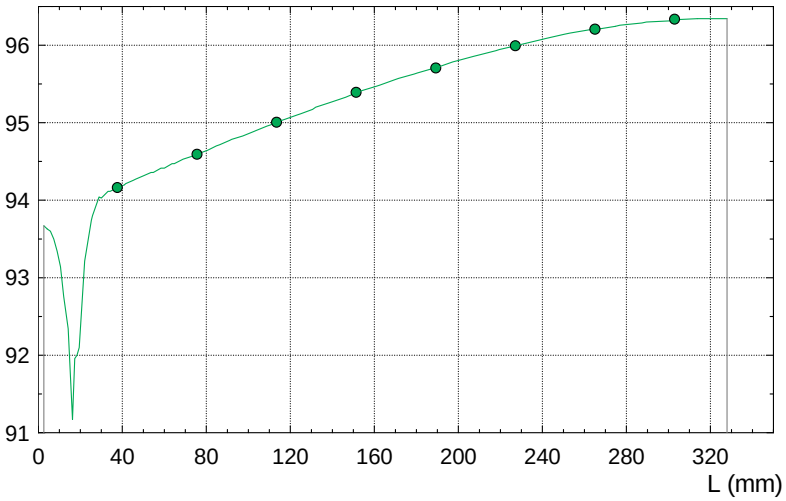

Fig. 4.22. Temperature distribution along thin fin. *Case #3*

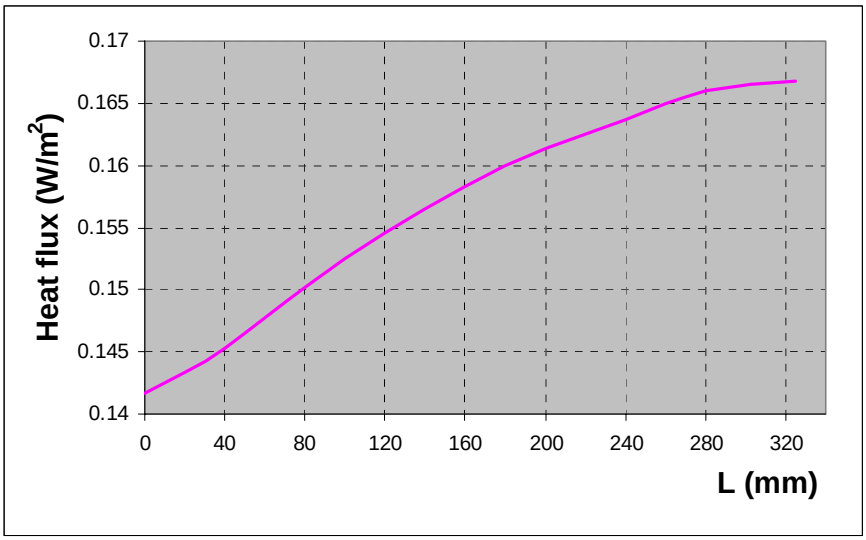

Fig. 4.23. Heat flux to TFC distribution along thin fin. *Case #1*

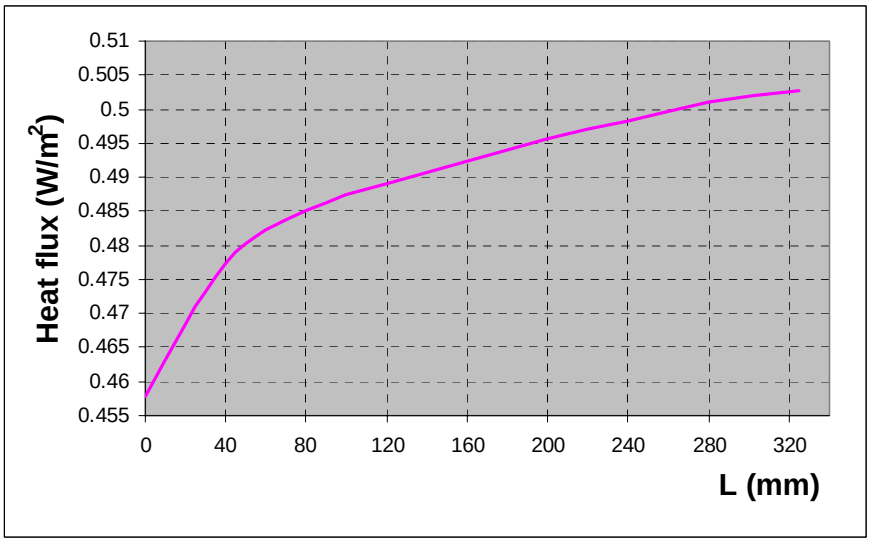

Fig. 4.24. Heat flux to TFC distribution along thin fin. *Case #2*

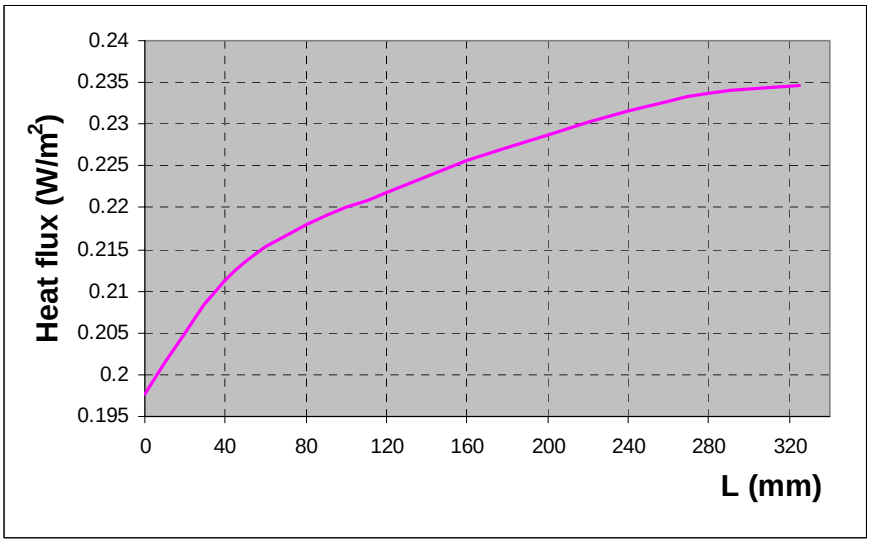

Fig. 4.25. Heat flux to TFC distribution along thin fin. *Case #3*

Table. 4.2

Case	Pipes type	VV temp era-ture	Max temperature	Heat flux		
				Max local	Average	Exceeding the base radiation
		°C	K	W/m^2	W/m^2	
#1	Extruded	200	151	0.17	0.16	1.38
#2	circular with SS brackets	200	169	0.50	0.49	4.22
#3	circular with SS+Cu brackets	200	148	0.23	0.22	1.90

Conclusion

The obtained results allow us to draw the following general conclusion:
The proposed by RF PT team VVTS panel design (with welded extruded pipes) as well as the design with circular pipes attached by 2 mm stainless steel brackets cladded with 0.5 mm copper are characterized by enhanced thermal insulation performance against reference design and could be recommended for the ITER application.