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DESIGN OF THE TWO-LAYER GIRDER FOR ACCELERATING TUBE

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Abstract

Accelerating tube is one kind of important acceleration equipment of linear accelerator. It is often made up of oxygen free copper with long tubular structure. It's easy to suffer from deformation. Based on support requirements, the reasonable structure of the girder was obtained. Four supporting blocks were installed on the top surface of aluminium profile with the uniform distribution along the beam direction. The support strength with static condition and different working conditions were checked by ANSYS simulation calculation to ensure the stable operation of the girder. The two-layer girder can be used as a reference for other similar slender part for its simple structure and reliable support.

INSTRUCTIONS

Accelerating tube is often applied to the linear accelerator to speed up the beam. Based on the functional requirements, it's manufactured as long tubular structure with oxygen free copper. It's easy to suffer from deformation for its special structure and material. So it's necessary to design a two-layer girder for accelerating tube to decrease deformation.

SUPPORTING STRUCTURE

Structural Plan

To meet the functional requirements, the accelerating tube was designed as tubular structure with a length of three meters. Four supporting blocks with the same height were used to support the tube, which were installed on the same foundation. Meanwhile, the located block and sleeve were applied to locate the tube together. A standard pipe was applied to adjust the four blocks in the same line. And two locating pins were applied to ensure the position for the repeated installation. According to the supporting requirements and the disc size, the supporting blocks were set in the middle of the disc with the uniform distribution along the beam. The following figures showed the detailed plan. Figure 1 illustrated the supporting position and Fig. 2 showed the structure of the girder.

Locating Analysis

Flat surfaces and arc curved surface were used to restrain the tube position. The top surface of the located block restrained Z rotation. The front surface of located sleeve restrained Z movement. And the arc curved surface restrained XY movement and rotation. Figure 3 showed the detailed analysis.

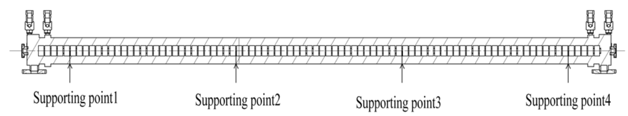

Figure 1: Supporting position.

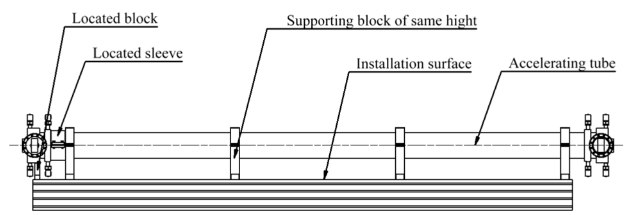

Figure 2: Structure of the girder.

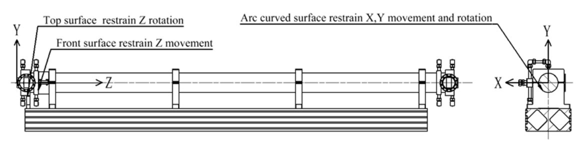

Figure 3: Locating analysis of the girder.

STRENGTH ANALYSIS

Related mechanical parameters were listed as Table 1, which were from www.matweb.com [1].

Table 1: Mechanical Properties Parameters

Material	ρ	E	λ	α	σ_S
Cu	8940	115	0.31	17	195
Al	2830	70.3	0.33	21	296

Note:
Cu-Oxygen free copper Al-Duralumin aluminum alloy
ρ - Density [kg/m^3] E -Modulus of elasticity [MPa]
λ - Poisson ratio α - Line inflation coefficient [μm/m-°C]
σ_S - yield limit [MPa]

Strength Analysis of Supporting Block

Gravity of the tube was loaded on the supporting block surface with the fixed bottom surface. According to the area of supporting surface, the value of the load was calculated and then the final result was achieved accordingly

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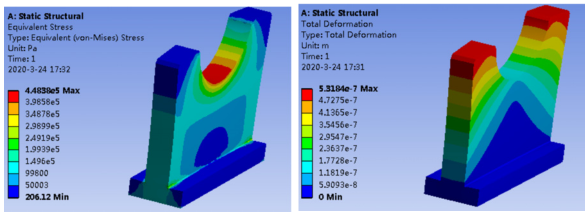
[2, 3]. The maximal stress was 0.45 MPa and the maximal deformation was 5.3*10^-4 mm. The result was acceptable. Figure 4 showed the analytic results.



(a) Stress (b) Deformation

Figure 4: Analytic results of supporting block.

Strength Analysis of Accelerating Tube

The gravity of the tube and the atmospheric pressure outside the tube were loaded with the bottom surface of supporting blocks fixed and the stress and deformation were calculated. The results showed as Figs. 5 and 6. The maximal stress was 4.39 MPa and the maximal deformation was 1.4E-6 mm. Both of the results were acceptable.

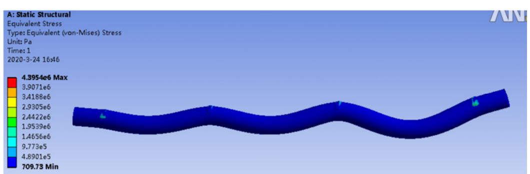


Figure 5: Distribution of stress for the tube.

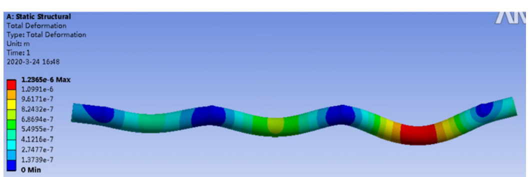


Figure 6: Distribution of deformation for the tube.

Strength Analysis Under Different Temperature

According to evaluation, the normal working temperature of the tube is about 30 °C. But some special cases might happen occasionally. For example, the air-conditioner in the tunnel is broken suddenly in summer or winter. Here assumed the abnormal temperature as 0 °C and 40 °C. The stress of tube was evaluated under the three temperatures.

The bottom surface of the girder was fixed and tube was bundled with the first supporting block. The other three blocks were kept as contact constraint. Meanwhile, the atmospheric pressure, gravity and temperature difference with normal condition were loaded when the strength was calculated. The result showed as Table 2 and Figs. 7 and 8. Here just one case was listed; the other two cases were similar.

According to above analysis, we can conclude that the girder can work normally even under some abnormal conditions.

Table 2: Margin Specifications

T_W	T_E	Δ_T	$\sigma_{\max}$	$\delta_{\max}$
30	0	-30	9.35	1.19
30	25	-5	2.24	0.24
30	40	10	3.91	0.71

Note:
T_W - Working temperature [°C]
T_E - Environmental temperature [°C]
Δ_E - Difference of temperature [°C]
$\sigma_{\max}$ - Maximal stress [MPa]
$\delta_{\max}$ - Maximal deformation [mm]

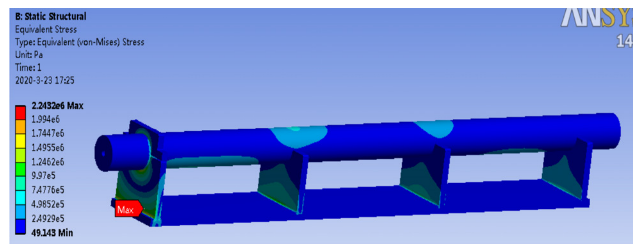


Figure 7: Distribution of stress for the girder (just case 2).

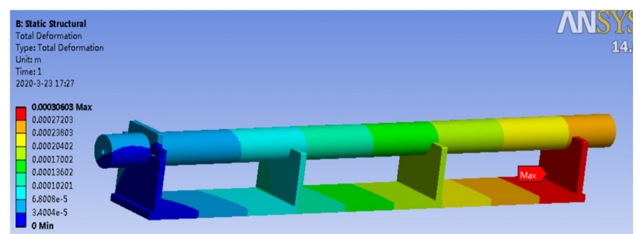


Figure 8: Distribution of deformation for the girder (just case 2).

CONCLUSION

The structure of the two-layer girder was decided based on the accelerating tube structure. The supporting strength and its self-deformation were calculated by ANSYS. The stress and deformation of the tube under different temperature were also evaluated at the same time. The analytic result showed that the strength of the girder is enough. It can still meet working requirement even under some abnormal conditions.

ACKNOWLEDGEMENTS

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