WAVEGUIDE CHANNEL FOR TNK LINEAR ACCELERATOR – INJECTOR

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Abstract

80 MeV linear accelerator is a part of the industrial storage facility at the State Research Institute for Problems in Physics named after F.V. Lukin (Moscow, Zelenograd). 6-meter long accelerating DAW structure operates at 2.8 GHz and is powered by Olivin klystron station. The power is transmitted through the long waveguide channel, which is made of rectangular copper pipes with 90x45 mm cross section and 5 mm walls, with no circulator. The paper deals with the waveguide channel construction features, including indium gaskets to connect individual parts. The waveguide channel length correction procedure for the purpose of overvoltage decreasing during accelerating structure breakdowns is also described.

INTRODUCTION

The waveguide channel connects the RF power source (KIU-53 klystron) with the accelerating structure. The 6-meter long disk-and-washer (DAW) accelerating structure operates at 2.8 GHz. The maximum power level transmitted through the waveguide is 18 MW at pulse duration up to 10 μs with repetition rate up to 5 pps.

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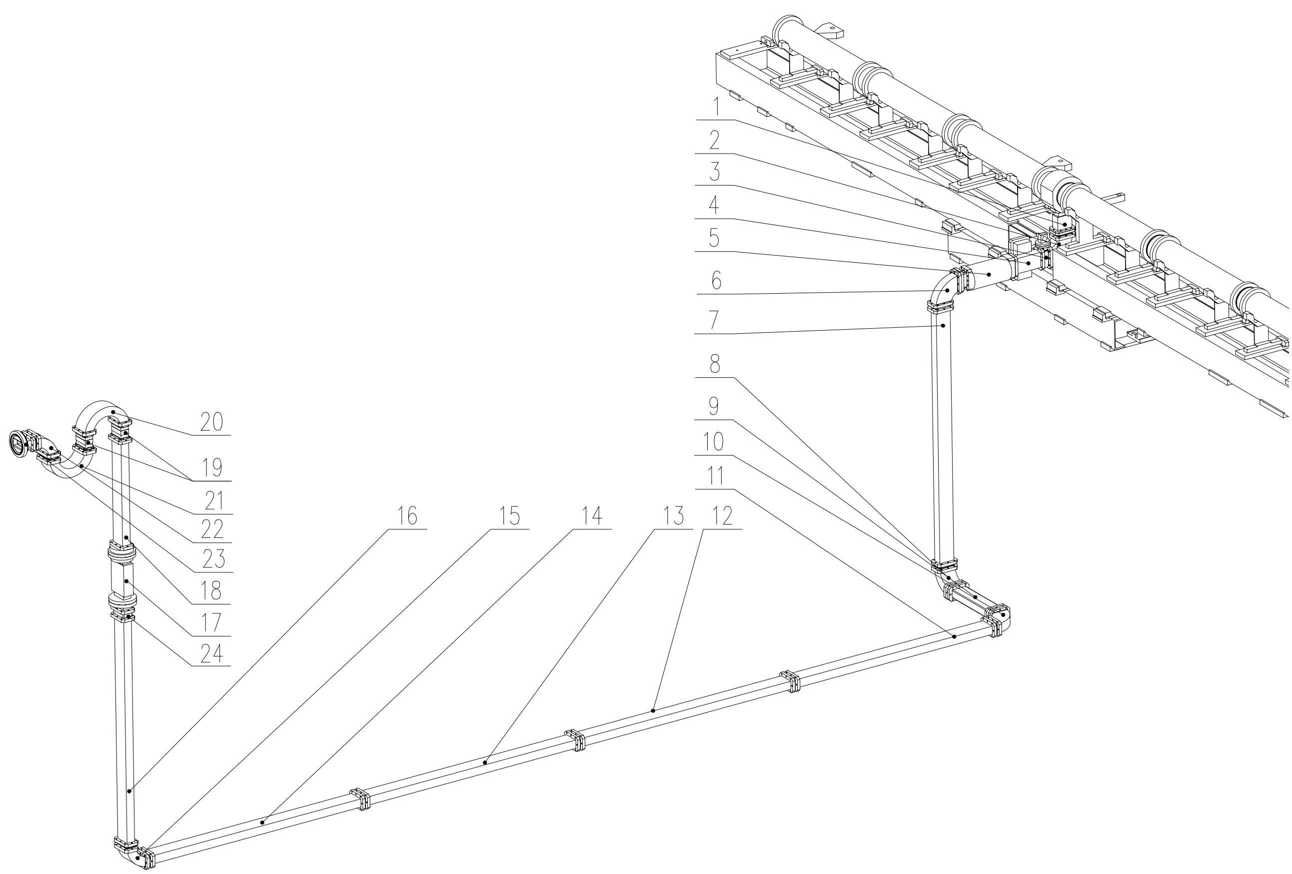

Figure 1: Waveguide channel:
1–reducer; 2–turn; 3–manometer unit, 4–directional coupler, 5–waveguide window; 6–turn; 7–turn; 8–turn; 9–waveguide; 10–turn; 11-waveguide; 12–waveguide; 13–waveguide; 14–waveguide; 15–turn; 16–waveguide; 17–directional coupler; 18–waveguide; 19–spacer; 20–turn; 21–turn; 22–turn; 23–connector assembly; 24–gas unit.

DESIGN

The waveguide channel is shown on the Fig.1. Its length is about 15 m with cross-section of 45x90 mm^2. It consists of a vacuum section connected to the linear accelerator and a gas section connected to the klystron. Separation of these sections is realized by a TWS-type waveguide window, which has been developed by S.Yu. Kazakov [1] and has been produced at INP subdivision in ProtvinoThe waveguide input of the accelerating structure has a conjunctive size for waveguide cross-section of 34x72 mm^2. So, the reducer (1) with the connected turn (2) is used. The manometer unit (3) is used for vacuum measurements. The next is the directional coupler (4) used for incident and reflected wave voltage measurements in the weavegude. The waveguide window (5) ends the vacuum part of the waveguide. Its vacuum pumping is effected from the accelerating structure, connected to it.

The gas section of the waveguide channel contains the directional coupler (17), used for measurements when operating on the equivalent load, as well as the staggered phase shifter, formed by elements (19) and 20). The waveguide channel is connected with the klystron by connecting unit (23). Filling by dry nitrogen is carried out via the gas unit (24). Turns (6, 8, 15 and 22) and waveguides (7, 9, 10, 12, 13, 14, 16 and 18) provide the space configuration of the waveguide channel suitable for the location of the klystron, accelerating structure, and building structures.

Waveguide elements are mainly made of copper.

Seamless copper pipes with inner rectangular cross-section 45×90 mm^2 and outer rectangular cross-section 55×100 mm^2 were used to produce waveguides (7, 9, 10, 12, 13, 14, 16 and 18).

Conjunction of waveguide channel separate parts were performed with indium seals, which provided both conjunction hermiticity and electrical conduction. Variant of flange brazing to waveguides was declined because of waveguide pipe shrinkages during brazing.

Still, brazed flanges have been used in short elements such as turns, directional coupler, reducer, etc. Here, contact-sealing section design has been made similarly to the described below. An example of construction of the the conjunction with throw on flange is shown in Fig. 2.

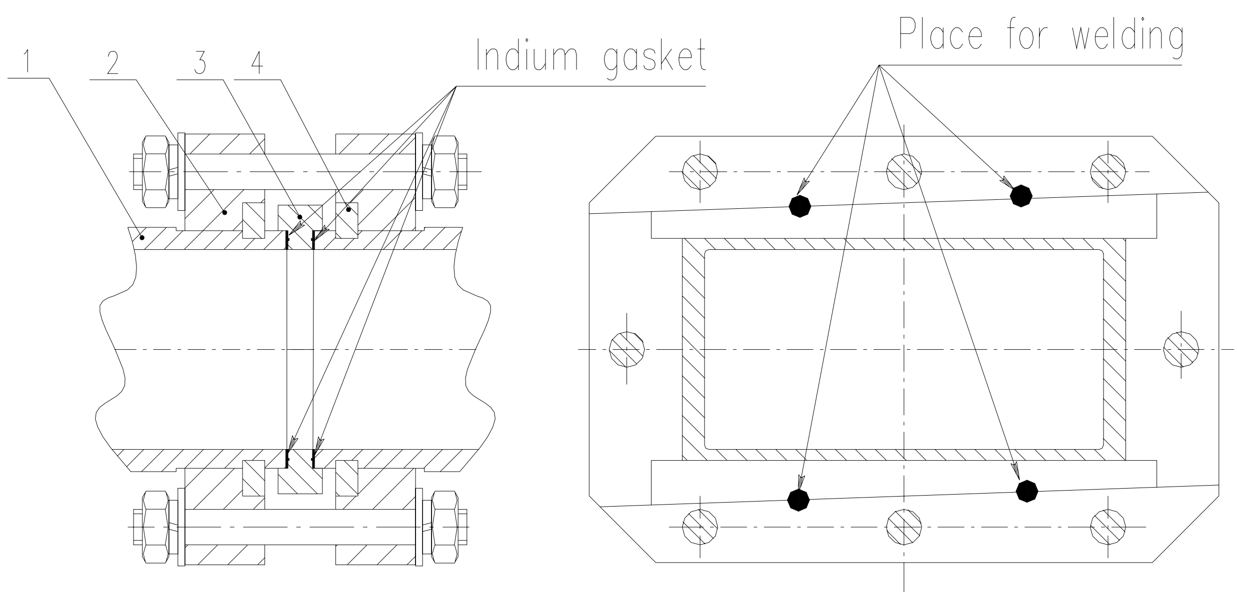

Figure 2: 1 – waveguide, 2 – flange, 3 – frame, 4 – spline.

The waveguide end (1) is handled to the required dimensions, so that the flat surface accuracy at end-walls is not worse than 0.05 mm and surface finish is not worse than Ra 1.6. Two flutes are implemented along the wide sides. The junction assembling is carried out in the following sequence. At first, the flange 2 is installed on the waveguide end 1, then draw keys are installed into the flutes of the waveguide end 1 and flange descent 2. After that, brazing are carried out in four places (see figure) to prevent moving and rotating of these wedge splines. The second waveguide is handled in the same way. The frame 3 serves for mutual fixation of the waveguide ends. The ∅0.7 mm indium wire is fastened on contact surfaces of the frame and is flatten down to 0.1–0.2 mm thickness. The frame is provided by special slots of rectangular shape for wire holding, its contact surfaces have flatness not worse than 0.05 mm and surface finish not worse than Ra 1.6. Then the waveguide to be connected are placed on the adjustable bench (not shown). The frame is inserted between waveguide ends; the construction is constricted with studs. By doing so, the indium wire is finally squashed down to 0.03–0.05 mm thickness and pressurizes the junction providing good electrical conduction. Flanges and splines are made of common carbon steel, and the frame – of stainless steel 12X18H10T.

TUNING

The accelerating structure operates in energy accumulating mode [2], so gently inclined fronts of the RF excitation pulse are allowable. This circumstance enables us to exclude sharp differences at pulse fronts and omit the circulator. Tuning of the waveguide channel length consists in measurement of its eigenfrequencies near the operating frequency in order to detune them, and matching the waveguide length to be divisible by $(2n+1)\lambda_w/8$ to decrease overvoltages. It is realized by changing the electrical length with the set of waveguide spacers of different sizes (pos. 19 on Fig. 1). The measurements were carried out at lowered anode voltage of KIU-53 klystron down to 100 kV, when the klystron output cavity was practically the RF current generator exciting the waveguide. Figure 4 shows the dependence of the incident and reflected wave voltage within a frequency range. The ceramic window disc is placed at distance $L=n\lambda_w/2$ from the accelerating structure input to decrease the overvoltage on the window at accelerating structure discharges. λ_w is the wavelength in the waveguide, n is integer.

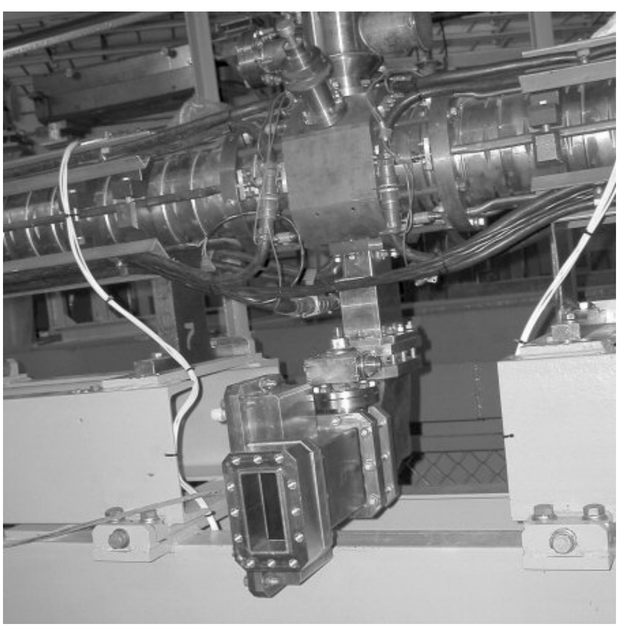

Figure 3: Waveguide fragment.

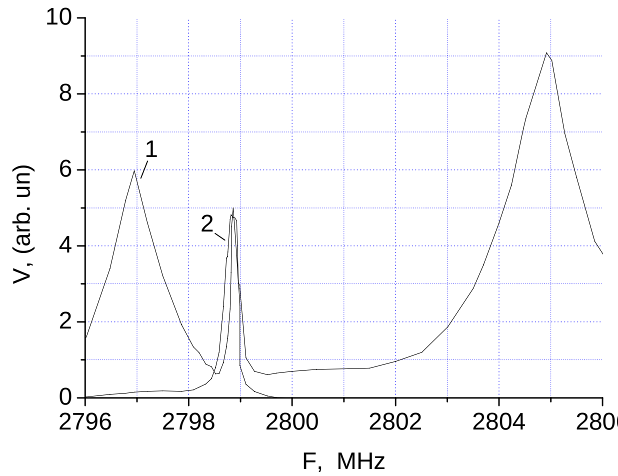

Figure 4: Resonant frequencies of the waveguide (1) and linear accelerator (2).

CONCLUSION

The waveguide channel is easily assembled. Junctions between its elements have no irregularities, providing air-tightness and good electric contact. It proves correctness of choice of indium as a material for contact-sealing gaskets. During balancing and commissioning of the linear accelerator [3], there were no discharges in the waveguide at power level up to 10 MW. Seal failures in the vacuum and gas section also were not observed.

REFERENCES

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[3] V.N. Korchuganov et al., Commission of the Linear Accelerator – this Conference.