D13-2005-190

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SKLUST DEVICE FOR HIGH-PRECISION GLUING OF MWPC

Submitted to «Nuclear Instruments and Methods A»

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Устройство СКЛУСТ для высокоточного склеивания МППК

Описано устройство СКЛУСТ для склеивания высокоточных плоскопараллельных анодных, катодных и разделяющих планок или же цельных рам МППК, а также плоских катодных поверхностей для них при использовании в качестве катода фольгированного стезалита или стеклотекстолита большой площади, например, для CSC-камер. *В отличие от обычного склеивания, в нем совершенно отсутствует прижим склеиваемых заготовок друг к другу.* СКЛУСТ позволяет изготовить точные изделия в лабораторных условиях без предварительной механической обработки его составных частей и получить высокоточное изделие практически любой площади с плоскопараллельностью или плоскостностью от ± 0,030 до ± 0,006 мм при использовании некалиброванного листового стеклотекстолита, стезалита и других гибких материалов с допуском по толщине ± 0,2–0,5 мм или хуже.

На самом большом из существующих устройств можно изготовить изделие размерами 2400×250 мм^2 при плоскопараллельности (6 ± 0,015) мм (максимальное отклонение).

Ввиду того, что в технологическом цикле полностью исключена механическая обработка заготовок по толщине или применение точных заготовок, процесс производства упрощается и существенно удешевляется, особенно при массовом производстве.

Работа выполнена в Лаборатории физики частиц ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна, 2005

Amaglobeli N. S. et al. D13-2005-190
SKLUST Device for High-Precision Gluing of MWPC

The SKLUST device has been created for gluing precision plane-parallel anode, cathode or spacer bars and integral anode and cathode frames of the MWPCs or flat surfaces of the large-area cathode planes for them in the case that thin copper clad stesalit or glass-cloth-base laminate is used as the cathode, for example, for the CSC chambers. *In contrast to usual gluing, in this device the glued components are not pressed to each other.*

SKLUST allows making high-precision products in laboratory conditions without preliminarily machining its components and receiving a precision article practically for any area at the plane parallelism from ± 0.030 up to ± 0.006 mm using a non-calibrated sheet of the foiled (or unfoiled) stesalit, glass-cloth-base laminate or other flexible materials to a tolerance for the thickness ± 0.2–0.5 mm or worse.

On the biggest of the existing devices it is possible to fabricate an article with the maximal sizes 2400×250 mm^2 at the thickness accuracy (6 ± 0.015) mm (maximum deviation).

Whereas in the technological cycle machining of blanks to the thickness or application of exact blanks are completely excluded, the manufacturing process becomes simpler, and the price of the articles essentially reduces, especially for mass production.

The investigation has been performed at the Laboratory of Particle Physics, JINR, and IHEPI TSU, Tbilisi.

Preprint of the Joint Institute for Nuclear Research. Dubna, 2005

INTRODUCTION

It is well known that for effective performance of a variety of multiwire chambers, good agreement of their considered geometrical configuration with the configuration of really manufactured chambers is necessary. Along with uniformity of wire tension and wire pitch, this is one of the main conditions for obtaining uniformity of an electric field from wire to wire, over the whole sensitive volume of the chamber, and, as a consequence, the uniformity of the electrical performances, such as gas amplification and efficiency of each anode wire. To meet this condition, enough expensive high-accuracy-machined anode and cathode printed-circuit boards and spacer bars are usually used, which then stick together under pressure as the anode or cathode planes and spacer bars separating them. If it is required to stick together the surfaces made of several printed-circuit boards, their joining on the frames of the chamber by gluing without formation of steps is enough challenge.

In the article [1] the original way of producing exact wire anode and cathode surfaces, which bypasses this problem, is resulted, but when using the traditional frame construction of chambers and for creating the copper clad glass-cloth-base laminate planes it cannot be used.

The device suggested in this work first of all is intended for manufacturing precision anode or cathode and spacer bars or even integral frames MWPC. It can be also applied to creation of flat cathode surfaces of big area when as the cathode serves copper clad glass-cloth-base laminate or stesalit (including with strips for CSC, for example) planes. Depending on the desired thickness of a product, the device makes it possible to carry out two-layer splice, or in other cases to lay between layers metal, honeycomb or other material as a load-carrying structure or simply filler.

The SKLUST device is very convenient for gluing printed circuit boards with patterns on a basis, in view of difficulty of their exact machining, especially when the working surface is made of several printed-circuit boards (for the anode or the cathode bars) as at usual splice a step is almost always formed on their joints.

The device can also be applied in other cases when precision products of big length or big area are necessary. Since there is no need for preliminary precision machining of the parts of a product, production becomes easier, especially at the mass production, and the cost of a product essentially decreases. It is also important that the accuracy achieved with the device practically does not depend on the sizes of a product.

Thus, the gluing device SKLUST allows creating in laboratory conditions the precision long plane-parallel bars or large-area surfaces from inexact preparations, without their preliminary machining. Having in laboratory this device, it is possible if necessary to make quickly skilled copies of the MWPC's parts of any form and thickness on it. Note that the SKLUST operating experience is more than 15 years.

Here we shall describe a principle of the SKLUST device performance, ways of its practical realization for different variants and then we shall indicate the accuracy of products being of different lengths or areas.

PRINCIPLE OF OPERATION [2]

The SKLUST has one essential difference from usual gluing devices, which use for gluing a pressing of the components of a product to each other. There is no pressing at all of the components glued to each other in it.

In Fig. 1 the general view of the SKLUST and its transverse section are shown. The device for gluing contains the top *1* and the bottom *2* metal plates having ground surfaces, covered with thin through apertures *3* distributed on them

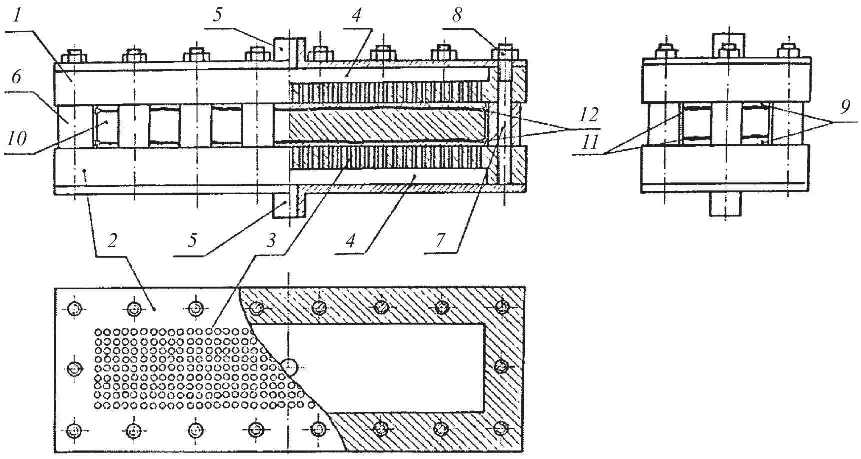


Fig. 1. The general view of the SKLUST device and its transverse section: top (*1*) and bottom (*2*) steel plates; through apertures (*3*); vacuum volumes (*4*); branch pipe (*5*) connecting these volumes with the forevacuum vessel; spacer rings (*6*); stud-bolts (*7*) and nuts (*8*) for clip scorches; flexible external preparations (*9*); load-carrying structure or filler (*10*); layers of glue (*11* and *12*)

in regular intervals. On the other side these apertures lead to hollow cellular volumes of the plates *4*. These volumes, for their part, are connected with the pumped out forevacuum vessel, not shown in the figure. The vacuum through the apertures allows sucking flexible preparations to plates. Between the top and bottom plates along the perimeter there are spacer rings that separate them. Their thickness should be equal to that of a product being glued and they also are made with high accuracy. In the locations of the rings the surfaces of the plates are forced against them by stud-bolts and nuts (through the apertures located at equal distances along the perimeter of the plates). Such a design provides strict parallelism of these surfaces, and, hence, high-accuracy straightening of the working surfaces of the flexible external parts of the product sucked to them. This is exactly what allows manufacturing precision products without preliminary processing of preparations because in this case all the roughnesses of sheet preparations concentrate on their opposite sides.

After laying and joining the preparations on pre-adjusted edges on the top and bottom plates, the vacuum is turned on. The layers pressed to the plates by means of vacuum are then filled in by glue. Further the spacer rings are positioned along the perimeter of the bottom plate, the top plate is stacked on them to press them to each other by the stud-bolts and nuts. The accuracy obtained after the stacking and suctioning to the plates is kept after the glue hardening.

But, as already noted above, in contrast to usual splice, in our case the preparations of the product to be stuck are not pressed at all to each other. *The rings that separate the plates have a thickness equal to the thickness of the future product. And the total thickness of preparations is selected so that it is less than the thickness of the required product.* This condition is rather easy to meet, as its size is not set strictly. (Practically it is approximately about 0.1–0.5 mm.) Outside preparations are pressed to the plates and leveled by the vacuum and, hence, all their roughnesses in thickness will be concentrated inside technological cracks of the future splice and fixed by glue.

Thus the thickness and accuracy of the surfaces of the product obtained is determined completely by the thickness of the spacer rings and the accuracy of processing sucking plates. Besides, the accuracy of the obtained product should apparently depend on the thickness of its external facings as well, but notice that when we used the external layers of a product of thickness in the limits from 0.5 up to 2 mm, this distinction in thickness did not influence the accuracy.

When a basis (load-carrying structure or filler) is used, it is also covered with glue and is stacked between sucked layers. Any material, including metal, a cellular design, for example, the honeycomb, etc., can serve as a basis.

It is necessary to note that when only a unilateral smooth surface is required it is possible to use only one plate with vacuum sucking, having fixed the basis of a product above the preparation straightened on it.

The device is simple enough to manufacture. It contains two plates with well-processed surfaces and spacer rings which define the thickness of a product and demand high accuracy of manufacturing. The products thickness can be changed easily by using the rings of other thickness. In view of absence of preliminary machining of preparations, the manufacturing process becomes easier and much cheaper.

CREATION AND USE OF THE SKLUST

A total of four different configurations of the device with the working area 2400×250, 1500×150, 350×460 and 200×200 mm^2 was manufactured and used in work. Here we shall briefly describe each of them and adduce the results obtained on them.

I. The first SKLUST device has been created for manufacturing two-coordinate MWPC of sensitive area 1500×1000 mm^2. Structurally the chambers consisted of three duralumin frames, with the bars working surfaces 150 mm wide and 15 and 25 mm thick, covered with the anode or cathode printed-circuit boards, see [3]. Accordingly, the plates with vacuum suction cups for them had the working area 1500×150 mm^2. The device represented the metalwork support, on which two actually identical steel plates 25 mm thick separated by the spacer rings, shown in Fig. 2, a, are stacked one above another in working position.

a

b

Fig. 2. SKLUST of sizes 1500×150 mm^2 during splice (a) and after its completion (b)

Each of them, on the sides facing each other, has a smooth ground surface with thin through ($\varnothing$ 3 mm) apertures*. On the opposite side in them there are hollow volumes of cellular structure tightly closed by a steel sheet of 5 mm thickness. Silicon seal was used as condensation.

The internal cellular structure is necessary for elimination of the curvature of the working surface under the action of atmospheric pressure and forms the overall vacuum volume. By means of flexible vacuum hoses and gates these two volumes are connected through a forevacuum vessel to the vacuum system. Manometers carry out the vacuum check over the plates. The suction vacuum

*For connection of the surfaces of the plates with the vacuum volume, instead of through apertures it is possible to use superficial milled cracks on the surface of the plates, terminating in the apertures connected with their hollow part.

system has been made on the basis of a powerful forevacuum pump and a vessel of volume about 1 m^3 with a dust separator for protection of the pump against premature deterioration. But other decisions are also possible.

The bottom plate is motionless and lays on the rack with smooth surface upwards. Along its perimeter the stud-bolts are screwed for installation of spacer rings between two plates during the gluing (see Fig. 2). Under it heaters are brought for its heating in the course of glue hardening. This essentially accelerates the hardening process and improves the gluing quality.

The top plate is mobile. It is possible to have its working surface upwards on a special substrate for stacking, adjustment and sucking to it of the printed-circuit boards. In the working position it is stacked with a smooth surface downwards on the spacer rings located on the stud-bolts along the perimeter of the bottom plate. Along the geometrical axes of both plates at a distance of 256 mm from each other, apertures are adjusted for strict positioning of the printed-circuit boards on the plates by the pins. Two directing cores on the bottom plate and two apertures corresponding to them on top, located on a diagonal of the plates, serve for strict joining of the plates during gluing. By this means the strict relative position of all components of a product with an accuracy of $\leqslant 0.1$ mm is achieved.

The long anode and cathode bars of the chamber consisted of three parts 512 mm long each, and the short ones consisted of two parts of the same length. Preparations of the printed-circuit boards with the patterns, beforehand adjusted in places of their joint, were consistently stacked on both plates with the help of apertures. After their stacking the vacuum was turned on for the blanks sucking. Outflow was supervised by means of a manometer. Usually it was about 1 mmHg.

After that the prepared epoxy resin is uniformly distributed on the opposite sides of the printed-circuit boards, in amounts slightly exceeding the appreciated volume of technological gaps. If the carrying structure or filler is necessary to glue between them, it is also covered by glue and stack on the bottom plate. Then the spacer rings of required thickness are installed along the perimeter of the bottom plate. By imposing the top plate on the bottom one by the directing catchers, the system was assembled and nutted up. Note that the first crackdown up to a maximum is not final. Resistance gluing pressure in the beginning is so great that after a time nuts can be drawn up manually. Full jamming of the rings, or, in other words, the absence of their rotation between the plates, can serve here as the final control.

At heating, the temperature of the plates is brought up to the hardening temperature, recommended by the glue manufacturer (usually about 150°C), and is kept during the glue hardening, also on the recommendation of the manufacturer. As a rule in 2.5–3 hours the process of gluing comes to an end.

The first 12 bars of the MWPC manufactured with this device showed a plane parallelism accuracy of $\pm$ 0.05 mm. It was quite enough at the anode wires step of 4 mm and interelectrode gaps of 6 mm, see [3]. Later on, more careful improvement of the technology of pasting, first of all keeping the plates and glued surfaces clean and keeping the vacuum from leaking, has enabled one to get better accuracy. At good adjustment the vacuum must be better than 1 mmHg. In case of leakage at the joints the blanks are packed by a very thin jet of silicon sealant from a syringe with an outlet $\leqslant$ 0.3 mm. Under the action of pressure this jet is pressed through up to the thickness of the pattern foiled copper of the printed-circuit board and does not worsen the quality of a product. All these measures have allowed realizing plane parallelism along the whole length of all the sides of the chamber $\pm$ 0.030 mm, which practically reflects the accuracy of manufacturing the surfaces of the plates used. Later, such an accuracy was achieved in manufacturing of 12 bars for the chambers of the same type [3], but with the sizes $1000{\times}800$ mm^2 and the anode wires step 2 mm.

II. For big MWPC of the magnetic spectrometer in the NEPTUN experiment at the accelerator UNK being designed in Serpukhov [4], the device SKLUST has been developed for the plane parallel bars of sizes $2400{\times}250$ mm^2. By design it is close to the device described above, but has a higher superficial accuracy of plates ($\pm$ 0.010 mm). Besides, it is supplied with a pair of semiautomatic lifts allowing easy lifting of the heavy top plate and overturn through 180° of the product preparation, see Fig. 3.

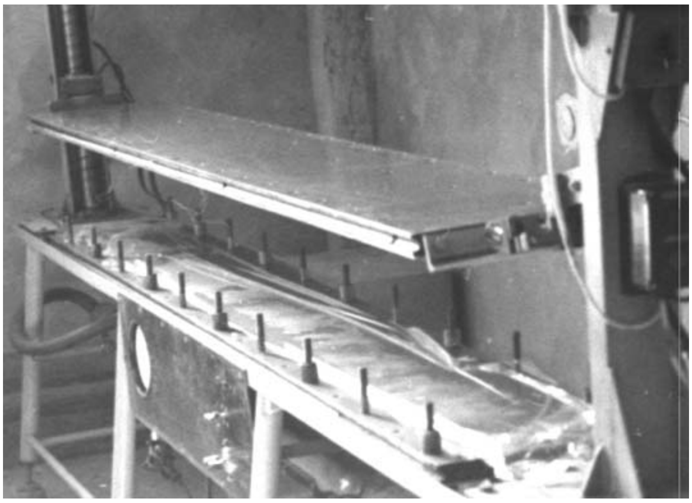


Fig. 3. SKLUST of sizes $2400{\times}250$ mm^2 in the open condition

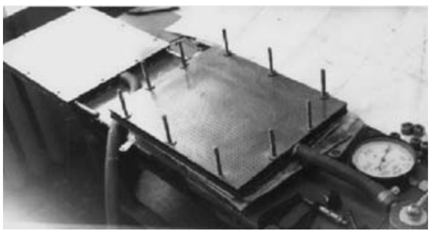
One of several test splices carried out with this device for bars 2400 mm long and 6 mm thick, consisting of several outside sheets, gave the result shown in Table 1. As is apparent from the table, the deviation from plane parallelism exceeds (5.990 $\pm$ 0.015) mm (maximal deviation).

Table 1. Results of the deviation measurements from a planeparallelism for 6 mm thick bar, produced on the SKLUST 2400×250 mm^2

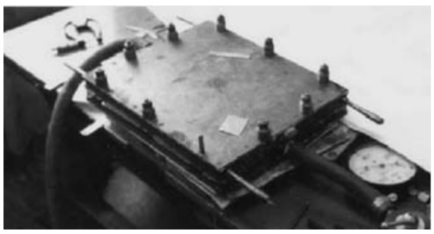
L, cm	δ, μm	L, cm	δ, μm	L, cm	δ, μm	L, cm	δ, μm
0	–30	70	0	140	–9	210	–2
10	–21	80	–2	150	–6	220	–1
20	–15	90	–5	160	–6	230	–4
30	–20	100	–5	170	–16	240	–6
40	–26	110	–5	180	–10		
50	–17	120	–1	190	–5		
60	–9	130	–3	200	–9		

III. The small plates SKLUST of sizes 200×200 mm^2 have also been manufactured for pasting the small MWPC integral frames. For the frames of these chambers two sheets of glass-cloth-base laminate with patterns (for anode and cathode frames) were used. The thickness of these sheets was 1.4 mm and the product 3 mm thick was obtained. The frames were then cut out from them for chambers of external sizes 150×150 mm^2 and sensitive volume 80×100 mm^2. A total more than 30 such frames has been made, with accuracy in plane parallelism (3.0 $\pm$ 0.006) mm (maximal deviation). Note that the obtained here accuracies of products are close to the accuracy of manufacturing of the plates.

IV. And, at last, high accuracy for plane parallelism and flatness has been attained at manufacturing a sector-shaped prototype MWPC with stripped cathodes. This chamber has been made as the prototype for chamber system of a telescope with 2π geometry for an experiment on the diffraction scattering research at the LHC accelerator [5]. For its manufacturing, smooth steel plates SKLUST of sizes 460×350 mm^2 have been used (see Fig. 4). Complex-shaped integral anode and



a



b

Fig. 4. SKLUST of sizes 460×350 mm^2: *a*) in the open condition, *b*) in the gluing process

spacer frames and cathode planes of the same form have been made using this device. For eight frames 2 and 3 mm thick, plane parallelism (2.0 ± 0.020) mm and (3.0 ± 0.020) mm (maximal deviation) has been accomplished. The same accuracy has been obtained for cathode surfaces ± 0.020 mm (maximal deviation from flatness) on the honeycomb basis. A total of six such cathode planes has been made. In Fig. 5 complex-shaped samples of cathode planes and spacer and anode frames are shown.

Fig. 5. Parts of MWPC made on SKLUST of sizes 460×350 mm^2: cathode planes with strips (a, b), the spacer frame (c), the anode frame (d)

Table 2. Results of the deviation measurements from a planeparallelism for sector-shaped 2 mm thick frame, shown in Fig. 5, c, produced on the SKLUST 460×350 mm^2. (Measured by 4 cm step along the perimeter.)

L, cm	δ, μm	L, cm	δ, μm	L, cm	δ, μm	L, cm	δ, μm
0	–6	28	+18	56	+4	84	–6
4	–8	32	+18	60	+2	88	–8
8	+2	36	+18	64	0	92	–10
12	+6	40	+12	68	–2	96	–20
16	+6	44	+8	72	–2	100	–4
20	+8	48	+6	76	+2	0	–8
24	+16	52	+6	80	–2		

In summary we shall note that a device such as SKLUST for gluing has also been used in the St. Petersburg Institute of Nuclear Physics (Gatchina) for an experiment where it has been made as a rectangular frame for pasting integral frames for MWPC.

Table 3. Results of the deviation measurements from a planeparallelism for sector-shaped 3 mm thick frame, shown in Fig. 5, d, produced on the SKLUST 460×350 mm^2. (Measured by 4 cm step along the perimeter.)

L, cm	δ, μm	L, cm	δ, μm	L, cm	δ, μm	L, cm	δ, μm
0	–12	28	+18	56	+16	84	+14
4	–4	32	+18	60	+12	88	+4
8	0	36	+16	64	+18	92	+12
12	0	40	+12	68	+16	96	+4
16	+8	44	+10	72	+12	100	–10
20	+12	48	–4	76	+10	0	–14
24	+16	52	+8	80	+14		

CONCLUSION

Creation and operation of the gluing device SKLUST which allows obtaining to high precision the big-area plane-parallel bars and flatness have been described. It is simple enough in manufacturing and in work and can be used in laboratory conditions for manufacturing several kinds of MWPC. A total of four device modifications with the working areas 2400×250, 1500×150, 360×460 and 200×200 mm^2 has been created. The products made on them have accuracy in plane parallelism or flatness ± 0.015, ± 0.030, ± 0.020 and ± 0.006 mm, respectively.

For the device operation a method of flexible external preparations suction to even surfaces of metal plates by the vacuum is used. But in contrast to usual gluing, in our case the preparations of a product to be stuck are not pressed at all to each other. The rings that separate the plates have a thickness equal to thickness of the future product. And the total thickness of preparations is selected so that it is less than the thickness of the required product. Outside preparations are pressed to the plates and leveled by the vacuum and, hence, all their roughnesses in thickness are concentrated inside technological gaps of the future splice.

The experience gained during the operation of the device shows that the results obtained are not limiting and, if necessary, their improvement is possible. For manufacturing cathode planes from foiled glass-cloth-base laminate or stesalit there is an experience on the area 460×360 mm^2 with accuracy in flatness ± 0.020 mm, see [4]. But, as in case of plane-parallel bars, we do not see an obstacle for manufacturing cathodes of greater area, for example, for chambers with the maximal length of sides 1200 mm or more, with the same or better accuracy.

It will allow one to reduce the interelectrode distance in the chamber, thus reducing the drift time of the change carriers in chamber and also the amount of substance along a beam, which is often required by the experimental conditions.

Acknowledgments. We are grateful to N. M. Agababian, V. A. Gromov, A. I. Ocherashvili and V. A. Voloshin for assistance and effective help in the work.

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Received on December 2, 2005.

Редактор *Е. И. Кравченко*

Подписано в печать 15.02.2006.
Формат 60 × 90/16. Бумага офсетная. Печать офсетная.
Усл. печ. л. 0,93. Уч.-изд. л. 1,35. Тираж 175 экз. Заказ № 55235.

Издательский отдел Объединенного института ядерных исследований
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