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УДК 681.7.023.72

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PROBLEMS OF THE REMOVING MID SPATIAL FREQUENCY FEATURES FOR PRODUCING LARGE OPTICS

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ПРОБЛЕМИ УСУНЕННЯ ПОШКОДЖЕНЬ ПІДПОВЕРХНЕВОГО ШАРУ ПРИ ОБРОБЛЕННІ ВЕЛИКОЇ ОПТИКИ

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ПРОБЛЕМЫ УСТРАНЕНИЯ ПОВРЕЖДЕНИЙ ПОДПОВЕРХОСТНОГО СЛОЯ ПРИ ОБРАБОТКЕ БОЛЬШОЙ ОПТИКИ

This article analyzed the main problems of productions of the large optics. Main part of the time for producing optical lenses take time for removing mid spatial frequency features. Technological process should be improved for increasing effectiveness of the process productions of the lenses.

***Key words:** telescopes, optical lenses, polishing, smoothing mid spatial frequency features, effectiveness, European Extremely Large Telescope, Zeeko, robotic systems, lapping.*

Проаналізовано основні проблеми виготовлення великої оптики. Усунення мікронерівностей підповерхневого шару у процесі виготовлення оптичних лінз займає левову частку часу, спрямованого на виробництво оптичних лінз. Для підвищення ефективності процесу виготовлення лінз технологічний процес має бути вдосконалений.

***Ключові слова:** телескопи, оптичні лінзи, полірування, згладжування мікронерівностей, ефективність, Європейський надзвичайно великий телескоп, Zeeko, роботизовані системи, притирка.*

Проанализировано основные проблемы производства большой оптики. Устранение микронеровностей подповерхостного слоя в процессе изготовления оптических линз занимает львиную долю времени, отведенного на производство оптических линз. Для повышения эффективности процесса изготовления линз технологический процесс должен быть усовершенствован.

***Ключевые слова:** телескопы, оптические линзы, полирование, сглаживание микронеровностей, эффективность, Европейский чрезвычайно большой телескоп, Zeeko, роботизированные системы, притирка.*

Background. The process of manufacturing of the optical lenses is the main stage of creating of new telescope. Extremely Large Telescopes under development by the European Southern Observatory (ESO) will consists of 984 segments, what have hexagonal shape and 1.4 m across [1]. The target competition date is 2018, first light for telescope should be get in early 2020s so required rate is 1 day for 1 mirror [2]. According to using technologic processes was defined a problem of mid spatial frequency features. To remove features using polishing take approximately 3 month – is not acceptable for such project.

Analysis of previous investigations and articles. Previous investigation was provided by Research and Development team of National Facility for Ultra Precision Surfaces Optic. The team works in this area in head of Professor David Walker and Doctor Gouyu Yu. the team work on the project of creating European Extremely Large Telescope in area of production of the mirror segments.

Bold unsolved aspects of the general problem. Project have quite many problems for creating European Extremely Large Telescope. In this article will shown a problem of production optical lenses on time. The main unsolved problem for creating European Extremely Large Telescope on time is removing mid spatial frequency features

Aim of the articles – improve process of the production of the optical lenses for creating the European Extremely Large Telescope and improving of the quality of the finish surface of the mirror segments for the telescope. Solving this problem should increase effectiveness of the production of final product.

The main part. National Facility for Ultra Precision Surfaces for production the Extremely Large Telescopes will have energy beam machines, polishing, grinding and measurement. Traditional Ultra Precision Surface (UPS) process chain of hexagonal mirror will consider in the work shown in figure 1 [2]. But process have big disadvantage RAP Plasma does not work with Zerodur material [3]. So RAP Plasma could be used only with ULE materials. For project of E-ELT was accepted Zerodur as basic material, so was decided that process of manufacturing should be changed. Process of producing was improve by Research and Development team of National Facility for Ultra Precision Surfaces Optic. Process by National Facility for Ultra Precision Surfaces Optic shown in the figure 2.

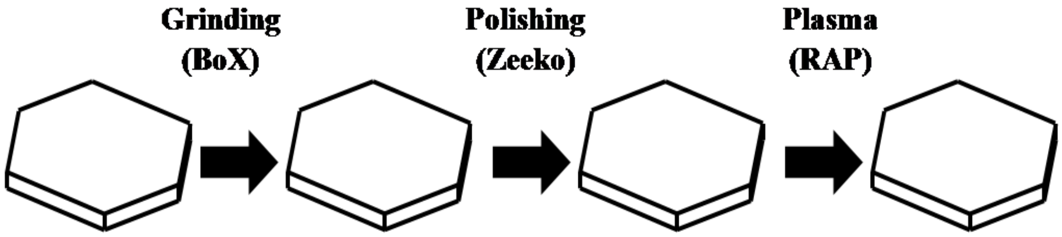

Fig. 1. UPS process chain 2 [2]

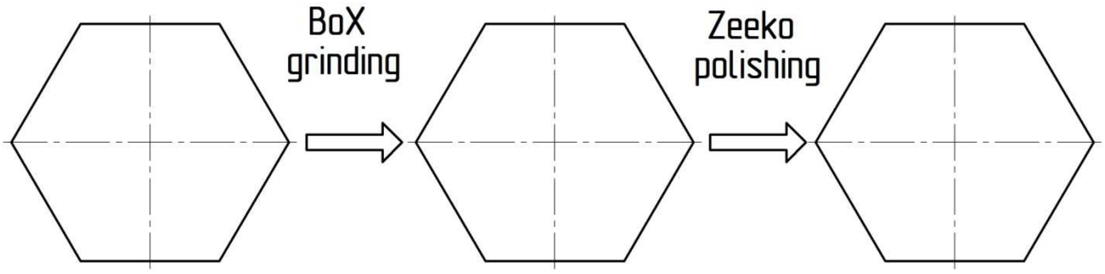

Fig. 2. Process by National Facility for Ultra Precision Surfaces Optic

For grinding process was chose a Cranfield University BoX grinding machine. The BoX grinding machine for manufacturing mirrors for E-ELT base in 2 laboratories:

– Ultra Precession Surface laboratory at Technium OpTIC, North Wales;

– Cranfield University Loxham Hexagon laboratory, England.

In order to achieve low SDD and be able to control it, this machine have high dynamic and static loop stiffness. BoX grinding machine 1,5 m capacity shown in the figure 3 [4].

Typical removal rate for Large Optics generator and Off-axis Grinding machine is 28 mm^3/s, and removal rate for BoX grinding machine is 200 mm^3/s [5]. So BoX grinding machine give us to reduce greatly a time for producing our telescope what is quite important for the project.

For polishing process was chose Zeeko *"Precessions"* process. The *"Precessions"* process was introduced on new Zeeko 7-axis computer numerical control machine, what was produced for special propose. Tool have special form, called "bonnet" – usually cover by one of the flexible non-pitch material. During work such type of membrane have a contact with surface of workpiece everywhere. For this kind of tool such parameters as tool hardness and contact area or polishing spot size, usual from 5 to 15 %, in other words can be varied independently, when varying [6]:

1. Position of the polishing tool in axial direction it define a degree which membrane tight to part.

2. Pressure working air or fluid inside of instrument.

Fig. 3. BoX grinding machine [4]

The bonnet contacts spot very important parameter for quality of finish surface. Different tools position match to different attacks direction. Good results was achieved using processing in four x 90^o steps, shown in the figure 4, the marks in each individual position was smoothed [6].

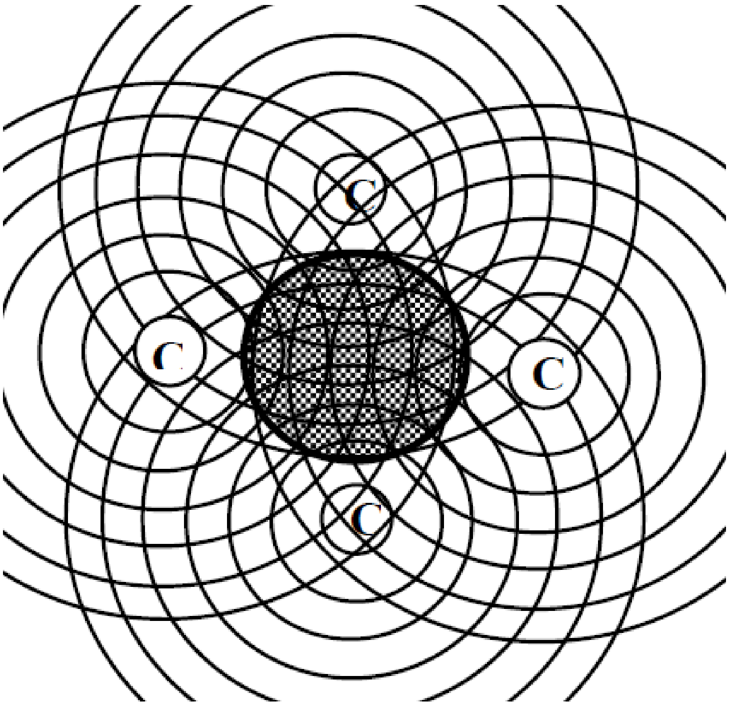

Fig. 4. Speed contours [6]

Zeeko Precessions bonnet polishing with ability to provides capacity and correcting form [7].

Quality surface achieved after grinding Ra = 50-100 nm and Pt = 50-100 μm. For Zerodur subsurface damage approximately 8 μm. Grinding for aspheric glass surfaces use method of grind by edge of the 'cup wheel'. It help to achieve good form with minimal form-errors. Although during grinding by this method contact area is small, so it give mid spatial frequency features [5].

Example surface with mid spatial frequency features show in the figure 5. According to work by Dr Yu and Professor Walker [8] mid spatial frequency in range of 0.5-0.029 / mm after 160 hours of polishing still visible, but if mid spatial frequency in range > 0.1 / mm it could be removed after polishing.

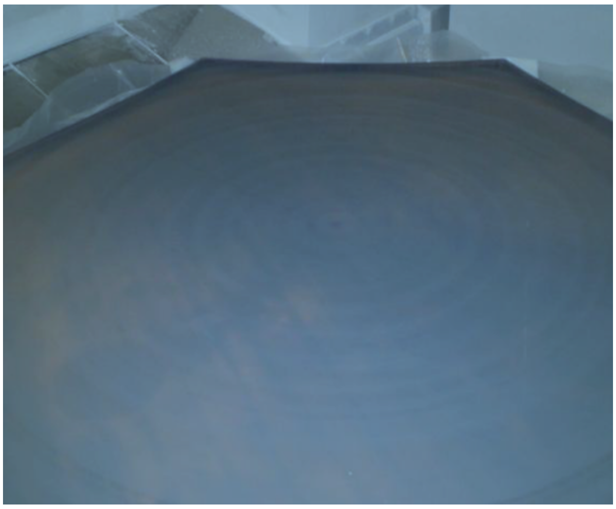

Fig. 5. Mid spatial features after BoX grinding [8]

For remove mid spatial features rigid or semi-rigid nature 'spatial filter' can applied [8]. According their experiments was used grolishing process on Zeeko IRP-1200 machine using tool show in the figure 2.32.

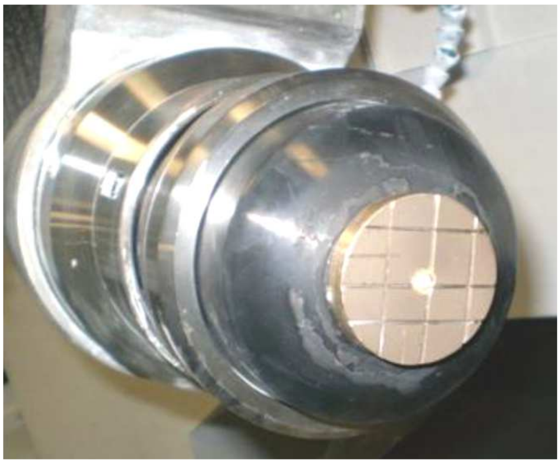

Fig. 6. Brass tool for grolishing [8]

Grolishing process should be applied to remove high-frequency errors (> 1 μm) and should be stands after grinding and before polishing. One of the important parameters is tool diameter. it should be:

– able to cover wavelength range to remove mid-spatial features;

– misfit between aspheric surface of the workpiece and tool not introduce new mid-spatial features.

During process of grolishing uses abrasive slurry C9 (micron aluminium oxide**).** For measuring was used 4D interferometer mounted above machine.

Also high-frequency errors could be avoid with using small bonnet tool. But in this case removal rate is too small [5].

Additional process of smoothing on Zeeko IRP-1200 machine was provided. After smoothing surface was measured by Glyndwr University interferometer. Result shown in the figure 7.

According to smoothing process was achieved surface without visible mid spatial frequency features.

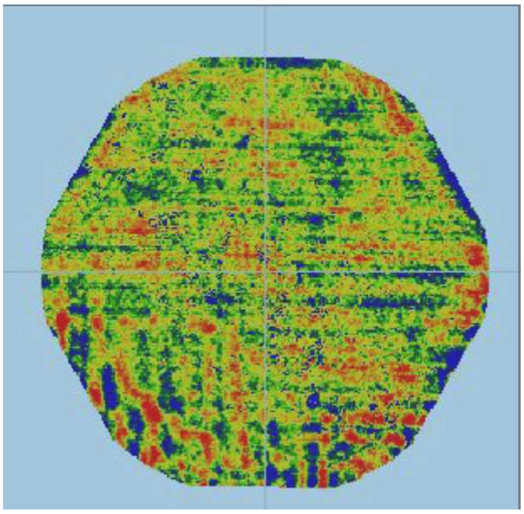

Fig. 7. Results of smoothing

Conclusions and recommendations. According to the analysis and experiments what was provided was achieved next results:

1. Technological process for producing large optics was improved. Process of smoothing was added to the process.

2. Results of smoothing for robotic system was achieved. Mid spatial frequency features was removed.

3. Process of smoothing make able to decrease technological time for machining of optical lenses.

Although this process achieve good results, it is not effectively to use Zeeko IRP-1200 robotic system for this process. The main disadvantages of the process shown below:

– power of machine is much higher than need for smoothing;

– time of machining is not enough high, than could be achieved with using robot arm.

According to the analysis was decide:

1. To solve problem of removing mid spatial frequency features should be added special process of smoothing.

2. Process of smoothing should be done on Robot arm system, so it be lapping process.

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