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APPLIED PHYSICS

DEVELOPMENT OF PLANT FOR COATING AND DRYING OF LINSEED OIL

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The aim of the research is to create a technological scheme for an industrial plant, which uses linseed oil (*Pone oleum*) paint as a finishing material upon working with coniferous wood components of different length and shape. On the basis of the technological scheme developed in the research, the prototype of the equipment will be produced at the factory of EKJU Ltd., with drying of products also being included.

Keywords**:** *linseed oil, plant, prototype, wood*

1. INTRODUCTION

Due to a lack of industrial and commercial demand, one cannot purchase a ready-made linseed oil coating plant. Trends of ecological construction and increased consumption of paint of biological origin have brought this issue onto agenda and created a need for industrial equipment [1]. Moreover, various paints based on solvent have a negative impact on the surrounding environment that has contributed to regulatory efforts to limit the use of solvent in the future [2].

2. PROBLEM

Operations with linseed oil are considered craftwork, while in volumes the application of it could be done automatically. As mentioned earlier, due to relatively low demand there is no such plant, as well as various risk factors are existent. Caused by oxidation processes, rags smeared with linseed oil can heat and ignite. When self-ignition temperature is reached, the substance ignites in the presence of oxygen. Any oil in contact with clean oxygen may ignite or explode. When working with linseed oil, safety rules must be followed, and it is known that linseed oil, unlike water or solvent base, is warming-up during the drying process. Due to a chemical process, it is prone to oxidation. This process can affect highly flammable products, such as paper, chips, but the flames cannot been observed immediately. The process takes time: the more the flammable material will have absorbed linseed oil, the sooner the flame may appear. However, the filter design of the plant may accumulate tiny particles of linseed oil, which through oxidation processes and in contact with dust may cause heating and self-igniting [3].

3. OBJECTIVE

The aim of the study has been to develop a technological scheme for a linseed oil (*Pone oleum*) application that could be used in industrial production as a finishing material for works with components of different length and shape and would dry them. The physicochemical properties of linseed oil are known, but deepened product research must be carried out, and subsequent technological solutions are necessary to make an industrially scalable linseed oil application plant that meets the needs of production. It is necessary to consider technological processes and conditions for development of a prototype of an experimental linseed oil application plant. The equipment must also be able to operate various units so that each of the units performs the task assigned to it. The possible prototype is displayed in Fig. 1 and marked with numbers: 1 – automatic loading with storage, 2 – exhaust and draining of chips and their dust, and various debris, 3 – heating of the surface of the component prior to dyeing, 4 – heating, re-circulation, and filtering of linseed oil; to achieve a high-quality coating, alignment of the material is performed during the application of linseed oil; removal of excess paint for re-use, 5 – discharge of preforms shall be performed after application of the paint. A cycle of re-application of linseed oil for the second or third rounds (layers) may be possible.

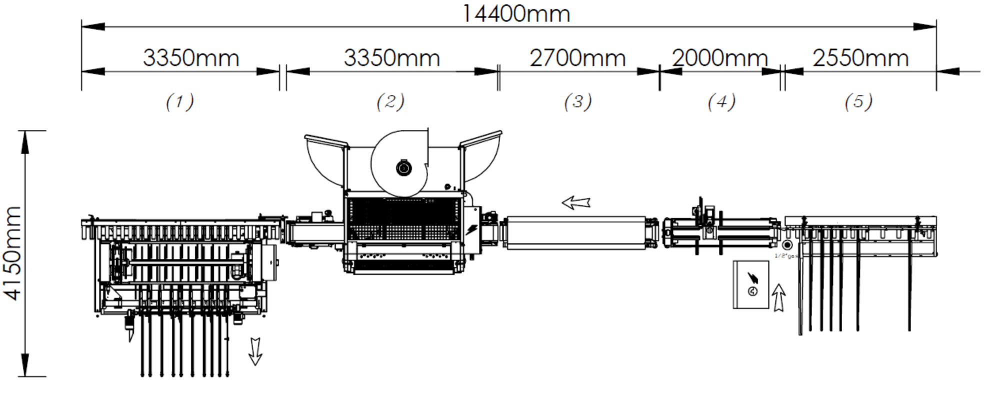

Fig. 1. Plant prototype.

4. DRYING PROCESS

In a natural environment, the process of drying of linseed oil may take up to several days until it is dry enough to stay intact upon direct contact with other surfaces, but the process of drying is continuing, and gradual hardening takes place [4]. EKJU ltd. conducted an accelerating experiment to speed up drying of linseed oil in order to be able to find a solution of what parameters must be present to accelerate the drying process to the utmost extent without losing the linseed properties simultaneously.

In an experiment, which tested the effects of temperature on paint drying, parameters characterising the process typically – adhesion and soakiness – were assessed. Planed pine (*pinus*) samples with a humidity of wood of 18 % (85x250 mm) were treated at a temperature of 25 °C or 40 °C after coating and the degree of drying was checked after certain periods of time. The paint-coated surfaces were no longer sticky after a 20-minute drying, but the spirit stain-coated surfaces reached such a state one hour later. When comparing the coatings to each other, the samples dried under a temperature of 40 °C were no longer soaked after 2 hours, while those of spirit stain reached this condition after 24 hours. It took more than 24 hours to reach a condition where both painted and spirit stain-coated surfaces were no longer soaked. These results show that increased temperatures affect drying of the first layer. The effect of temperature on the second layer, regardless of the temperature after 24 hours, resulted as follows: although the coating no longer soaked, it dipped by squeezing. In the case of use of paint and spirit-stain, drying at high temperatures is not effective enough to ensure rapid drying of the second layer.

An ultraviolet (UV) radiation experiment was conducted for acceleration of drying to test the effects of UV radiation on drying of coating. A UV-blacklight lamp with a capacity of 13W was used, radiation was 315 to 400 nm in the area, and radiation intensity on the surface of samples was 700μW/cm^2. Samples were irradiated for 4 hours, but none of the coatings were dried completely during that time. The stage of drying was tested by rubbing the surface with a cotton slab and by visual assessment of the presence or absence of coating pigments on the slab.

According to the data obtained in the study, it is possible to evaluate the provision of an artificial drying process in the plant unit.

5. HEATING OF LINSEED OIL

A similar experiment was conducted with heating of linseed oil. Three coatings were used in the study: black linseed oil colour, white linseed spirit stain, and grey linseed water emulsion. The viscosity for all coatings was determined at three temperatures: 25 °C, 35 °C, 45 °C, ensuring a stable (± 0.5 °C) solution temperature throughout the effluence period. The coating densities and effluence periods with viscosity-determination are given in Table 1.

Of the coatings studied, the lowest temperature impact on viscosity is for emulsions which, when the temperature is increased by 20 °C, will reduce the effluence period by 24 % while the paint and spirit stain have a reduction of 33 % to 34 %. After the coating was dried, samples were sawn, and microscopy samples were prepared for each sample taken from at least 10 points. The results of microscopy show that although viscosity of the emulsion at 40 °C is lower, it does not significantly affect depth of its penetration in the wood by spraying the coating and, in both temperatures, penetration is no more than 2–3 cell layers on average.

Table 1

Densities and Effluence with Viscosity-Determination, Depending on Temperature
** diameter of viscosimeter aperture – 4 mm; ** diameter of viscosimeter aperture – 2 mm*

	Paint*	Spirit stain*	Emulsion**
Viscosity			
Temperature, °C	Effluence period, s		
25	187	45	217
35	149	36	190
45	124	30	166
Density, g/cm^3			
	1.30	1.11	0.98

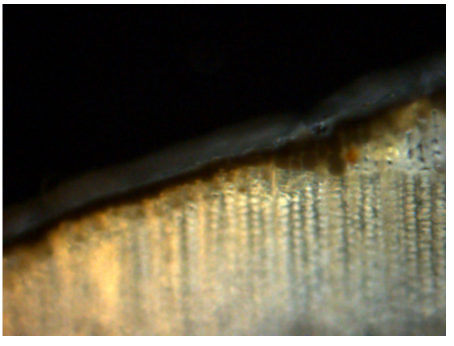

Fig.2. Microscopy image of the cross-section of sample sprayed with linseed oil at 30 °C (100 x magnification).

6. TECHNICAL SOLUTION TO THE PLANT

The plant feed speed shall be set from 15 m/min to 30 m/min. The preforms for painting will be loaded automatically from the stocking table with a minimum of 15 components, and the components will be wiped, and chips and dust of chips will be sucked out. Preforms shall be pre-heated from 35 °C to 40 °C before the finishing material is released. This finishing material will be applied to components at a temperature of 35 °C to 45 °C, maintaining a withheld viscosity. The application of the finishing material is designed from 3 to 5 sides, the layer being of thickness of 40 g/m^2. The extra linseed oil will be removed from the conveyor belt mechanically with a scraper and used for re-application to subsequent parts, the paint will be filtered. The application zone requires additional attention, taking into account the various risk factors for oxidation of linseed oil and requiring ventilation with an air exchange of 10,000 m^3/h with a changeable filter. A storage unit of freshly painted preforms is designed for drying of preforms within a period of 40 to 60 minutes, followed by brushing/sweeping of preforms with specially selected brushes. This unit is intended to be individually connected and detachable from the total equipment, so that the components can, if necessary, be directed to drying without brushing/sweeping, bringing the components to the discharge unit. The drying unit is not incorporated into the plant directly, but for the purpose of the overall technological process, the coated parts will be delivered to a specially equipped drying room (chamber) with the possibility to transfer the dried parts to the re-application cycle of the finishing material in the dyeing plant or delivered to the re-brushing/sweeping in the plant assembly.

The plant will ensure that the following settings are met: no more than 5 to 10 litres of paint are needed to replace the colour tone during the washing of the plant by the end of the finishing process or shift. The control panel of the plant will be placed in a free-standing cabinet, and it will include all switches, safety systems and indicating lamps. The control cabinet will be equipped with ventilation and full dust protection, and the plant will be equipped with perimeter protection.

7. CONCLUSION

The technical solution provided for the plant does not cover drying unit, as the drying process has not been accelerated in an artificial manner during the experiment significantly, or it has not been effective to a large extent. This is the reason why a separate room (drying chamber) may be offered to store the components coated with the finishing material in order to ensure that drying is provided under controlled conditions and is slightly accelerated.

An in-depth study of the amount of finishing material is needed to mitigate the loss of linseed oil by wiping. A more accurate amount of linseed oil needed for paint and spirit stain to avoid wiping can be calculated.

A few unique solutions have been presented to the plant, mainly in terms of safety, as attention should be paid to oxidation processes of linseed oil, which may cause its self-ignition. Solutions have been found to improve the quality of work and the previously manual application of linseed oil could be automated.

Particular emphasis must be paid to cleaning of the plant because under no circumstances linseed particles can be accumulated in the units (nodes) of the plant and its ventilation system. The plant and its ventilation system will be equipped with special smoke and heat detectors which, if needed, will send an emergency signal to the console of the plant and stop the equipment, as well as the emergency signal will be sent to the plant fire control centre and will trigger the alarm to eliminate emergency conditions. Location of the painting equipment shall be determined in a separate building to mitigate risks of fire and prevent threats other nearby buildings could be potentially exposed to.

ACKNOWLEDGMENTS

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LINEĻĻAS KRĀSAS UZKLĀŠANAS UN ŽĀVĒŠANAS IEKĀRTAS TEHNOLOĢISKO SHĒMU UN RASĒJUMU SAGATAVOŠANA

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Kopsavilkums

Šī darba mērķis bija pētniecības projekta Nr.1.2.1.1/16/A/009 ietvaros radīt tādas rūpnieciski izmantojamas iekārtas tehnoloģisko shēmu, kura kā apdares materiālu izmanto lineļļas (*Pone oleum*) krāsu vai beici, darbā ar dažādām garuma un formas koka detaļām, ietverot produktu nožāvēšanu. Ir zināmas lineļļas fizikāli ķīmiskās īpašības, bet, lai izgatavotu ražošanas vajadzībām atbilstošu rūpnieciski mērogojamu lineļļas uzklāšanas iekārtu, bija nepieciešama padziļināta produktu un procesu izpēte un tai sekojošu tehnoloģisko risinājumu izstrāde. Pēc padziļinātas lineļļas krāsas un beices īpašību izpētes tika radīta iespējamā prototipa skice.

Izskatot tirgū pieejamo krāsu uzklāšanas iekārtu piedāvājumu, tika secināts, ka gatavu lineļļas krāsas uzklāšanas iekārtu nav iespējams iegādāties, sekojošu iemeslu dēļ:

1. Šādai iekārtai nav rūpnieciska un komerciāla pieprasījuma;
2. Pastāv dažādi riska faktori, piemēram, ar lineļļu sasmērētas lupatas oksidējoties, var sakarst un aizdegties. Kad sasniegta pašaizdegšanās temperatūra, viela skābekļa klātbūtnē uzliesmo. Jebkura eļļa, kontaktējoties ar tīru skābekli, var aizdegties vai uzsprāgt. Strādājot ar lineļļu, jāievēro drošības noteikumi, ir zināms, ka lineļļa žūšanas procesā uzsilst, atšķirībā no ūdens vai šķīdinātāja bāzes krāsas. Tā vietā ķīmiska procesa dēļ tā ir pakļauta oksidācijai.

Izstrādājot lineļļas iekārtas uzklāšanas mezglu tehnisko risinājumu, tika ņemti vērā lineļļas uzklāšanas eksperimenti uzsildot krāsu un beici, lai iegūtu labāko viskozitāti. Mikroskopijas rezultāti parādīja, ka, lai arī emulsijas viskozitāte pie 40°C ir zemāka nekā pie 25°C, tas būtiski neietekmē tās iespiešanās dziļumu koksnē, pārklājumu uzklājot ar uzsmidzināšanas paņēmienu, un abu temperatūru gadījumā iespiešanās vidēji nav dziļāka par 2 – 3 šūnu slāņiem.

Saskaņā ar projekta rūpnieciskā pētījuma dotajām vērtībām tika atrasts ražotājam piemērotākais tehniskais risinājums iekārtas tehnoloģisko shēmu rasējuma izstrādei, kurā tika iestrādātas tādas iespējas kā krāsojamo sagatavju automātiska ielāde un izlāde no uzkrājuma galda, pirms uzklāšanas sagatavju virsmu uzsilde no 35 līdz 40°C. Apdares materiāla uzklāšanas veids paredzēts no 3-5 pusēm, plānā kārtā 40gr/m^2.

Pētniecības projekta ietvaros tika veikti arī paraugu žāvēšanas eksperimenti, lai izpētītu, pie kādiem parametriem lineļļa visātrāk nožūst, nezaudējot savas īpašības, kas ir ļoti būtiski produktu ražotājam. Žāvēšanas paātrināšanai tika veikts eksperiments arī ar ultravioleto starojumu (UV), lai pārbaudītu UV starojuma ietekmi uz pārklājuma žūšanu

Žāvēšanas mezgls netiek tieši iekļauts iekārtā, taču, kopējā tehnoloģiskā procesa nodrošināšanai, pārklātās detaļas tiks nogādātas speciāli aprīkotā žāvēšanas telpā (kamerā) ar iespēju nožuvušās detaļas pārvietot uz atkārtotu apdares materiāla uzklāšanas ciklu krāsošanas iekārtā vai nogādātas uz atkārtotu nobirstēšanu/noslaucīšanu iekārtas mezglā. Vadības skapis tiks aprīkots ar ventilāciju un pilnīgu putekļu aizsardzību, kā arī iekārtai tiks uzstādīta perimetra aizsardzība.

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