UTILIZATION OF DROP TEST TO DESCRIBE VISCOELASTIC BEHAVIOR OF LUBRICANT

Jiří SOBOTKA, Pavel SOLFRONK, Michaela KOLNEROVÁ, Lukáš ZUZÁNEK

Technical University of Liberec, Liberec, Czech Republic, EU, jiri.sobotka@tul.cz

Abstract

Problems of different lubricant types and their properties represent the very important parameter to successful manage production in automotive industry. Such reality is mainly important at production within press-shop itself as one part from the production chain. Lubricant itself here influences almost all aspects of stamping production. Its influence in mainly important for tribological system material - tool - machine, but it also contains tribological aspect or e.g. problem with zinc layer coating. There are many of different technical parameters of lubricants (temperature parameters, types of lubricants,…) and there are also many tests for determination suitability of relevant lubricant fro given material (mostly tribological tests). Nevertheless there are also other tests of lubricants and one of them is so-called drop test. Such test can be shortly described as testing of drop creation (and its falling down) at vertical position of sample in closed chamber during given time. However, such test can be also used for determination "topography" of sample. This can be carry out by measurement amount of lubricant in given points, 3D evaluation of these values and creation the certain topographic map describing amount of lubricant distribution on sample after drop test. From these 3D graphs can be observe e.g. "drop" tendency of tested lubricant at given conditions (mainly time and temperature), shape of these waves just before the loser edge namely also in the cases where was not observe fall of drop and also e.g. change in amount of lubricant distribution from the initial condition (mostly 3 g·m^{-2}).

Keywords: Drop test, Tribology, Lubricant, Topography, 3D Graphs

1. INTRODUCTION

One of the basic factors arising from cooperation between universities (labs) and industry is utilization of the common tests and their modifications for better and simpler industrial utilization for such data or e.g. graphical illustration of any results. This paper deals with such factor since it takes one of the most common test to characterize lubricant behavior (so-called drop test) and via modification and new graphical approach to such test tries to give better and much more user-friendly results in the form of 3D surface maps (graphs). The next chapter is describing such effort and showing the most important graphical processing of data.

2. EXPERIMENTAL PART AND CREATION OF 3D SURFACE MAPS (GRAPHS)

Drop test as it is used all over the world rests in holding the specimen (mostly sheet with required dimensions 300x300 mm) in the vertical position for required time (mostly 24 hours) and at required temperature (mostly 35°C). On the surface of such specimen is applied lubricant at required amount (mostly 3 g·m^{-2}) [1, 2]. The aim of such test is just to determinate whether there is a drop under the specimen or not after required time. Such specimen (sheet 300x300 mm) and parameters were also used in the experimental part of this paper but moreover after required time of test as a result there was not taken only drop. As a result of this paper was attempt to graphically characterize amount of lubricant all over the specimen surface and based on these results (3D surface graphs) to describe behavior of lubricant thus receive fast, simple and well-arrange graphical description of lubricant distribution on the specimen surface. And just by using these graphs one is able to characterize lubricant behavior or e.g. to compare such behavior among different lubricants. Such procedure is described on the following pages.

The tested specimen is taken in the vertical position (see **Fig. 1**) for required time (normally about 240 hrs).

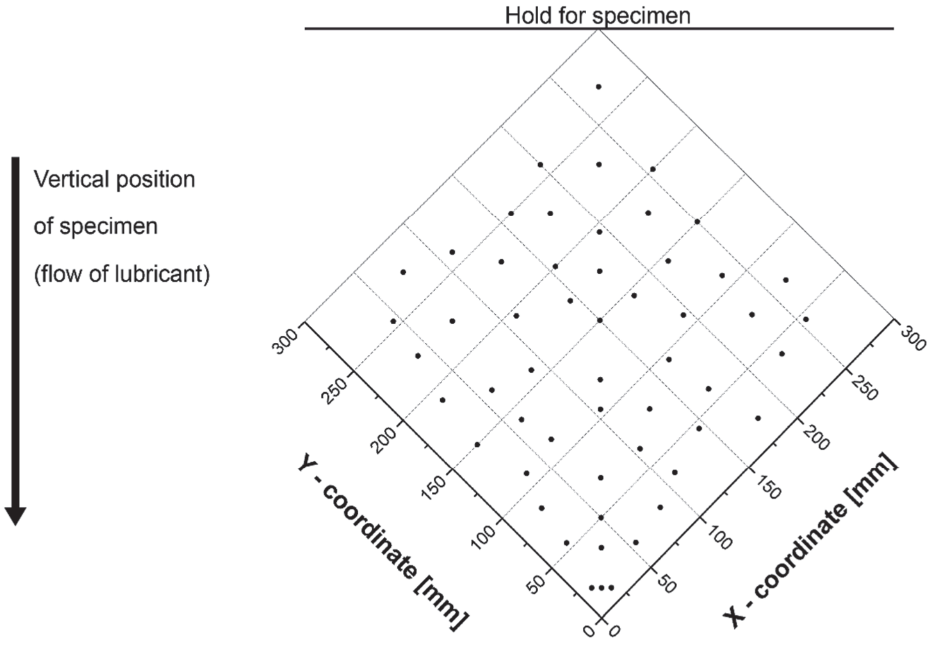

Fig. 1 Schematic of the specimen position at drop test and XY coordinates of chosen points

As was already written, the drop test doesn't need to have as a result only if there is a drop of lubricant but on the testing specimen can be applied points with predefined coordinates (see **Fig. 1** and **Fig. 2**) and after test is possible to measure amount of lubricant in these points to characterize lubricant behavior.

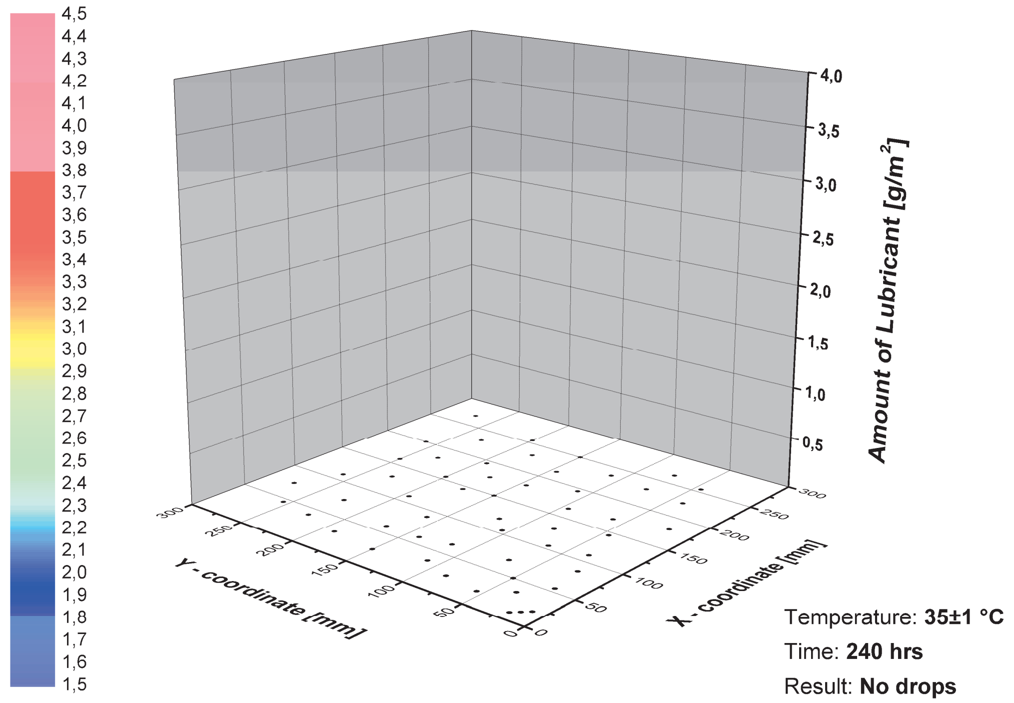

Fig. 2 Graph for 3D surface maps with XY coordinates of chosen points

In the **Fig. 3** are added Z-coordinates (amount of lubricant) to relevant X-Y coordinates (flat at the bottom).

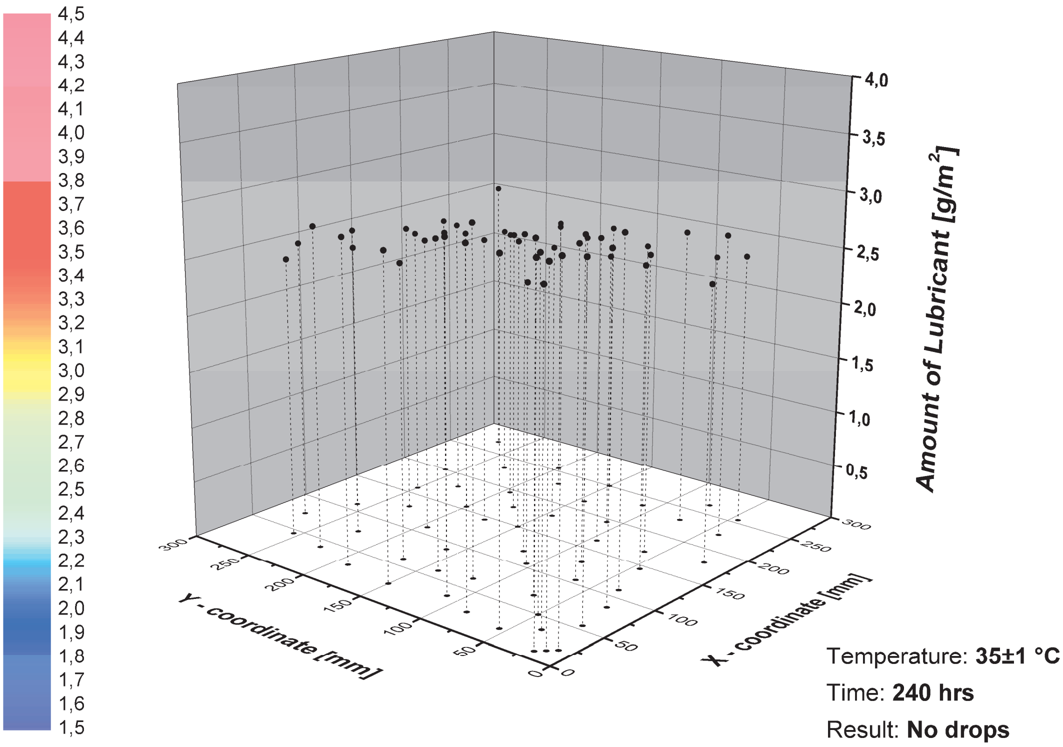

Fig. 3 Z-values (amount of lubricant) for relevant XY coordinates

The next step is the crucial one because from common 3D scatter is made required 3D surface map. That is done by converting data into matrix (via XYZ gridding) and as gridding method thin plate spline with zero extrapolation was used. The result (3D surface map - mesh) is shown in the **Fig. 4**.

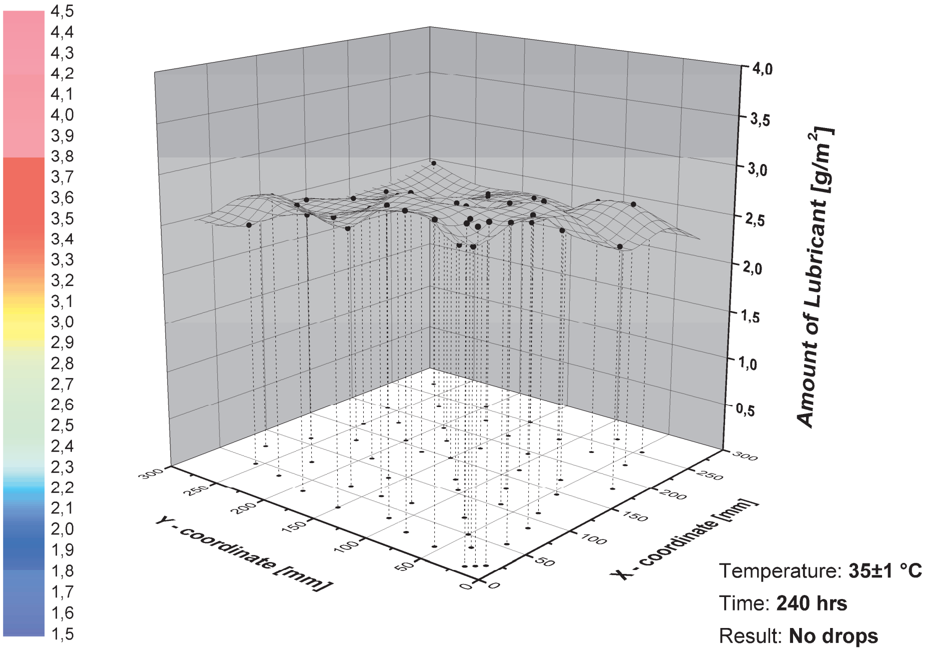

Fig. 4 Application of 3D surface map (mesh) via XYZ gridding method (thin plate spline)

Next step is to add color-map (as rainbow palette) and contours within the required range - see **Fig. 5**.

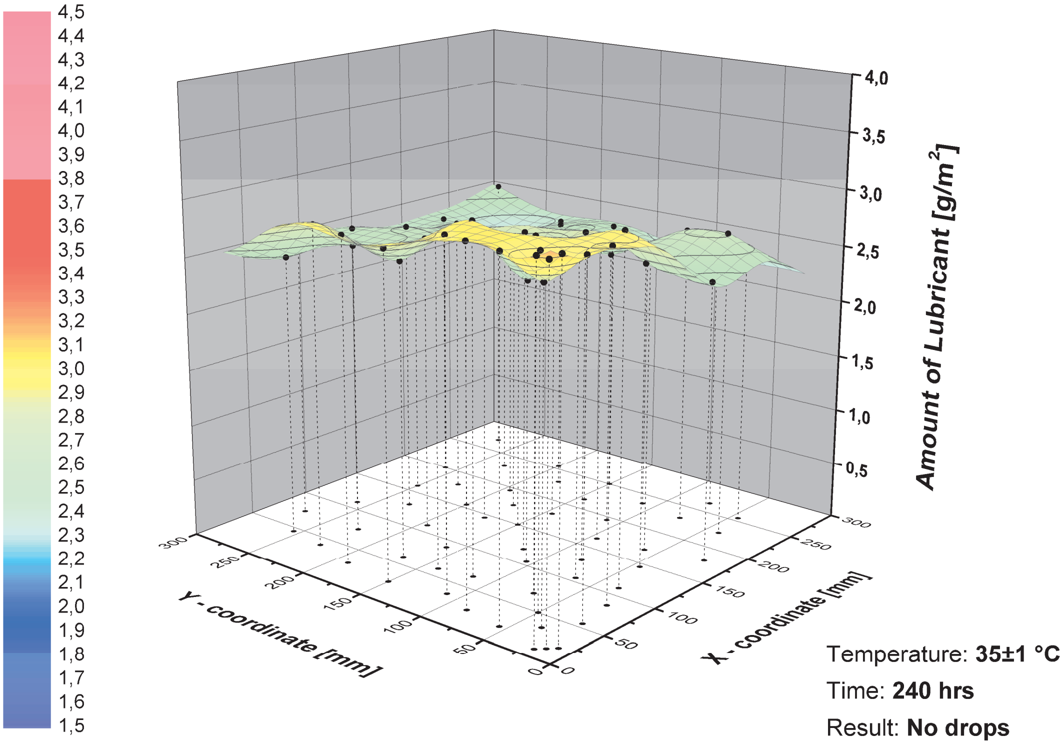

Fig. 5 Application of color-map (as rainbow palette) and contours within the required range

Such display for amount of lubricant is almost that one which is required from 3D graphs. However it´s quite difficult to see all "peaks and valleys" and that is why there is add one more flat display at the bottom. Such additional display (see **Fig. 6**) makes whole image much more user-friendly and well-arranged.

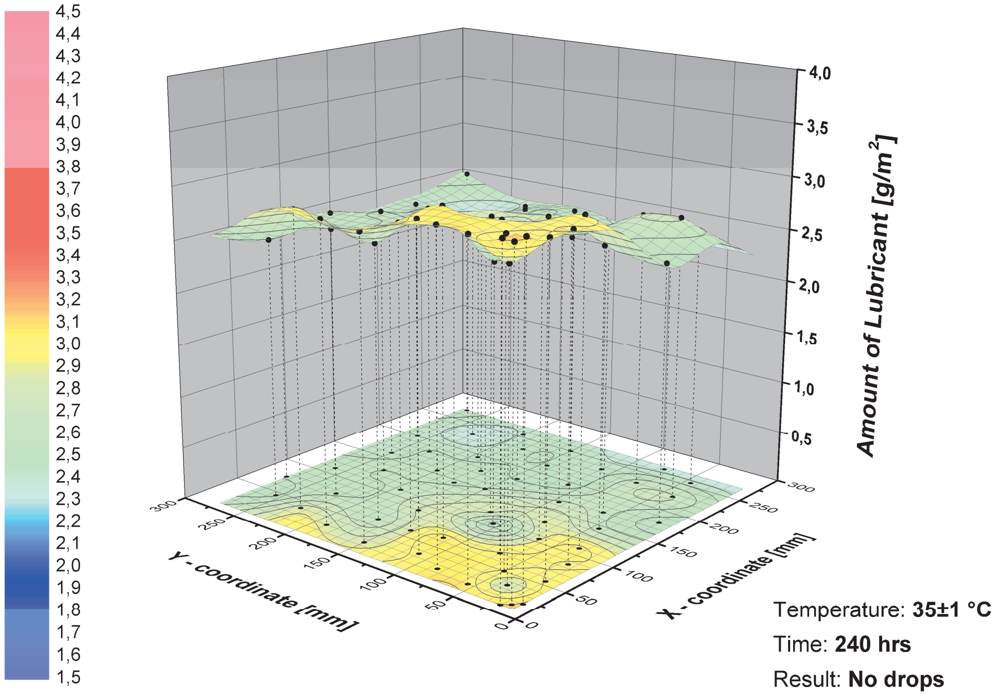

Fig. 6 Addition of another surface map as flat one at the bottom

The final image as it is shown in **Fig. 6** can be considered as very user-friendly because there can be found all important indicators required from this attitude to drop test. From such graphical illustration it is possible to clearly see "waves creation" after required time of drop test, differences (from amount of lubricant point of view) all over the specimen surface and last but not least also change between amount of lubricant at the beginning of test (mostly 3 g·m^{-2}) and at the end of test. Such graphical comparison can be done via utilization of another 3D surface map (may be better to name it as a mesh - see **Fig. 7**) which contains only one value (amount of lubricant equals 3 g·m^{-2}). This illustration again can help for much better orientation in 3D space but it can also help as rough approximation for evaporation of lubricant. But just still it is very rough approximation, it cannot be taken for calculations. It can be taken as difference between ideal initial state and attempt to describe situation at the end (after required time of test). It is also very strongly recommended to add one more 3D surface map as a flat map at the bottom (this was firstly used in the **Fig. 6**) because it can also greatly help for better orientation in 3D space for the first sight. Moreover it can be also used as only result from these graphical illustrations of drop test and based on these maps one can graphically compare different lubricant from their flow behavior point of view. On the other hand it is still just 2D map (flat one). For comparison of different lubricants between each other I strongly recommend to use image as it is shown in **Fig. 8** and to make well-arranged lay-out for required number of lubricants. In this paper is described creation of 3D surface map just for one lubricant, however it can be saved as template and then to use these formats (axis, text, range of values, color-map, rainbow palette and so on) to any other tested lubricant. Another very important parameter is selection of palette and mainly range of values within these palettes. In this paper was chosen rainbow palette (another choices can be e.g. solar storm, thermometer, watermelon, pumpkin patch or red white blue) because for engineering industry (end especially automotive industry) such palette is the most important one (same palette is e.g. used in FEM - thus numerical simulations). From our experience from meetings with lubricant and car producers this type of image (**Fig. 8**) is the most requested one mainly because of its well-arrange and simple. The main effort of this chapter was to familiarize the reader with the whole procedure how to get the final image that can be taken as a final graphical report from this drop test modification to be able to describe lubricant behavior.

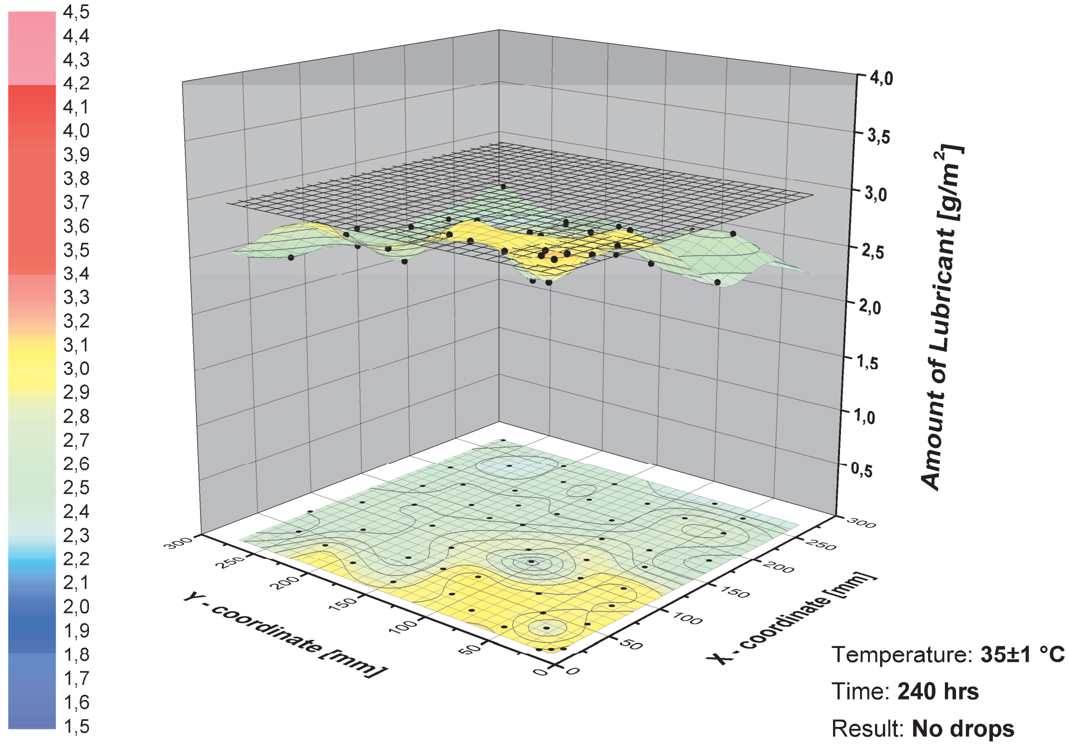

Fig. 7 Comparison of initial state (amount of lubricant 3 g·m^{-2}) and final state (color-map)

CONCLUSION

The basic effort of this paper was to give reader opportunity to modify well-known drop test to graphically characterize lubricant behavior from its viscoelastic properties point of view. There was described whole procedure how to get required values from points selection on the specimen surface with XY coordinates, to measure amount of lubricant in these points and finally how to process these data for 3D surface maps. Moreover there were described the graphical arrange of possible images to achieve the mostly required type for engineering industry. Such required type of graph is shown in the **Fig. 8**. This type of graphical modification of drop test is probably the best one for required description of lubricant behavior. The crucial parts of such procedure are mainly data conversion into matrix (via XYZ gridding), type of gridding method (here thin plate spline with zero extrapolation) and final graphical lay-out. It can be stated that from common drop test one is able to get quite good graphical characterization of lubricant distribution on the whole specimen surface just via using 3D surface maps. The biggest advantage of such approach rests in its very good simplicity, easy creation and utilization in the engineering and chemical industry (mainly for lubricant and car producers).These days is the bigger car producers in EU preparing the methodology hot to handle the whole procedure described above and to receive the same format from different labs.

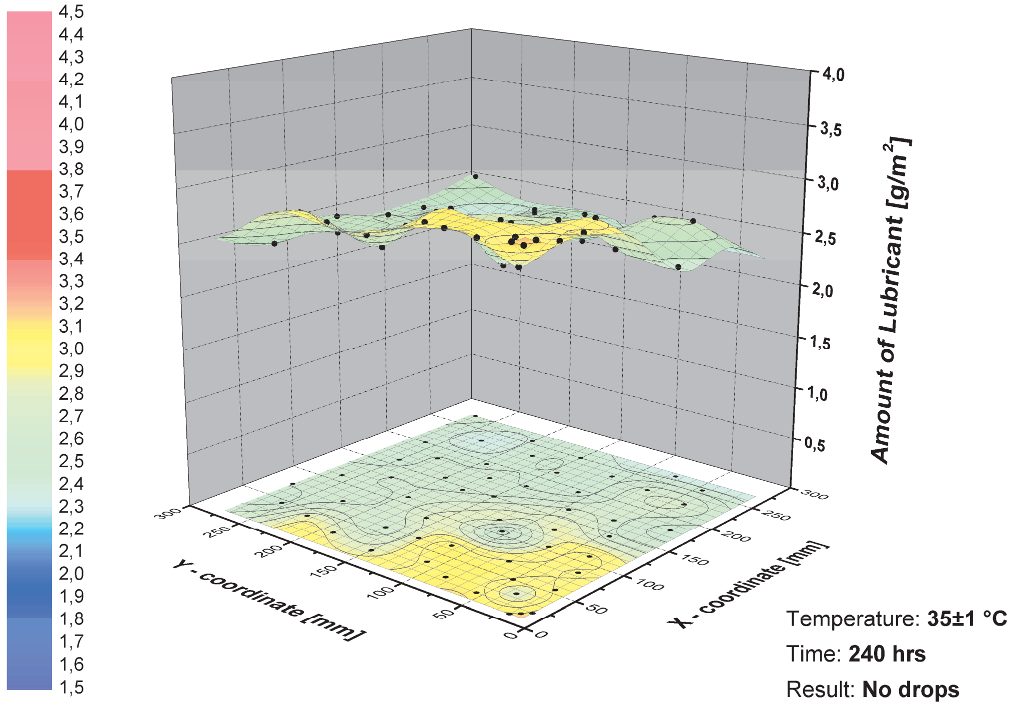

Fig. 8 Requested type of display for industrial applications

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