

PRECISE QUANTITY SURVEYING AND WORK PLANNING IN TECHNOLOGY FOR REGENERATIVE SHAPING THE WATERCOURSES

Summary

In this paper possibilities of precise quantity surveying and work planning in mechanized technologies for regenerative shaping the water courses were presented. Survey needs of melioration objects for newest technologies were described. Method of creating spatial map of ditches based on RTK GPS survey, and rating of ditch destruction based on this map were presented. Use of spatial maps for planning and cost calculation of maintenance works were described.

Key words: watercourses and drainage ditches, RTK-GPS ditch survey, maintenance of drainage facilities, ditch maintenance planning, automatic leveling, machines for melioration

PRECYZYJNY OBMIAJ I PLANOWANIE OPERACJI W TECHNOLOGII KSZTAŁTOWANIA CIEKÓW WODNYCH

Streszczenie

W pracy przedstawiono możliwości dokonywania precyzyjnego obmiaru i planowania operacji w technologii kształtowania otwartych cieków wodnych. Omówiono potrzeby obmiaru obiektów melioracyjnych dla nowoczesnych technologii. Przeszawiono metodę tworzenia przestrzennych map rowów przy wykorzystaniu obmiaru RTK GPS oraz możliwości oceny ich stanu drożności na podstawie tych map. Omówiono wykorzystanie przestrzennych map na potrzeby planowania i kosztorysowania prac konserwacyjnych obiektów melioracyjnych.

Słowa kluczowe: ciek i kanały melioracyjne, obmiar rowu RTK-GPS, utrzymanie urządzeń melioracyjnych, planowanie konserwacji rowów, automatyczna niwelacja, maszyny do prac melioracyjnych

1. Introduction

Relations of water in the soil structure are one of the factors which determine agricultural productivity. There can be neither too much nor too little water on the field. Much depends on proper maintenance of open watercourses - ditches, irrigation channels and drainage constructions.

Over the time, each drainage ditch is getting to be silted, contaminated, overgrown by plants etc. The bottom of the ditch begins to loose proper leveling, the escarpments in some places are broken and the ditch gradually stops to fulfill its task to keep ground water at desired level. To prevent this, removal of silt and debris, mowing of escarpment and bottoms, repair of broken ditch fortifications etc. are carried out [1].

Maintenance works, if possible, are carried out using a mechanized technology. In addition to the well-known classic mechanical equipment such as: backhoe - loaders or tractors with side boom arm [2], there are some new innovative solutions with much greater efficiency. These are for example, developed in the Industrial Institute of Agricultural Engineering multipurpose vehicles with special central single-track chassis and supporting arms on both side [3]. This devices can ride on the bottom of the ditch and perform maintenance from space inside the ditch.

One of the new solution consists also in accurate control of machines based on precise RTK GPS signals, including control of whole vehicle and control of mounted working tool [4]. To make the RTK GPS steering system efficient, three-dimensional map of melioration devices has to be prepared. This map must include: shape of ditch on its en-

tire length, warnings about objects inside, flow capabilities and list of regenerative works to do. In this paper, it is described how to create and analyze efficiently this kind of three-dimensional maps of ditches. Presented research results are achieved in project*) being dedicated to new technology and new machines for renovation of the open watercourses.

2. The precise quantity survey of ditch

Fundamental operation in 3D map of ditch creation is to make precise survey on the melioration devices. Several methods of measurement are known [5, 6]. The easiest way to do this is to use GPS receiver on the stick (fig. 1) which is receiving hotfixes from ground reference stations (measurements with an accuracy of 1 cm) and special software for measurement data archivization. This software allows user to attach some additional information to the measurement points, such as: short codes, notes or digital pictures of survey object. All of that is really helpful and makes data processing and work planning much easier.



Fig. 1. Set for quantity survey of ditch - GPS stick with wheel and receiver

Rys. 1. Zestaw do obmiaru rowu - tyczka GPS w opcji z kołem wraz z odbiornikiem

Technology of ditch quantity survey is based on its cross-sections determinations. These shapes have to be checked every tens of meters or in places, where some significant changes of shape are identified, like: throats, road crossings, corners etc. For this purpose, the measurement of the characteristic points must be executed (fig. 2), like: coastal zones (PrzP, PrzL), the upper part of escarpment (SkG), means of escarpments (SkSr), the lower part of escarpment (SkD), bottom (DnP, DnS, DnL), and additionally: the water level (Wod), mud level (Nam) and others - if needed. Object inside the ditch like trees (Dre) can be determined by alternatives methods, such as distance between object and two helper measured points.



Source: own work / Źródło: opracowanie własne

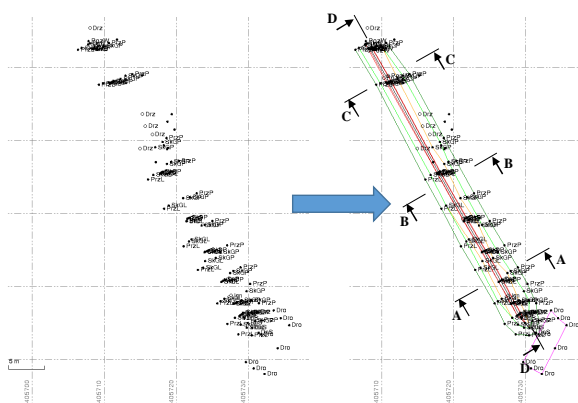
Fig. 2. Characteristic measurement points of ditch profile
Rys. 2. Charakterystyczne punkty pomiarowe kształtu rowu

If needed, some additional information from penetrometer can be added. This kind of annotation is useful when traction capabilities of the bottom have to be rated. Good practice is also to make helpful notes, which can be used by machine operator in the future.

3. Processing and analysis of measurement data

In the next step, measured cloud of points can be processed in desk software. Firstly, all points with the same code are linked by 3D lines. Next, on the basis of those lines 3D surfaces, representing: shape of ditch, level of water/mud, road bridges etc. are defined (fig. 4). Elements of ditch infrastructure like: drainage pipes or landmark can be marked by lines or points. 3D lines and surfaces can be also used to mark trees or level of plants.

Created spatial map of the ditch can be upgraded with archival data, such as ditch course from 2D maps or designed shape of the ditch in the past.



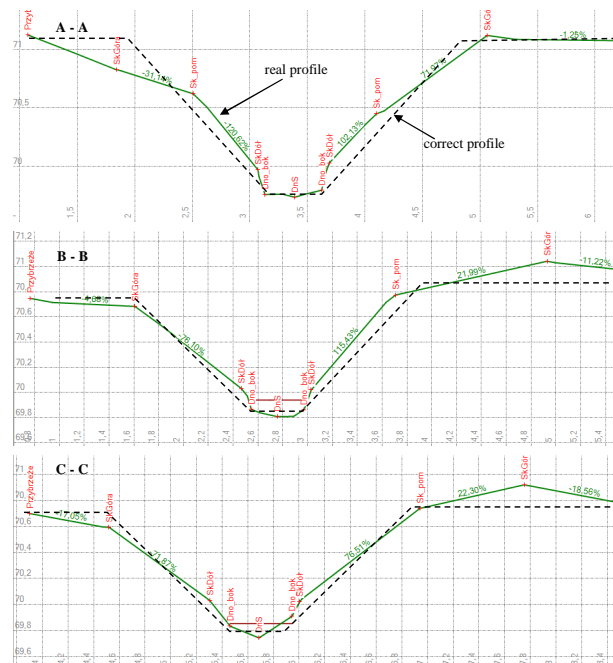
Source: own work / Źródło: opracowanie własne

Fig. 4. Three-dimensional map of measured ditch before and after data processing
Rys. 4. Przestrzenna mapa rowu przed i po obróbce danych pomiarowych

During the analysis of measuring data, ditch cross-section deformations are rated. Comparing to known designed shape renovation and regeneration works are determined. Malfunction of ditch can be caused by:

- silting and contamination of bottom of the ditches,
- plants overgrowing on escarpments and bottom,
- damaging of ditches by the flowing water or freezing and thawing of soil,
- sliding and reducing escarpments in places with large groundwater infiltration,
- destruction of escarpments by animals and people,
- damaging fortification of ditches.

Often seen, in case of improper cleaning of the ditches, tendency to expand of bottom is result on vertical trimming the lower part of the escarpment (fig. 5).



Source: own work / Źródło: opracowanie własne

Fig. 5. Real shapes of ditch on different sections in reference to perfect shapes

Rys. 5. Rzeczywiste profile poprzeczne odcinków analizowanego rowu w odniesieniu do profilu wzorcowego

This phenomenon causes significant distortion of the cross-section profile of the ditch, and in effect: meandering of ditch bottom or distortion of escarpments. Destroying is faster and level of flowing water getting to be low (because of expansion of the bottom) and plants are growing on the bottom much faster.

In some cases, because of long term neglect or improper conservation, level of the ditch bottom is no longer correct (fig. 6). Based on past project dimensions and people experience necessary for renovation works and reconstruction level need to be evaluated.



Source: own work / Źródło: opracowanie własne

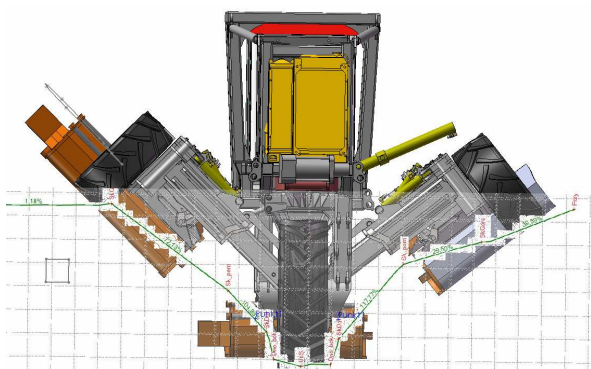
Fig. 6. Real and proper leveling of the ditch bottom
Rys. 6. Rzeczywisty spadek dna rowu w odniesieniu do spadku prawidłowego

If it's possible, during the mud removing process right direction - from ditch outlet to origination have to be kept. It will secure water to drain freely and renovation work will be much easier.

4. Planning of technological operations

If precise spatial maps of the melioration objects, including renovations and regenerations needs are prepared planning process can be started. Taking into account the human and machinery resources, can be defined:

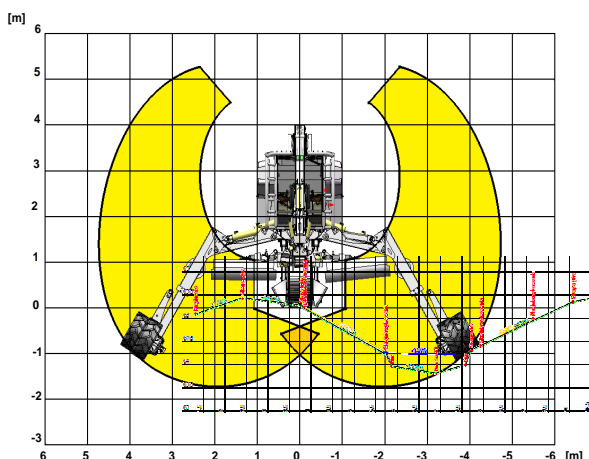
- orders and technology of works to do,
- necessary working tools,
- manner of management of excavated material and biomass,
- predicted amount and place of storage of excavated material and biomass,
- regenerative tools manipulation trajectory, which secure to get correct bottom leveling or shape of ditch cross section,
- rightness of use of multipurpose vehicles [7] which can ride in space of ditch (fig. 7),
- places where and how these vehicles [8] can get inside and outside of the ditch, or eventually what kind of job has to be done to prepare the right entrance (fig. 8),
- working time and fuel consumption, including how many technological rides have to be done.



Source: own work / Źródło: opracowanie własne

Fig. 7. Possibility of adaptation of multifunction devices comparing to real shape of ditch

Rys. 7. Możliwości adaptacji urządzenia wielozadaniowego do rzeczywistego kształtu rowu



Source: own work / Źródło: opracowanie własne

Fig. 8. Working range of the multifunction drainage de-vice in relation to the actual shape of the ditch

Rys. 8. Zakres roboczy urządzenia melioracyjnego w odniesieniu do rzeczywistego kształtu rowu

This comprehensive approach in planning allows to get an accurate estimate of work, including demarcation which operations are truly necessary, and which can be done another time. There are known some ranking methods of conservation needs of melioration devices which can be great complement [9]. It is important, especially for companies with limited year budget. After that kind of analyzes, companies can - in safe way make cost and time optimization of keeping whole watercourses system right.

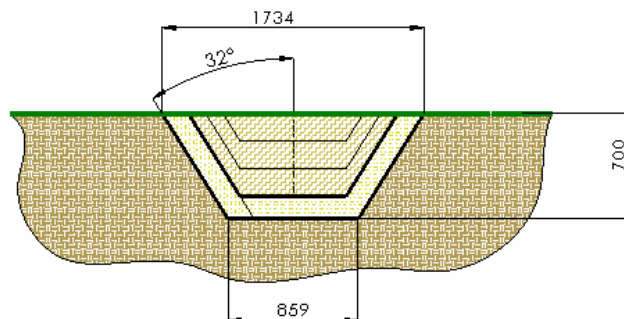


Fig. 9. Layered scheme of shaping new drainage ditch [2]
Rys. 9. Schemat warstwowego wykonywania rowka odsączającego [2]

Precise planning can be also useful when some new ditches have to be designed and realized - for example additional small drainage ditches. After proper survey of the field, using desk software shape, depth and leveling of new ditch can be designated [10]. Depending on kind of available technology, can be set: exact manipulation trajectory of working tool or couple layered trajectory - in case of tool with limited depth excavation (fig. 9). Control points can be also defined. They can be checked to provide excavation according to the design.

5. Summary and Conclusions

Presented precise measurements of melioration objects method can be great help for all companies, which are responsible for keeping whole watercourses system in right conditions, especially in:

- assessment of patency and kind of renovation works which are needed,
- selection of available technology,
- planning the development of machine park,
- calculations of cost and working time consumption.

With precise spatial map of the ditch, incorrect estimates associated with failure to the documentation and just visual assessment of the melioration object can be eliminated. In particular the unnecessary treatments that visually appear correct, but in practice disturb the operation of devices can be eliminated. For example, such an approach to the matter - through BIM (Building Information Modeling) is becoming the norm in the construction industry today [11, 12].

Assuming that such a quantity survey would be carried out periodically on a given catchment area, and all archived data would be compared, one would over the years assess the appropriateness of performing maintenance. As a result of such observations it might be that the used technologies are not as effective as the look just after the work, and the effects of work disappear within a short period of time.

The precise quantity survey and work planning in mechanized technologies for regenerative shaping the

opened watercourses can and should soon become the standard for many companies taking care of melioration objects.

6. References

- [1] Przybyła C., Bykowski J., Rutkowski J.: Środowiskowe uwarunkowania konserwacji cieków melioracyjnych w aspekcie wykorzystania wielozadaniowej maszyny nowej generacji. *Journal of Research and Applications in Agricultural Engineering*, 2011, 4, 71-78.
- [2] Rutkowski J., Szulc T., Szczepaniak J.: Ekologiczne i użytkowe potrzeby renowacji cieków wodnych inspiracją dla opracowania koncepcji nowej maszyny technologicznej. *Journal of Research and Applications in Agricultural Engineering*, 2011, 4, 87-92.
- [3] Rutkowski J., Pawłowski T., Szczepaniak J., Szychta M., Łukasiak Ł., Bąkiewicz P.: Wariantowanie rozwiązań konstrukcyjnych maszyn wielozadaniowych do renowacji cieków wodnych. *Technika Rolnicza Ogrodnicza Leśna*, 2014, 4, 2-5.
- [4] Vicente N., Rutkowski J.: Testing of the GPS receiver accuracy from the point of view of application in the multi-task machine form watercourses renovation. *Journal of Research and Applications in Agricultural Engineering*, 2011, 4, 178-183.
- [5] Kizil U. et al.: Performance and Accuracy Comparison of GPS and Total Station in Land Surveing. ASABE Meeting Presentation Paper, 2006, No. 061043, St. Joseph, Mich.: ASABE.
- [6] Paff K., Frankenberger J., Celik N.: Estimation of Two-Stage Ditch Excavation Volume Using LiDAR Data. *Purdue University. GIS Day, 2013, Paper 29.*
- [7] Rutkowski J.: Chosen issues of the concept forming of the structure of a multitask machine for the work in drainage ditches. Part 2. Choice of method of putting machine to the ditch. *Journal of Research and Applications in Agricultural Engineering*, 2013, 1, 157-161.
- [8] Rutkowski J.: A method of carrying out renovation works in melioration ditches and a multifunction device implementation of the method. Europejskie zgłoszenie patentowe EPO-PCT. Nr PCT/PL2012/000020. Poznań: Przemysłowy Instytut Maszyn Rolniczych, 2012.
- [9] Bykowski J. et al.: Maintenance needs assessment index of streams and ditches in planning of drainage works. *Acta Sci. Pol., Formatio Circumiectus*, 2013, 12(2), 23-32.
- [10] Renchler C.S., Flanagan D.C.: Site Specific Decision-Making Based on RTK GPS Survey and Six Alternative Elevation Data Sources: Soil Erosion Predictions. *American Society of Agricultural and Biological Engineers*, 2008, vol. 51 (2): 413-424. ISSN 0001-2351.
- [11] Miecznikowski P.: BIM – wybór czy konieczność. *Materiały Budowlane – Konstrukcje, Technologie, Rynek*, 2013, 10, (nr 494), 59.
- [12] Kacprzyk Z.: Idea BIM – nowa jakość kosztorysowania. *Budownictwo i Prawo*, 2014, 3, 28-33.

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