CONTEMPORARY TRENDS AND TASKS IN AGRICULTURAL ENGINEERING RESEARCH

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Abstract. A brief review of contemporary trends and tasks in the agricultural engineering research is given. The main directions in this field of research in the European countries and a number of world states with the climate and agricultural production conditions, similar to those in Latvia, are: improvements in technologies and machine designs (energy, resources, labour saving, environmental and health protection, processes and machine parameters optimization, automation), alternative energy sources (solar and wind energy, biofuels, wood), physical and mechanical properties of agricultural materials (soil, seeds, fertilisers, crop products), conditioning and storage of agricultural products, simulation of the processes and functioning of machines, precision agriculture and its implementation, management of production, creating databases.

Key words: agricultural engineering research, directions of research, main trends and tasks of research.

Introduction

Science is a totality of attainments about objective regularities existing in nature, production, society, technology; it performs cognition of these regularities, clarifies the possibilities and expediency of their application.

Some years ago a question was discussed: is science necessary for practical agriculture or not, partially the science of agricultural engineering. But in this time it is others. Now there is an opinion that science is a basis for its successful development. We need to create society based on wide objective knowledge.

For successful advancement of agriculture one should know the regularities existing there to use them efficiently in the direct production of agricultural products, their processing; in the improvement of technologies, machine designs and functioning; in the organisation of production and the use of machinery. A conclusion is made that science is necessary for successful agricultural management.

Acquisition of knowledge about the regularities:
- training of the personnel at the corresponding educational establishments (basic learning, distance education) in the known, previously clarified regularities;
- scientific research in the cognition of still unknown regularities, improvement of the known ones.

Some years ago in the Soviet Union as well as in Latvia we had a simple division (separation) of the agricultural engineering well matched to branches of the agricultural production and organisation.

Contemporary we have not generally acknowledged attitude to classification of the agricultural engineering research directions. In similar international scientific conferences of the agricultural engineering there are different divisions and subdivisions of the research theme. For example, for the 5th International Conference ‘Engineering for Rural Development’ taking place in Jelgava topics are:
- Application and operation of mobile and stationary machines
- Alternative energetics
- Land cultivation and animal breading technologies
- Precision agriculture
- Biomass conversion
- Transport logistics
- Design of machines and equipment
- Engineering education

For the Agricultural Engineering World Congress 2006 that will be held in Bonn the main topics are:
- Land & Water use and environment
- Power and machinery
The purpose of this review is to determine the directions and tasks in agricultural research that are more suitable and important for the Latvian reasons.

Materials and methods

Based on the large-scale directions of the agricultural engineering research presented in latest years at the international conferences there is selected one specific for the agricultural production processes at the Latvian climatic conditions.

Results

Guiding by leading directions of world-wide agricultural research, the directions and tasks in agricultural research that are more suitable and important for the Latvian reasons are determined. The particular attention is devoted to study trends and tasks of the engineering research in crop farming.

The main directions of the engineering research

- Agricultural machinery (power and operating machines)
- Technological processes (selection, management, automation and robotisation)
- Soil and water management (use)
- Processing and storage technologies of the harvested crop
- Production of cattle-breeding products
- Agricultural buildings
- Precision agriculture, including GPS technologies
- Perspective (innovative) engineering solutions (technologies, machines)
- Industrial innovations
- Environment- and landscape-saving agricultural activities
- Physical, mechanical and technological properties of materials
- Power capacity of technological processes, its reduction
- Electrification, alternative renewable sources of energy
- Engineering solutions connected with biological agriculture
- Production management, data ware
- Ergonomics, improvement of working conditions, labour safety
- Rural development and communications (roads, means of communication)

Directions and tasks of the engineering research in crop farming

Agricultural machinery (energetic and operating machines)

- Energetic and efficiency assessment of tractors
- Agrotechnical, energetical and economical assessment of machines (in tillage, fertilisation, sowing, plant care and protection, crop harvesting, its post harvest treatment, storage, transportation)
- Combined machines and aggregates for simultaneous performing of several technological operations, their substantiation
- Parameter optimisation of aggregates (working width, the speed of locomotion and rotation)
- Functional simulation of machines and aggregates using the computer technology for calculation and optimisation of parameters
- Improvement of the design and functioning of machines and their operating parts
- Assessment of the undercarriage of tractors and self-propelled machines, their improvement
- Development of machines for growing unconventional crops
Technological processes (selection, management, automation and robotisation)

- Substantiation and assessment of technologies for growing and harvesting field crops (cereals, forage crops, potatoes, sugar beet, flax, etc.)
- Development of technologies for growing and use of unconventional crops (siderates, medical herbs, energetic plants)
- Simulation of technological processes for their control and optimisation using the computer technology (automated control of machines and processes, and their performance, accountancy, etc.)
- Improvement of unconventional technologies, development of new solutions (drying in the electric field, sorting and stimulation of seeds in the electric field)
- Methods for the assessment of the energy intensity and quality of technological processes (basic and pre-sowing tillage, control of the quality of the products and the losses of the crop)

Soil and water management (use)

- Energy- and resources-saving tillage
- Assessment and regulation of the moisture conditions in soil (drainage and irrigation)
- Optimisation of the physical and mechanical properties (density, humus and nutrient content, structure) of soil in conformity with the requirements of the plants to be grown
- A complex evaluation of the growing and production conditions of plants
- Assessment of the impact of the tillage and production systems upon the physical and mechanical, biological and chemical properties of soil
- The preservative use of soil, prevention of its degradation
- Prevention of undesirable compaction of soil and its upper layer, improvement of the filtration capacity of heavy soils
- Tillage minimisation (tillage without ploughing)
- Field mapping depending on the properties of soil, terrain, and other conditions of production

Processing and storage technologies of the harvested crop

- Conditioning of products (drying, sorting, ensuring the desired conditions of storage (for grain, forage, potatoes, sugar beet)
- Preparation and storage of grass forage (ensilaging, preservation, roll baling technology)
- Rape seed conditioning and storage

Production of cattle-breeding products

- Assessment of the grass forage growing and preparation technologies and machines, their improvement
- Assessment of the technologies and machines for the production of maize, beet and other kinds of forage crops, their improvement

Agricultural buildings

- Drying and storage rooms for grain on agricultural farms, the substantiation of their design
- Storage facilities for forage on farms (mechanised haylofts, haylag silos), substantiation of their design
- Storage facilities for potatoes and other vegetables (red beets, cabbages, carrots)

Precision agriculture using GPS

- Tillage variation (types, depth, intensity) depending on the physical and mechanical properties of soil
- Exact dosage of fertilisers, uniform spreading, correct introduction, variation of doses on the plots of the field
- Exact sowing and introduction of seeds (sugar beet, vegetables, onions, potato tubers, etc.)
- Regularities of plant distribution in sowings and plantations, their impact on the yield and its quality
- Correct choice, dosage, sprinkling of the plant protection agents, increasing their efficiency
Supervision of the performance of sprinklers and control of the quality of work, control testing under the conditions of farms (methods, equipment)

Formation of qualitative plant products during their growth, systematic quality control

Requirements for machines, seeds (beets), fertilisers and other materials satisfying the requirements of precision agriculture

Field mapping for the estimation of tillage methods, fertiliser doses, plant protection measures, the expected yield

**Perspective (innovative) engineering solutions (technologies, machines)**

- Growing heat-loving crops (maize, cucumbers) in the plastic film tunnels
- Biostimulation of seeds by means of the laser equipment
- Sorting of seeds in the electric and magnetic field
- Constant rail technologies of production (in tillage and crop harvesting too)
- Sowing wheat after sugar beet combine harvester
- Harvesting robotisation of cucumbers and other vegetables
- Sorting of carrots by their shape with the help of a teleequipment

**Industrial innovations**

- Automatic steering of grain harvesters and other machines
- Increasing of capacities, the speed of performance and transportation
- Load optimisation of aggregates
- Increasing the length of service of machines and their operationing parts
- Automation of the control of aggregates and their performance, and the accountancy of work

**Environment- and landscape-saving agricultural activity**

- Conservation of soil fertility and rural scenery, its perfection
- Management of the production and municipal waste collection, processing, and the use environment-friendly equipment
- Prevention of soil erosion
- Prevention of harmful gases, emission of malodour
- Restriction of the use of chemicals, strict control of their application and technical means
- Solutions for the rehabilitation of degraded environment

**Physical, mechanical, and technological properties of materials**

- Physical, mechanical, and technological properties of soil in connection with its tillage, regularities of their changes, their impact on the tillage quality and energy intensity
- Physical and mechanical, and technological properties of organic and mineral fertilisers in connection with their distribution
- Biological and physico-mechanical properties of root crops (sugar beet) and tuberous plants (potatoes) in connection with their growing and harvesting
- Biological and physico-mechanical properties of cereals and grasses in connection with their growing and harvesting

**Power intensity of technological processes, its reduction**

- Power intensity of field crop production for different technologies, solutions for its reduction
- Power intensity of soil tillage, its determining factors, possibilities to reduce its power intensity
- Power intensity of field crop harvesting processes, possibilities for its reduction
- Power intensity of the crop conditioning (cleaning, drying), measures of its reduction

**Electrification, alternative renewable sources of energy**

- The use of solar energy
- The use of the wind energy
- Extraction and use of biogas
- The use of the field crop remains (straw, stalks) to produce heat
- Technology and machinery for the production of energetic crops (rape, arboraceous plants)
Engineering solutions connected with biological agriculture

- Tillage peculiarities
- Agrotechnical solutions and machines of weed control
- The use of biological plant protection means
- The use of papilionaceous plants for the introduction of nitrogen into soil

Production management, data ware

- Systematised use of production resources (land, people, machinery) to produce competitive products
- Simulation of production and obtaining data ware
- Creation of a data base for the production management
- Development of cooperation with the product processors and dealers

Ergonomics, improvement of working conditions, labour safety

- Assessment of working conditions, solutions of its improvement
- Assessment of labour safety
- Assessment of lighting for the work at night, solutions of its improvement

Rural development and communications (roads, means of communication)

- Optimum use of the existing resources, harmonisation of production structures and scenery (landscape)
- Provision of sustainable profitable production on the farms of various sizes
- Management of the use of the production and municipal waist and biological purification of sewage
- Organisation of the network of rural roads and public transport
- Retention of the old structures (buildings, bridges) by solving their contemporary utilisation
- Solutions for the development of tourism

Conclusions

1. For successful farming extensive knowledge is required that must be obtained by serious studies.
2. The most important trends and tasks in agricultural engineering research for Latvian reasons are determined.