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Development of Software for Module-assembled Process Simulation in Field Operations

Process investigations have shown often that with simple calculation schemes and assumptions a good average can be achieved. Special requirements, regarding disturbance and auxiliary times, plot form and size, operators' individual performance differences and the various ages of machines, cannot be met by these calculations. New simulation approaches are necessary. The software solution presented integrates innovations from the manufacturing industry. For application in agriculture, modules with laminar and spatial dimensions must be developed.

With new investment or substitute investment the main question is how to integrate the new machines into the existing fleet. The most important part is the harvesting and transportation technology, because discrepancies in the performance can cause financial losses. Therefore future throughput and shelter volumes of the harvesting machines have to be evaluated as much as load weight, dead weight, load volume, universal applicability, prices and regulations for use in the public traffic are concerned.

In practice pretty dubious machine comparisons are often done. But for a real machine comparison, it is necessary to pay special attention to the basic conditions (temperature, moisture of grain, straw and soil, relief). These basic conditions should be subject to the ceteris paribus principle, but that is impossible for practical use. So only biased impressions of the performance of several machines can be the result. It is also not practicable to organise all available machines for testing in personal use.

Because of this situation, new solution methods with the ability to demonstrate such processes independent of the mentioned influencing factors have been searched for.

Computer aided process simulation, which is already used in the automobile industry, seems to be forward looking. With its assistance it should become possible to show the route of all machines and to give an answer for questions in process engineering with a low input of time, material and staff. After an investigation in simulation software the choice was made for the application software "SIMPRO", that is used in the automobile industry to develop and test whole factory buildings before the first spade cut is done.

With this event controlled simulation software material flow systems can be demonstrated in rough and detailed planning for transport, storage, manufacturing and logistics.

For this purpose existing modules (e.g. store, drive way, work centre etc.) are taken from a module box, put into a mask and can be parameterised. A simple model is shown in *figure 1*. It is a paint line with controls for ordering, transport and progress. An operating calendar and a flow control can be added to simulate not continuously working processes. An interesting possibility is to program modules themselves.

Adaption

Transport, handling/envelope and storage processes from agricultural practice can already be reproduced now without program extensions. Surface-bound simulation, which is mandatory in agriculture, cannot be illustrated with conventional simulation software. Special attention is given to the development of the modules "FIELD", "HARVESTING MACHINE" and "TRANSPORTATION UNIT", for illustration and analy-

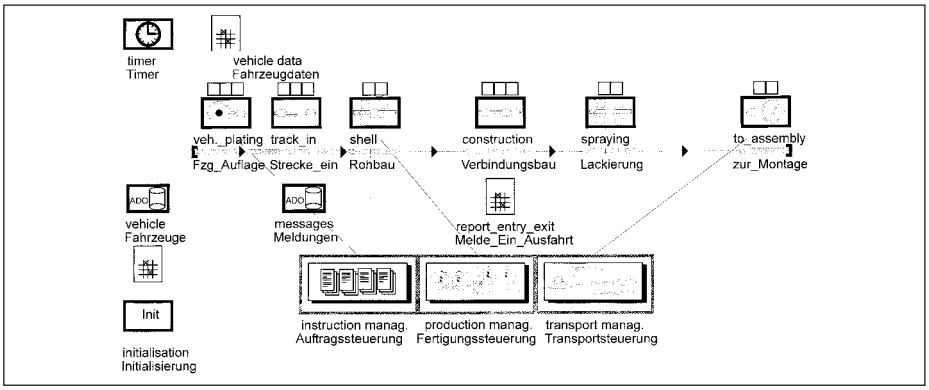

Fig. 1: Model of a varnishing line with order, transport and manufacturing control

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ses of transportation and envelope scenarios on a surface (second and third dimension). This kind of "not point like" working modules represent a new development.

A great practical importance is for example the analysis and evaluation of different procedural variants especially in liquid and solid manure application. The optimisation of the work width, applicated quantity, loading and dead weight as well as impact characteristics and relief is the centre of attention, regarding the lowest ground pressure and lowest costs.

Further there is a demand for the optimised throughput performance of the harvesting machines, specific to this company. On the one hand transportation capacity must be available to prevent downtimes of the harvesting machines. On the other hand, attention has to be paid to the tractor power, costs, ground pressure etc. Another important research work is to find out about obstructions by harvesting machines of different performance classes, and different manufacturing age. This concerns especially the the question: "Do I have to replace all my combines altogether or individually from year to year?", in order to avoid e.g. very large investment in one financial year.

Not less important as the highest possible performance of the tested machines are the linked process engineering effects on transport, envelope and storage equipment. The existing transportation and handling capacities are often co-ordinated with the existing harvest technology. If the harvest capacity is increased, there are during the day temporarily downtimes of the harvesting machines, because of the insufficient storage and transportation capacities.

Conclusions

The result is that in considering these and further problems for process engineering, it is important to take new paths. Therefore existing potentials of agricultural and industrial research and practice should be used together and meaningfully introduced to the practice. Further additional parameters, e.g. ground pressure, yield, "stonyness" etc. can help by being mapped and digitised. By means of these maps and data there will be further possibilities in the future, e.g. the GPS-controlled soil-cultivation and -loosening of part-fields, fertilisation, plant protective measures, optimised field pass strategies etc. This multiplicity of possibilities must be used in the future, in order to be competitive in the course of the agrarian structure reforms and for the world market.