Advanced Engineering

Production innovation under changing market conditions and new technologies

In the middle of the last century tractors experienced a surge in development. It is important to realise what caused this and why it flattened off again after 25 years. Only when this pattern is understood can one appreciate the challenges involved (fig. 1).

Machines are applied as production factors in farming and thus every function improvement or introduction of a new component must increase customer utility. One can see what happens when this principle is not followed by looking at the experiences in eastern Germany.

A customer-oriented basic approach requires permanent adjustment of company organisation to keep the economic process running. Short term, this means meeting customer requirement with acceptable products. Long term, it means anticipating such requirements so that the product solutions are ready at the right time: Product Innovation (fig. 2).

Product innovation, market assessment, technology assessment, advanced engineering

What is advanced engineering?

It has already been made clear that comparative investigations and customer surveys cannot deliver basically new product ideas and because the competition is hardly likely to reveal marketing strategies and latest technological achievements, each company is left to make these decisions on their own. Advanced engineering can be compared with shooting at a running boar: aim a little too far ahead and you miss, wait too long and your bullet is also wasted.

There are risks both ways because when you’re assessing the market the application requirements are often not yet clarified. At this stage the real role of advanced engineering can be appreciated: the formulation of product suggestions against calculable risks so that these suggestions can be further checked-out in context.

With the organisation of advanced engineering as a progressive decision-making process, the reconnection with marketing or...
work preparation must not be forgotten. Fixed procedural rules must be followed for these adjustment processes (fig. 3).

**Processing of future perspectives**

**Examples for changing market**

Because even in 1975 there was a flattening out of tractor numbers, manufacturers were already then seeking solutions.

Tractors have no productivity of their own and are thus dependent on their interaction with implements, a reason why self-propelled machinery such as combine harvesters, beet or potato harvesters or self-propelled sprayers must be regarded as competition for tractors (fig. 4).

All these developments tend towards tractor number reductions, a situation which need not be alarming for a „full liner“ where a large tractor and a combine can be instead of two smaller tractors.

**Agricultural change and mechanisation adjustment**

The following data were processed in a diploma paper [2] and relate to a 150 ha farm in the Kölner Bucht which is almost fully ring-fenced and has three tractors of differing power. All other data for the system comparison regarding tractor numbers was from KTBL models and calculated with AVORW simulation software.

Total costs for variant 1 were 310 000 DM. So that the results here could be better compared with the average 300 ha farm in eastern Germany, input costs were raised to 620 000 DM (fig. 5).

A ring-fenced area of 300 ha was taken for variant 2 with the power for the biggest tractor raised from 111 to 149 kW. For this power figures for associated implements were once again taken from the KTBL databank. Here the cost saving was 60 000 DM compared with variant 1. This is not a real cost saving, however, because the extra 150 ha was not available as self-enclosed land. Because of this, the results from variant 3 recognised the additional 150 ha as out with a ring fence with an average distance of 10 km from the farm and leading to extra costs of 100 000 DM compared with variant 2.

As this was attributable to the extra transport requirements it can be assumed that there’s additional tractor sales potential in farm transport work.

**Further tractor development targets**

Farming customer requirements can be roughly aligned to three basic wishes (fig. 6).

- Increasing productivity
  Because the tractor alone gives no productivity, this increase can only be achieved in association with implements and while there are such a lot of those the focus should be on the tractor/implement interface – a point where, after 75 years, the Ferguson three-point hitch has found a worthy successor in the hexapod hitch, a development aimed at, and still worked upon, within the project „Development of new structural concepts for tractors“ through cooperation of John Deere Werke Mannheim and the Chair of Agricultural Machinery, TU Dresden.

  The hexapod hitch fulfils all the above basic requirements and allows a simplified operation through to automatic hitching and detaching of implements. Efficiency improvements and productivity increases are achievable through adjusting draught point and this ability to adjust the draught point means axle loads can be influenced thus allowing soil compaction risk reduction through ballast reduction with utilising mounted tyre pressure regulation.

- Increasing comfort
  Because of the expected increase in work hours per day and year the driver wants more comfort and a reduction in physical stress.

  The multiple possibilities through electronics currently go as far as self-driving farm machinery. Two innovations from Agritechnica 2001 can be mentioned.

  On the Stand same a self-leveling cab was shown. Unlike cabs with conventional suspension, this allowed the driver platform to be kept largely level on up and down and lateral slopes. As backache can be regarded as a professional disease with farmers the improved seating comfort is eagerly accepted by customers.

  Also at Agritechnica, John Deere presented the stepless „AutoPowr“ transmission, or rather a seamlessly-changing hydro-mechanical transmission. The transmission is a cooperative development of John Deere Werke Mannheim and ZF Friedrichshafen whereby the preselect gear change was developed in Mannheim. ZF also delivers the Ecom transmission to Deutz.

- Protecting the environment
  The automatic adjustment of optimum tyre pressure when moving from street to field or vice versa, the reduction of tractor ballast through regulating the hexapod hitch control of axle loads and implement steering all show that „environmental protection“ is no empty phrase.

**Preparing for the new conception of a product**

**Structuring the tractor in modular component groups**

The organisation of a tractor with a multiplicity of functions and controlling of a large number of variants and options represents a great challenge for the manufacturer (fig. 7).

For those who have not yet been able to visit the transmission and tractor assembly in Mannheim the ground principle can be summarised as follows:

- Construction of tractor via preliminary assembly of basic parts, then assembling...
these to more complex components,
• Arrival of these components and their pre-
 paration on the tractor assembly belt,
• Assembly of different models in mixed mo-
  dels and for pre-series and pilot models.

The assembly of parts into components re-
 presents the organisation principle which can
be carried through from the manufacture
to the repair of a tractor. With presentation of
the cost list of a comparative tractor this ad-
 vantage also serves the pre-development sta-
ges. The SFC (Structured Functional Codes)
represents a measuring rod for the adjust-
ment of function and costs.

All non-altered components can be ig-
nored for the moment and first orienteering
data is already present for those that have to
be newly conceived or altered.

Where a change takes place from three-
point to hexapod hitch or from shift trans-
mision to stepless, certain adjustments have
to be made to SFC structure.

Gradual filtering out of the best technical
variant in each case
From the information so far, following spe-
cifications for a future transmission can be
roughly deduced.
• maximum speed 50 km/h and higher
• stepless speed setting from 0 km/h to ma-
ximum
• in forward and reverse
• speed adjustment as with „AutoPower“
• all-wheel differential

With this information it is possible to estab-
lish detailed comparative criteria for all
transmission variants weighted through cost-
benefit analyses and evaluated per individu-
al criterion and variant. Totalling the points
gives the required system comparison (fig. 8).

Because electro-transmissions achieved
the highest points total, their suitability for
tractors must be further investigated. Here,
the first question is differentiating between
electro-drives (fig. 9).

If one simplifies the analysis by consider-
ing combustion engine and generator as a
central power unit, in that this can be the
same for all variants, one can differentiate
between three electric drives: central drive
with one motor; front and rear axle drive
with respective motors; and four motors for
individual wheel drive. For these variants a
further cost/benefit analysis with following
result would be conducted (fig. 10).

Investigations for military vehicles led to
the same result: that the individual drive of
wheels and adjacent aggregates including
guns was the best solution. The transmission
in such cases is extended to the vehicle dif-
ferrals and axle drive and situated bet-
ween combustion engine and wheels.

Through rpm selection and monitoring for
every wheel, all working conditions can be
regulated including these of the differential.
Cost-benefit analyses were conducted on
five levels for comparative evaluation of transmission variants.

Every wheel drive consisted of a controller, a frequency converter, the wheel motor and possible a final drive. This drive unit represents a self-supporting function unit being controlled through the communication bus from vehicle management (fig. 11). Additionally every unit is supplied with electricity over a central power network and is connected to the coolant circulation and other servicing facilities.

Modeling of complete tractor concept

To gain information on function capabilities of a tractor, it is modelled as a multibody entity and all individual functions programmed and simulated via Matlab/Simulink (fig. 12). The simulation results were verified on a test stand at the TU Dresden (fig. 13).

The individual results of the simulation are represented as follows using the example of the turning circles (fig. 14).

Summary and outlook

Vehicle demands must be extended in multiple aspects for a high-speed tractor or be re-defined in order to offer the farmer a suitable transport system in the future.

In that the standard tractor with front loader is already threatened through the telescopic loader, a further platform extension in the direction of a high-speed „Trac“ tractor represents only a logical step.

Indications that the system tractor has been unable to achieve sustainable economic success so far were taken seriously, critically checked, but in the end classified as unsupportable because no „new version of the MB-Trac“ was suggested but instead a further development on the basis of new technologies. Here one can speak about a paradigmatic change because the functionality of the tractor is changed regarding many aspects at the same time.

In conclusion another nostalgic look back (fig. 15). The illustrated car with electrical front wheel drive was exhibited by Ferdinand Porsche 100 years ago at the World Exhibition in Paris and 300 examples produced.

Literature
