

MODERNISATION PROJECTS: CONDITIONS FOR SUCCESS

Gabriele Barten, Heinz Löcker, Wilhelm Friedrich Sommer,

Changes in the state of the market for rolled products, as well as advances in manufacturing technology, mean that rolling companies have to consider new factors in production programme planning, such as new investments or the modernisation of existing plants. In any case, the expenditure associated with such changes can be justified only if a concrete development is achieved, or, at least, the likelihood of success potentials in the strategic business field is concerned, and that this will result in a specific Return On Investment (ROI) within a predictable time-scale. Thus the transition between the modernisation of an existing plant and a completely new investment may not be easily distinguishable: the modernisation can be so fundamental that, apart from the heavy basic components, all elements of the mill will be renewed, and the rolling company will have an essentially new system (fig.1 and 2) after the rebuilding action. The fact that the costs of a system modernisation are substantially lower than those of a new investment, explains the comparatively higher likelihood of renovation, as well as its increased importance, in particular in the current economic climate of consolidation.

Decision Field in Modernisation Projects

Conditions of saturation in many market domains have shown that, fundamentally, modernisation projects are not always exclusively connected with increases in productivity. In order to be competitive, as well as having or maintaining a high productivity rate, it is often the case that the adaptability of production facilities to the changing demands of the customers of flat-rolled products is the deciding factor. In addition to the two parameters of success, “product quality” and “productivity”, a third one “flexibility” has to be added. Flexibility denotes, on the one hand, the spectrum of products which can be rolled on the system -the product-mix-, and on the other the time factor, in regard to possible “just in time” production.

Hence modernisation, as well as the desire for improved product quality, means, to one extreme, a move in the direction of the “universal machine” in order to be able to

service varying requirements within changing time constraints, and in this way to strengthen one's position in the market, and to the other extreme, the abandoning of universal production possibilities in favour of maximum productivity, in order to combat the pressure of rising prices by minimising costs. Advances in today's production technology towards "flexible automation" make it possible for the objectives of a productivity increase to be connected, at least to a certain extent, with those of an enhancement in flexibility.

The concrete motivation in modernisation projects (fig.3) as a rule lies between the desire of the rolling company for productivity increases, in order to achieve an internal cost reduction, and the attempt to meet more exactly the market demands. Modernisation directed towards a higher market-compliance of the products, enables the rolling company to preferably meet customer demands for the respective flat-rolled products. This can be done by an increase of product quality with regard to strip thickness, strip flatness and surface quality, through an extension or restriction of the product spectrum with respect to thickness, width and coil diameter, and/or via the provision of a time-optimised production. In the first case, a higher productivity is achieved via the "economies of scale" and directly results in an increase of returns. In the second case the operating company intends to improve profits somewhat indirectly, trying to keep up the production to the demands of the rolling mill market to an even higher degree, in other words via the "economies of scope". In addition to the individually defined goals, each modernisation project is ultimately limited by minimum shut down and rebuilding times.

Concept Development by Dialogue

The optimal modernisation concept, (fig. 4), requires close co-operation between the system operator and system provider:

- The system operator brings his "know what" into this co-operation. His sales forecast, the related market strategy, as well as his production philosophy lead to the formulation of appropriate targets. These concern, on the one hand, the productivity increase desired from the refurbishment, and on the other hand detailed specifications for the improvement of product quality, for the modification of the product spectrum, and/or suggestions by which production can be made

more time-flexible. In addition, realistic ideas about the necessary ROI are defined.

- The system provider, correspondingly, places his “know how” at the disposal of the system operator, or in other words, he provides his technology. The important features are his technological developments and practical experiences, placed in the context of an explicit quality philosophy. Essentially, this means rolling-mill technology and science, commissioning know-how in connection with appropriate references, and knowledge and experience of project management.
- Both the targets of the system operator and the ideas of the system provider as to their practical implementation are, in the course of the project, gradually realised. Long-lasting and good business relationships support both the effectiveness and the efficiency of the co-operation; by analogy, one could define this as “know how together”.

To summarise, it is the constructive conflict between “know how” and “know what” which, under the catalysing conditions of a “know how together”, enables the definition of the optimal modernisation concept.

As far as the modernisation of one’s own plant is concerned, it is, in the sense of “know how together”, favourable if the co-operation is carried out within the context of a long-term service concept. The service concept encompasses not only the maintenance of the initially-supplied plant, but also a system performance extension and modernisation consultation leading to a “life-cycle optimisation”. In this case, the operations of inspection, maintenance, repair, overhaul – right up to a complete refurbishment – form one seamless service package.

Success Conditions: Technical Considerations

In this context the technical and technological question arises concerning the identification of trend-setting factors from which bridges can be built to attain further improvements in quality, increased productivity, and the adjustment of flexibility to the changing conditions of the relevant markets for flat-rolled products. Closely tied in with this is the need for the plant provider to identify suitable fields for further development ideas.

Two starting points can, fundamentally, be distinguished. Particularly significant are the so-called “integrative problem-solving modules”, and, amongst these, those which concern the “roll flow” of production are considered particularly promising:

1. It is no longer the case that strip-thickness and strip-flatness control technology modifications are the only guarantee of satisfactory ROI's. Isolated thinking in exclusively process automation, mechanical or drive categories has reached its limit, and “integration” is the requirement of the future: the total is more than the sum of its parts! Thus the drive technology, and, in particular, the mechanical modifications are experiencing a certain renaissance. Strip thickness and flatness control, as before, still play an important role, albeit with new priorities and in increasing conjunction with elements of process automation, the mechanical systems, and drive technology. The question of a modernisation with a satisfactory ROI has become more complex, and therefore requires, as a solution, a more integrative approach (fig.5).
2. Within these integrative problem-solving modules, those which provide for the success of modernisation projects in particular - the “roll flow”-problem solution modules - are especially important in order to optimise the production flow and hence to increase the productivity of the rolling operation.

“Integrative” Problem-Solving Modules from Achenbach

Achenbach already successfully uses such integrative problem solution modules, especially those connected to roll flow, and utilises these in most modernisation projects. The following examples address, firstly, the areas of strip and coil handling and secondly, particular modules in the central rolling mill, and thirdly, the accessories for rolling oil treatment.

The following modules are important in the areas of STRIP AND COIL HANDLING:

- Automatic foil in- and out-feeding (fig.6): this takes place with the aid of a specially arranged air cushion. An air current is applied by special nozzles which are aligned in defined angles, so that a forward movement develops, and the foil is simultaneously held straight in the transverse direction. With this type of automatic strip feeding, manual intervention is unnecessary, and a smooth entry

into the roll gap is ensured. Additionally, both the threading time and the quantity of scrap material is reduced. In the production of aluminium foils, this method of automatic strip entry has special significance, as the material does not retain the necessary stability to be able to be driven forward by a feeder roll.

- Automatic handling of the strip nose of the coil (fig.7): during the roughing pass operation, the strip nose of the next coil is either lifted by vacuum from the coil, or laid into a roller drive manipulator. In both cases the strip nose is transported automatically to the entry feeding rolls or to the air cushions. In this way the threading process is optimised and time-intensive manual interventions are avoided.
- Coil transport with coil cars and cranes: specialised coil cars provide for the speedy and automatic transport of the coils from the coil storage depot to the decoiler and from the recoiler back to storage. Furthermore, delivery, and the removal of processed coils, can be accomplished with special fully automatic cranes, which are integrated into an automatic coil storage management system.
- Coil transport by pallets (fig.8): this serves to regulate the flow of production at strip mills with “back to back” rolling. The above pictures (fig.1 and 2) show a clear comparison resulting in an increase in productivity.

Secondly, the MODULAR DESIGN OF THE MILL STAND offers the possibility to make use of integrative problem solving components, whether mechanical, hydraulic, electrical, control or measurement, in a co-ordinated way, allowing service, repair, replacement, and system enhancements to be carried out in a modular way. In this respect, the following modules in the central section of the mill stand are particularly significant:

- Positive and negative work-roll bending devices in hydraulic blocks (fig.9): in order to avoid unnecessary manual coupling during roll changes, work roll bending cylinders in hydraulic blocks are provided, which are securely fixed at the mill housings. This fixed hydraulic block solution is, together with the automatic couplings of the bearing lubrication oil delivery and removal system, an essential component of the fully automatic working roll change set-up.
- “Variable crown” (VC) back-up roll: the use of this technology ensures a “mechanical” influence on the roll bending in the strip centre area and forms, therefore, an outstanding supplement to the roll bending, which, in contrast,

particularly affects the strip edge areas. Retrofitting a mill with a VC roll requires only a single additional high pressure hydraulic unit, supplying three connecting pipes to the roll. Furthermore, a control integration into the flatness control is obtained. The VC roll provides an additional control parameter to influence the roll gap profile. This is indispensable if adapting the mill to a “just in time” production philosophy is a priority. The effect of the VC roll on the roll gap corresponds to the formation of a thermal camber of the rolls. While a fast start of the mill with cold work rolls normally ends with a bad flatness, this is changed using the expandable VC roll. Its application, therefore, makes a clear contribution to the reduction of the non-productive time of the rolling operation.

- Double acting hydraulic push-up cylinders (fig. 10): double acting cylinders, in which rod and piston are hydraulically loaded and which operate with differential pressure, provide a high dynamic response. Diametrically or centrally located digital position transducers ensure high accuracy of the roll gap positioning. This module is a mandatory component for almost every rolling mill modernisation programme.
- Horizontal roll stabilisation mechanism: the parallelism of the work roll axes is indispensable, particularly in wide rolling mills. Any deviation, even very small, markedly impairs the flatness control. The hydraulically-operating horizontal roll stabilisation mechanism provides, after each roll change, for the optimal installation positioning of the roll axes.
- Entry device with exchangeable sub-modules: the multiple functional units on the entry side of the mill, in conjunction with the short distance between the coiler and the roll gap, raise the question of good accessibility during servicing. The answer to this problem is the development of an entry device as a compact displaceable unit. During servicing, this can be moved out of the mill stands, allowing an optimum accessibility. Essentially, the entry device consists of the following quickly demountable, sub-modules:
 - Cooling spray bars for the upper and lower pairs of rolls: the sophisticated distribution of coolant is the most effective method for flatness control in light gauge strip and foil mills. The patented WIN Spray® S system (fig.11) with its exact positioning at the strip edges as well as its spray-width of only 26mm provides unique flexibility and precise volume control.

- Strip thickness measuring device: the choice of a particular gauge must be made in consideration of the instrumentation requirements and in consensus with the mill operator. An entry gauge is a part of the recommended constituents for a strip mill. Together with a laser strip speed measuring gauge, a thickness control according to the mass flow principle can be installed.
- Strip tension measuring instrument: if required, the entry device can be additionally equipped with strip tension measurement.
- Bridle cassette: the cassette design of the entry bridle enables fast and simple changing of the entire bridle assembly. The bridle, which, because of its mode of operation, has to be located as close as possible to the rolling gap and is therefore not easily accessible, can be driven out on rails as a complete assembly.
- Exit device with changeable sub-modules: for the reasons given above, the exit device is designed as a compact unit incorporating the following sub-modules:
 - Strip thickness measuring device: at the exit side, a strip thickness gauge represents the basic requirement for the simplest form of thickness control. X-rays or isotope emitters are used. For reasons of control technology, the installation has to be placed as close as possible to the roll gap. The division of the usual C-frame into a table and guidance frame combines the instrumentation demands for a constant measuring gap as narrow as possible, with the largest possible gap for service. In the Achenbach solution, the part installed above the strip can be hydraulically lifted to facilitate the cleaning of the machine; in this way, the access to the roll gap is maximised.
 - Laser strip speed measuring gauge: in the case of mass flow strip thickness control, a laser strip speed measuring gauge is another essential component of the exit device. In addition, this extra measurement improves strip tension control by calculating the recoiler diameter more accurately.
 - Strip tension measuring instrument: a strip tension measuring arrangement can be integrated into the exit device if required.
 - Flatness measuring roll (fig.12): this measuring roll represents a module of the highest priority. Achenbach manufactures this roll licensed by BFI, specially developed for lesser forces, which occur particularly in foil rolling mills. The new solid roll is able to increase the transfer ratio from 65% to 94%. It is characterised by rotational speeds of up to 3600 rpm, permissible temperatures of up to 300°C, and a wear-free optical signal transmission system.

- Ironing roll (fig. 13): this provides for a clean, straight winding process on the recoiler by regulating the tough force. Sensitive controls, together with three damping elements, ensure, even at winding speeds of up to 3000m/min, trouble free running of the ironing roll on the coil.
- Belt wrapper (fig. 14): the belt wrapper is used in combination with the ironing roll on the empty spool as an optimised wrap up system for strips and foils minimising the amount of scrap.

ROLLING OIL MANAGEMENT has a significant influence on successful modernisation concepts due to the diverse influences it has on productivity, product quality, and flexibility of production. The demands on the quality of the coolant must be reconciled with the multi-faceted and, partly, very different conditions of production. We know today that it is not always important to obtain the maximum attainable purity of the rolling oil; the current emphasis is rather more on the maintenance over a period of time of a definitive quality of rolling oil.

The following process engineering and regularly integrated modules provide a considerable contribution to the regulation and transformation of important rolling oil parameters:

- Solid filtration systems: in modular designed SUPERSTACK® II horizontal plate filters (fig. 15) the rolling oil is continuously and finely filtered in full flow by means of different media for pre-coating and via hoseless oil feed design. The desired quality is continuously measured and adjusted by the application of a new sensor technology. The newly developed CONDUSENS® sensor offers simultaneous at the same time protection against uncontrollable electrostatic charging, substantially lowering the risk of fire in the rolling mill.
- Rectification systems: organic rolling oil contamination by tramp or hydraulic oils, is eliminated in a batch process by the application of a WOR® - rectification system. At the same time the recovery of the rolling oil as new is guaranteed, thus closing the complete “recycling loop”.
- Fume extraction system: the constant thermal equilibrium of the rolling mill, necessary for good production results is achieved, apart from the selective application of rolling oil, by an optimised atmospheric environment in the mill stand. New, effective fume hoods, and appropriate mill stand enclosures, together

with the appropriate extraction volume for maximum rolling speed, ensure economic exhaust air disposal, and pleasant working conditions for the operating personnel.

- Exhaust air purification plant: high performance AIRPURE® systems effect the elimination of rolling oil from the exhaust air in the system in an absorption and subsequent desorption process for direct re-use. These systems fulfil all valid world-wide environmental standards. They are characterised by a variable exhaust fume adjustment in connection with the rolling speed.

The consistent application of the cycle principle of process engineering systems described above allows OPTIPURE® systems (fig.16), with their high process efficiency, to deliver maximum working reliability throughout the entire rolling process, to minimise the rolling oil consumption, and, at the same time, to lead the way into extensive environmental protection.

Trends in the Development of Rolling Mill Building

In conclusion and without any claim to comprehensiveness, reference should briefly be made to trend-setting developments in the area of process automation, drive technology, and mechanical systems. These ideas should be considered with respect to the further development of the technologies mentioned above, as well as in the development of new integrated problem solution modules.

The following are examples of just some of the trends in the *area of process automation*.

- The comprehensive visualisation that all plant and process parameters comply with the standards demanded is progressing (fig. 17).
- The application of modern teleservices is increasingly supporting the normal maintenance functions. Without exception, all modern rolling mills today are provided with a dialogue option. Even in the planning phase, it is advisable to take this into consideration if only to evaluate the optional application of all conceivable tele-service instrumentation on the one hand, and to guarantee, on the other, compatibility with all available computer networks. In this way, world-wide communication with the rolling mills becomes possible. Some of the relevant

criteria are: data security, control of access authorisation, determination of local data transmission rates. These requirements are necessary to ensure that at all times, and from every location in the world, optimal connection quality can be established.

- A trend-setting feature, both in new mills, and in the refurbishment of existing rolling mills, is the implementation of mass flow control in strip and light gauge strip rolling mills. The result of this technology is the production of an increased material “filet”-cut of tight tolerances in the phases of acceleration and deceleration.
- In order to prevent unexpected downtimes plus their resulting costs, producers are going over to the idea of having early warning diagnosis systems in the planning stages of the plant control system. The foundation for such a diagnosis system is the analysis of any weak points of the final integrated system. In addition, modern SPS controls are already available providing a multiplicity of diagnostic possibilities with regard to malfunctions which may appear, and for the facilitation of preventive maintenance.
- The installation of interfaces for the download and storage of important plant and production data to a database on a master computer is of growing importance.
- Connected with the selection of the sensor technology, and with the design of the mechanical components increasing attention must be paid to the possibility of the regular use of mobile measurements, for example a vibration analysis of the mill stand or the transmission gears. In order to get repeatable signals, it is necessary to set the vibration sensors in exactly the same positions or build-in the measuring points in such a way that reproducible measurements are guaranteed during the application of the mobile device.

In the *area of drive technology*, the increasing importance of frequency controlled AC technology ranks among the substantial trends. The improved capabilities of inverters opens the way for their intensified application in the rolling mill drives. Among the undisputed advantages of the frequency controlled AC drive in relation to DC drives, from the point of view of the mill user are a minimisation of motor maintenance, a better overload capacity of the motors, as well as an optimal loading of the power supply. Consequently, rolling mills with large drive powers have already been equipped with this type of drive; in the case of foil mills, their application is, however,

currently being intensively discussed. The strip tension range, between the minimum and maximum values on the one hand, and the influence of strip tension on the quality of the strip thickness on the other, impose particular conditions on the torque regulations of the drives. Optimal control of this parameter is a substantial consideration of on-going developments in this field. The additional sensors necessary for the application of frequency controlled AC drives in foil mills are already available. By giving the feedback of the measured torque at the coiler into the model representing the asynchronous induction motor, a substantial prerequisite for the intensified application of the frequency controlled AC technology is fulfilled. A further advantage of induction motors is that they can be more compactly constructed than is the case with DC motors. Finally, if one considers only the investment costs required for AC technology, then they appear too high. But including the costs of foundation modifications, alterations to the power supply, and the time necessary for the modifications, the sum balances out. The comparatively small time spent on maintenance, as well as positive effects on the power supply costs due to the improved $\cos \phi$ lead to long-term savings in operation costs.

The complex target of strip area maximisation implies further development work, not least in the *area of the mechanics* of the mill.

A particular challenge arises after a certain level of control technology has been achieved and productivity increases are sought through the integration of the mill into the general production facility environment, as well as through *a) coil and spool handling* concepts which are designed to minimise non-productive time. This applies particularly if, apart from the goal of productivity increase, a strengthened universal application of the rolling equipment is desired, that is if a range of different products are to be rolled. In this case, the greatly varying spool dimensions may be very different, requiring new design solutions which nevertheless are easily put into practice. The ambitious target of downtime minimisation always requires a problem solution which is specific to the individual customer. In the following, just three mechanical aspects, particularly important for the future, are discussed:

- With regard to coil cars, the handling of spools and coils of differing dimensions implies, firstly, a requirement for high adaptability of the lifting rams according to

the spool and coil diameters. In addition to this, the adjustment of the side supports of the coil cars is necessary to accommodate different spool lengths.

- With regard to the coilers, it is important for strengthening the universal application of the rolling mill that the hydro-mechanical clamping mechanism is appropriate to the differing spools and coils and provides the highest reliability. This applies to expansion drums and to stub mandrel or cone arrangements.
- With regard to spool handling, it is important to support short coil change times of less than 3 minutes. On the basis of the individual production concepts of every rolling company, and the plant space constraints which can be particularly limited in modernisation projects, concepts of constructionally optimised spool handling systems have to be developed guaranteeing, on the one hand, that the transportation and cleaning of pup-coils is handled during the active rolling process, and on the other hand, that the refill of the emptied spools into the system is possible and problem-free, ensuring the optimum networking of the total system. Furthermore, it should be possible to insert empty spools without handicapping the active rolling process.

The development towards ever increasing rolling speeds, and the simultaneous increase in material width also raises complex problems for the mechanical design of *b) the central part of the mill*; in the following, the most significant trend-setting solutions in the mill central part are briefly discussed:

- With increasing width and the requirement of universality, it has to be considered whether 4-high or 6-high mills are more appropriate to fulfil the tight quality and productivity specifications. Even though 6-high mills are more sophisticated and require higher investment and operational costs, the advantages of their greater universality are sometimes convincing. Achenbach's 6-high mill design can be used for new mills and especially for conversions from 4-high mills in modernisation projects.
- Related to the trend towards the change over to frequency-controlled AC drives in connection with increasing rolling speeds, one can detect a movement away from the contemporary oil mist lubrication design for the roll bearings in favour of a return to classical oil circulation lubrication. This allows a better control of the bearing temperatures, which increase in proportion to the increased rolling forces

and rolling speeds, and will become extreme at future rolling speeds of more than 2500 m/min. A suitable cooling device for the circulating oil is required.

- Furthermore, special modifications to the design of the roller bearings, as well as to the sealings, are necessary in order to be able to roll at such high speeds. This refers to the design of new dynamic sealing elements and to the roller bearings themselves, whereby the thrust bearings have to be designed with one fixation only. Thus it can be ensured that thermal variations in the length of the rolls are compensated and also the bending of the rolls due to the applied rolling forces.

Summary

Taken on the whole, the topic of modernisation requires, to a particularly high degree of skill on the part of the supplier to project himself into the specific situation of the rolling company, and to understand concretely the production philosophy within the existing technical framework set by the existing rolling mill. Successful rolling mill modernisations require far reaching satisfactory ROI's, and increasingly "integrative" technical solutions.

Additionally, modernisation projects demand a special commitment from the plant supplier in order to achieve the ambitious and complex improvement targets within an environment in which the permissible technical degrees of freedom are smaller than those available in new projects. Consequently, even within a comparatively narrow project scope, it is necessary to pay attention to finding solutions for details. Integrative problem solving modules from ACHENBACH permit "soft transitions" at all levels in the various existing interface complexities. This presupposes, parallel to a high degree of technical expertise and experience, a high level of involvement and motivation on the part of the mill supplier in his relationship with the rolling company. Such commitment can only be a result of an exceptional readiness to provide customer service. Therefore, the selection of the right supplier for the planned modernisation counts as one of the most significant factors for the successful completion of a modernisation project.

Fig 3 – Goal Determinants

Changes in Product Flexibility (Product Mix)

Enhancements in Product Quality

Increase in Production Flexibility (Just-in-Time)

Increase in Productivity

GOAL – MODERNISATION

Fig. 4 – Determinants of Concept Development

System Operator

Know “What”

Sales Forecast

Market Strategy

Production Philosophy

Goals

Know “How Together”

Good Business Relationships

Effectiveness

Efficiency

MODERNISATION CONCEPT

System Provider

Know “How”

Technological Developments

Experience

Quality Philosophy

Technology

Fig. 5 “Integrative” Technology

Mechanics

Drive Technology

Automation Technology

"INTEGRATIVE" TECHNOLOGY

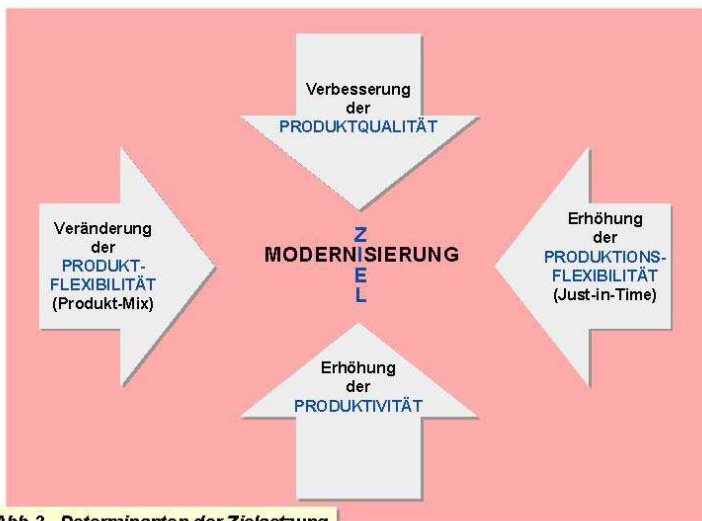


Abb.3 Determinanten der Zielsetzung

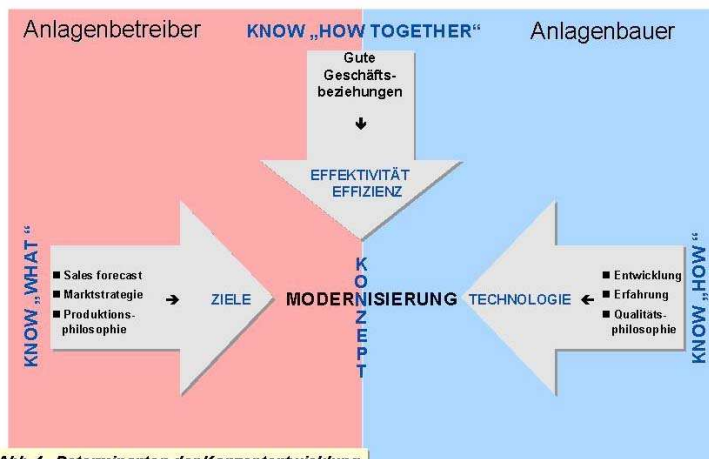


Abb.4 Determinanten der Konzeptentwicklung

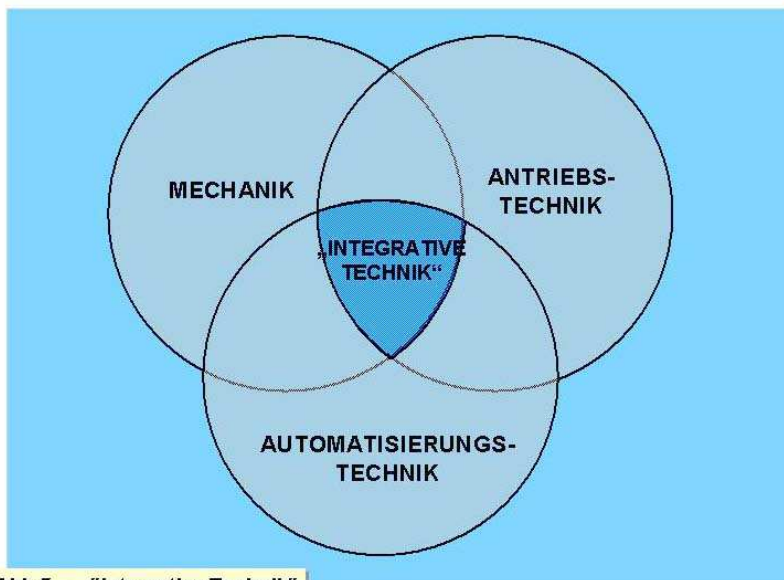


Abb.5 ... "integrative Technik"