

Modernization of extruders

Ready-to-connect automation system, part 1

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What distinguishes today's technology for extruder automation?

What are the effects on manufacturing quality, reliability, and setup times?

When does it pay to upgrade existing extruders with the new automation technology?

Which additional advantages emerge during practical use?

What are the future trends?

Based on examples of proven strategies and solutions, this article attempts to provide answers to these questions. Moreover, it will also be possible to give an initial assessment of the individual situation in an extrusion plant, and which benefits can be expected from applying the latest automation technologies in an equipment upgrade – for the machine operator as well as the company manager. The screenshots shown here come from a varioEC system, a new automation concept from PMA in Kassel, Germany, that is independent of the machine make.

Extruder automation – reflections on technology, then and now

If one takes a closer look inside an extrusion plant, one is likely to discover several generations of technology in daily use, all of which were introduced during the past decades. Thanks to robust machines and in-depth knowledge of process technology, it has always been worthwhile to keep the plant at the most up-to-date technical level in terms of measurement, control, and automation equipment.

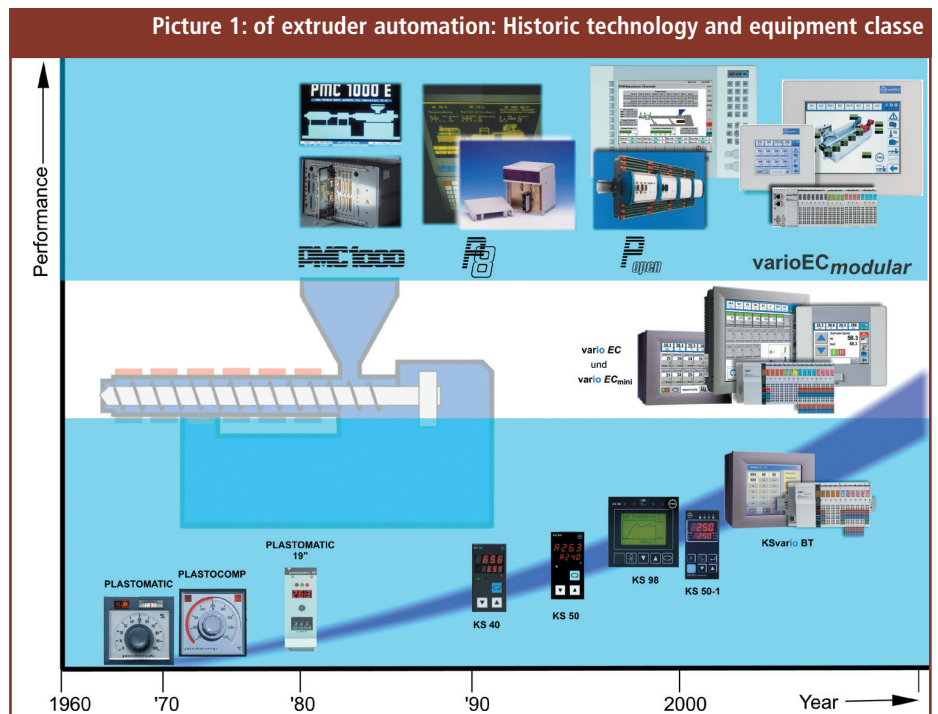
Starting in the mid-'60s, the shock and vibration-sensitive mechanical controllers with chopper bars were replaced on a wide scale with compact electronic ("transistorized") controllers such as the legendary Plastomatic. During the '70s, versions were available with analog as well as the more accurately reproducible digital setpoint adjustment. Similarly, relay-based programmers were replaced with their electronic counterparts. New control algorithms (DPID; PDPI; PID_) brought decisive improvements in control behaviour of the previously used PD or PID controller types. Integrated limit monitoring ("limit comparator") was used to enable screw operation or to maintain a quality tolerance band. At about the same time, digital process value displays ("nixie tubes") emerged, but they were unable to displace the lower-priced analog displays

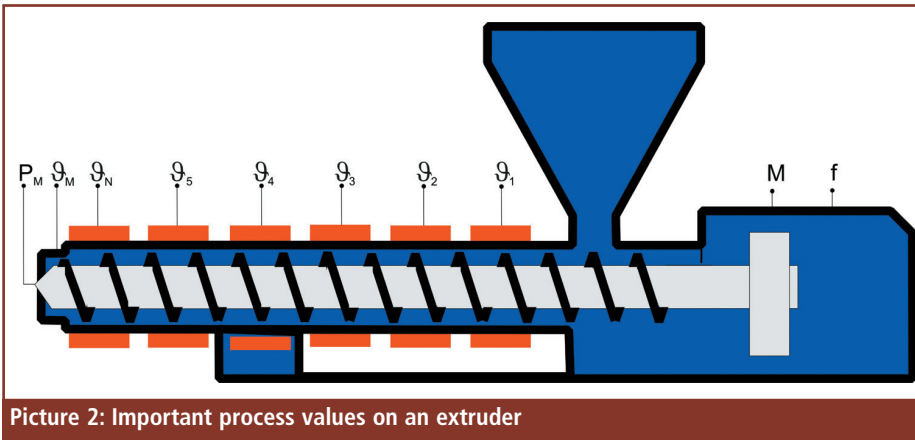
(pointers, string of LEDs; motor-driven red band). For single-loop controllers, digital technology was not introduced before the early '90's, when microprocessors became cheap enough to be used also in low-cost equipment. Widespread success of μ p technology in compact devices started with the KS 40 controller range in the early to mid '90's – also for standard extruder instrumentation. Functions intro-

duced in addition to temperature control (adaptive parameters for heating/cooling), were controlled setpoint (standby, ramp, profile), multiple limit monitoring (absolute and relative), and heating current monitoring (absolute, 1 and 3-phase). It was also automatic current monitoring and display that finally made the traditional ammeter superfluous.

However, the trailblazers for widespread use of digital technology were multi-zone controllers such as the Multiplastomatic (introduced at the K'79) and especially the PMC 1000 systems (introduced in 1983) with 12-channel temperature controller modules, colour terminal operation and recipe storage, as well as plug-in electronic data carriers. Operating convenience was greatly enhanced by sophisticated graphic elements such as pictographs and trend curves, self-tuning procedures for control parameters, automatic drive sequencers (teach function), and uniform, process-related operating strategies. Also introduced for this new generation were the first links to superordinate production management computers.

During the following decades, the modules became ever smaller and more powerful. Control algorithms were perfected and optimized for universal use. CRT displays were displaced by flat screens, and standardized field buses linked the compact automation modules (P8, P-open), which replaced the more voluminous 19-inch card technology. Optimization proce-





Picture 2: Important process values on an extruder

dures such as gravimetry, pipe centering and wall-thickness control were integrated by means of field bus concepts.

Today, a wide range of especially compact touchpanels (e.g. for the varioEC systems with screen diagonals from 5,7" through 10" and 12" up to 20") are available, and permit simpler fingertip operation – a method that has meanwhile been fully accepted in practice by machine operators. Moreover, current industrial PC technology allows the cost-effective use of established techniques from the office world (Ethernet port, OPC server) for linking into company Intranets, remote diagnostics via Internet, quality assurance procedures, database analyses, etc.

What's more, the performance of today's automation modules has increased to such an extent that many tasks can be handled reliably by a few or even a single microprocessor (multi-temperature control, melt pressure measurement, screw speed control, etc.). Simultaneously, the reliability of electronic components has also increased: Moving mechanical parts such as cooling fans or hard disk drives are no longer required, and a significantly longer service life of back-lighting are features of today's technology.

Another important development has had a significant impact: Costs have been cut dramatically during the past decades. Now, the purchase price of an extruder fitted with the most compact automation system varioEC is considerably lower than when fitted with discrete, individual devices (single-loop controllers, drive controls & displays, melt pressure monitoring), whereby the installation costs for the new compact systems are also far lower. In addition, the new technology offers numerous other financial benefits for the user, which will be discussed in detail in the following. (Picture 1)

Upgrading existing plants – Criteria for efficiency

Why should extrusion plants be upgraded at all?

The purely mechanical parts of an extruder remain functional for several decades, provided that wear-prone parts are replaced in good time. Nonetheless, the availability of older plants drops, and costs increase in spite of preventive maintenance measures. Defects in older relay-based controllers, CRT displays, and sequence controllers occur more often, which leads to increasing repair costs and more frequent production losses.

What's more, today's demands on production are increasing, and even with "simple" as well as older extruders there is a growing need for retrofitting measurement functions, e.g. for quality assurance or production optimization. However, the costs involved for the installation of separate data acquisition systems are practically the same as for an upgrade with the new, compact, all-inclusive automation systems.

Reproducible production also means archiving of recipes and reliable repetition of setpoint settings. Similarly, to exclude the risk of human errors as far as possible, comprehensive data processing methods are necessary, which older systems simply cannot offer.

In short: There is a wide range of wishes, but it is not always possible to invest in entirely new extrusion plants. In these cases, a cost/benefit comparison with upgrading measures is advisable before an investment decision is made.

However, one decisive question must be answered first:

Who can / should carry out the upgrade?

- If there is no in-house electrical department, upgrading and commissioning must

be done by external suppliers for automation and control cabinet.

- With in-house electrical competence, the necessary work can be shared: Electrical work can be done in-house according to the automation supplier's specifications, whilst commissioning requires the support of external specialists.

- If in-house electrical competence as well as own automation experts (programmers) are available, and provided that agreement is reached on disclosure of the basic software (sources of the entire package), it is even possible to implement customized solutions for the operator interface and the sequencing programs (PLC according to IEC 61131-3). Admittedly, this approach is more likely to be used by machine manufacturers and large extrusion plants.

Essential process values – the physical basis

Apart from the temperature control loops (heating/cooling) of the individual zones and the display of melt temperature with all monitoring functions (start-up disabling, screw enabling, tolerance band, excess temperature, e.g. alarm in case of excessive friction or short-circuited SSRs), the respective heating currents are also monitored. Screw speed is measured, and the associated load value (torque) is monitored. Melt pressure is also measured and monitored. Automatic calibration of the melt pressure strain-gauge sensor is integrated. Additional measured values from the periphery can be connected to the system within the scope of available free inputs. In this way,

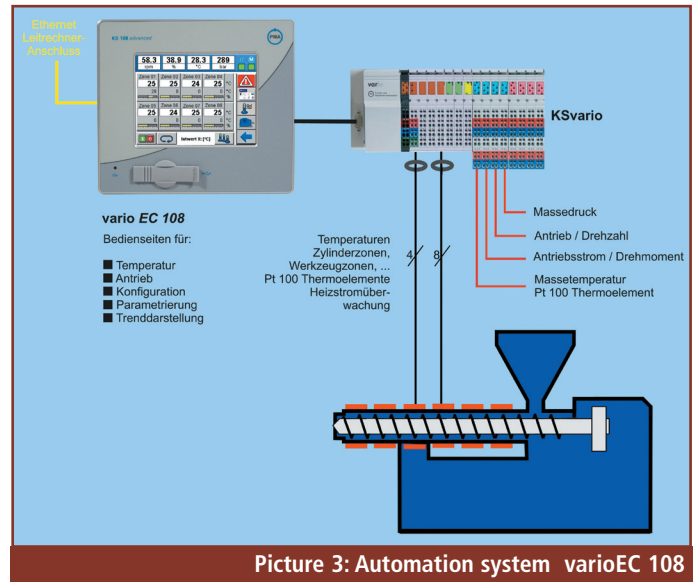
all the "classical" signals of an extruder are measurable and/or adjustable. (Picture 2)

Which tasks must be solved, and how?

The solution approach described here leads to a complete automation system consisting of a compact colour display terminal and modular, DIN rail mounted I/O units for the digital and analog signals from process and machine. The software for machine operation, sequencing, and control is "ready to use", and only needs to be configured on-screen for the application in hand (no. of zones, drives, etc.). Subsequently, only the necessary operating parameters will be displayed on the screen. (Picture 3)

The following classical standard extruder tasks are solved

Temperature control, screw drive with speed control and display, torque monitoring, melt pressure monitoring, synchronization of a second drives (e.g. haul-off). Similarly, various data interface ports (also acc. to EUROMAP 27) permit e.g. the synchronization with co-extruders (master/slave) as well as communication with supervisory computers (measurement data acquisition, MES/ERP host computer).



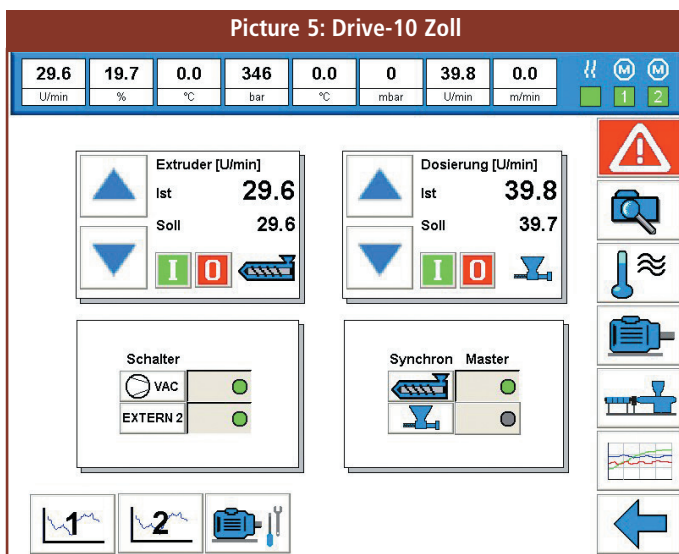
Picture 3: Automation system varioEC 108

Additional analog signals allow the connection of sensors and drives. However, due to the very compact design, there are hardware limitations regarding future expansion possibilities. But all the classical tasks are fulfilled, so that extruders upgraded in this manner can also be integrated as sub-stations into the overall automation of more complex extrusion plants, practically "without limits".

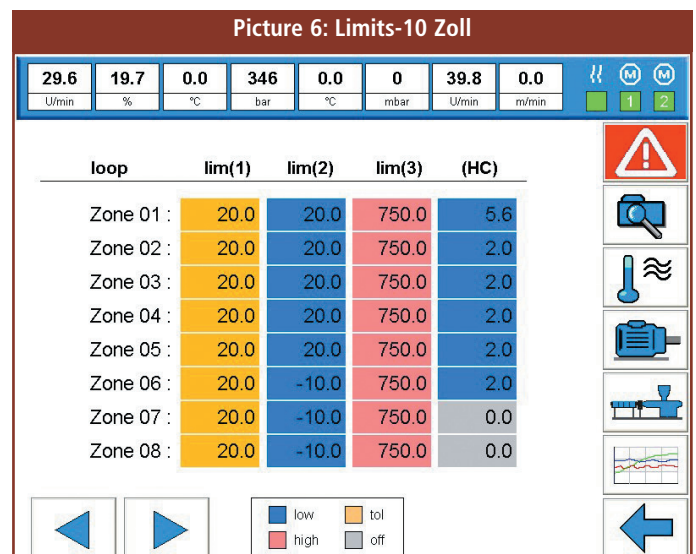
The table shows three upgrading options for various extruder types (standard extruder, laboratory extruder, satellite extruder, co-extruder, etc.).

Transparent processing – Staying in command through ergonomic display screen layout

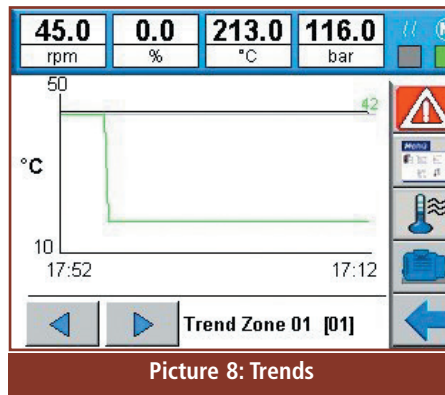
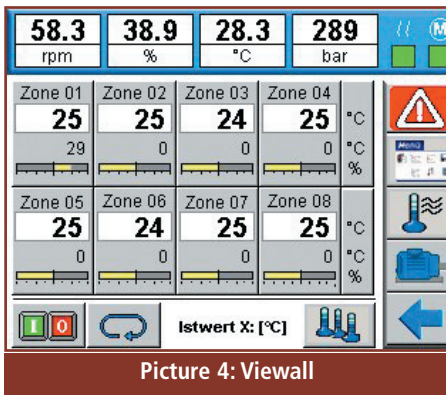
The following screenshots (Picture 4 - picture 8) show the basic layout principle:



Picture 5: Drive-10 Zoll



Picture 6: Limits-10 Zoll

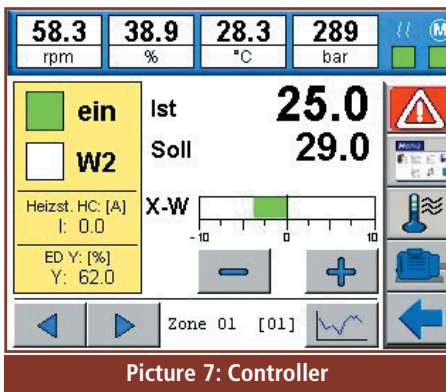


To prevent the "keyhole effect", important process values (e.g. melt temperature and pressure, screw speed) and statuses (e.g. heating and drives On/Off) are displayed in the upper part of the screen on every page. This refutes the argument that "screen-based systems can always show only part of the process, but installations fitted with individual instrumentation show all the data in parallel". Which ever process section page you happen to be on, you always have an overview of the entire process, so there will be no unpleasant surprises.

Process-related screenshots offer advantages: All zone temperatures are displayed on one page, where any deviations are seen clearly, trend curves provide a detailed overview, and from where they can be individually operated. All drives can be monitored and adjusted individually or synchronously. This also permits an automatic synchronization of the co-extruder with the main extruder.

Individual operating pages provide a condensed view of the adjustment parameters on a single page, e.g. there is no need to switch displays during special test runs – cause and effect are seen immediately.

The temperature controller pages serve as a transition to the next topic: Routines running automatically in the background, but which can be viewed on demand (no "witchcraft" is involved).



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Properties	Option A	Option B	Option C
Touchpanel size and type	5,7" / STN	12,1" / TFT	5,7" oder 10,4" / TFT
No. of temperature control loops	up to 12	up to 20	up to 16 / up to 20
No. of drives	1	2	up to 2
Melt pressure	1	1	1
Melt temperature	1	1	1
Timer	–	x	x
Datalogger	–	x	x
Data storage, recipe memory	Flash card	Flash card	Flash card
External, from the front	–	–	USB stick
Ethernet network TCP/IP	x / FTP	x / FTP	x / FTP
CANopen with EUROMAP 27.5	–	–	x
Integrated sequencing functions (acc.to IEC 61131-3)	x	x	x
Integrated visualization and operating functions	x	x	x