Press Technology for LFT-D Part Production

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Outline

- Introduction
- History
- Press Requirements
- New Press Concepts
- Presses & More - Teaming up in development
In-line compounder
LFT die
Conveyor belt for LFT strand
Provision of rovings
Mixing extruder
Hydraulic Press
Fully automated material handling
AVK-TV
Innovationspreis
2001
LFT-D-ILC
Base Equipment
High Speed Compression Molding
Growth of LFT in Europe

Quelle: AVK-TV 2005
History on Development
(based on Dieffenbacher development)

1929  The first plastics molding press

1960  The first SMC press

1970  The first large-sized SMC press with parallel motion control

2006  The COMPRESS PLUS
Why High Speed Compression Molding

- Reduced pressureless time
  Typical closing time $\leq 4$ sec

- High speed molding
  (increase of filling profile
  e.g. rips or shaped parts)
  up to 80 mm / sec
  [ 188 inches / min]

- High speed retraction
  (reduction of cycle time)
  up to 1200 mm/sec
  [ 2830 inches / min]

- Total achievable cycle time
  (reduction of cycle time)
  $\leq 20$ sec
  [ increase of part production per h ]
Why High Speed Parallelism Controlled

- Reproducible molding conditions even at eccentric load conditions
- Velocity controlled material distribution
- IMC availability
- Data Acquisition System
- PLL system provides parallelism of mold clamping system up to 0.06 mm
- PLL system provides high accuracy in closed loop control molding
- PLL system “learns” the actual position of the clamping profile and enables an even distribution of the IMC coat onto the product
- PLL system provides visibility of the forming process
One Year Ago – Advantages of LFT-D

Advantages regarding material properties

- Tailored LFT material → Choice of matrix resin, additives and fibers
- Adjustable and reproducible fiber length distribution
- Continuously adjustable glass fiber content
- Excellent homogeneity of LFT strands
- Co-molding of continuous reinforcements at low thickness and weight compared to injection molding possible
- Single heat history
One Year Ago – Advantages of LFT-D

Advantages regarding economical facts

- High productivity
- Low wall thickness possible compared to injection molding (material savings approx. 25%)
- Low down time due to turnkey production cell
- Significantly reduced expenses for total process energy consumption
- High material output rates at constant and reproducible material properties
- Extremely short cycle time (22 seconds for VW Golf V underbody shield)
- Reduced mold and screw wear
One Year Ago – Why?

- Energy consumption

- Energy costs are becoming an issue for part production

- Short Cycle Times
  Parts are getting thinner, now down to 1.5 mm, means speed is not only a factor of forming it is a factor of economy

Prediction: Oil Prices will further increase

![Bar graph showing oil prices from 2001 to 2006 with prediction for 2006]
Motivation for Further Development

Considerable decrease of production costs

Initial Situation

- Very high energy requirement with modern LFT-presses, e.g. 3600 tons press, installed power 600 kW at a 20 s cycle time
- Shortening of the closing cycle
- Decrease of consumables
- Modernization of press control

Targets

- Drastic saving of the energy consumption with press operations during parts production
- Increase of productivity
- Process improvement through reduction of the pressureless dwell time
- Less operating oil
- Less water consumption for oil cooling
- Increase of diagnostic possibilities
Measures Taken to Reduce the Energy Requirements

Considerable decrease of production costs

Initial Situation

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Measures Taken to Reduce the Energy Requirement

- Reduction of the compression volume
  - Development of a short stroke system

  Referred to the maximum stroke, only 12 % of the oil volume must be compressed within the cylinders.

\[
\Delta V = 88 \%
\]
Measures Taken to Reduce the Energy Consumption

- Effective utilization of accumulator energy
- Separation of high-pressure and low-pressure accumulator.
- Utilization of the high-pressure accumulator only for the residual 30 mm of the working stroke
- Reduction of the pump flow volume
- Reduction of the required pump drive power
- Reduction of the cooling power requirement
- Reduction of the oil requirement.
New Closing Concept COMPRESS PLUS

- Initial point of slide in upper dead center
  - DCP: Piston rod slides into trunk piston
  - DC: Pressure medium is sucked via prefill valve
- Braking of slide to working speed
  - DCP: Acceleration of the trunk piston
  - DC: Closing of the prefill valve
  - Locking of the piston rod with trunk piston
  - Changeover to pressing speed
- Build-up of working pressure
  - DCP: Pressure build-up low-pressure
  - DC: Pressure build-up high-pressure
  - DCP: Pressure build-up high-pressure
COMPRESS PLUS – Short Stroke System

Reduction of the energy consumption by means of new closing concept for the COMPRESS PLUS
### Energy Balance
**Long Stroke versus Short Stroke System**

<table>
<thead>
<tr>
<th>Cycle time</th>
<th>s</th>
<th>20</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving power</td>
<td>kW</td>
<td>360</td>
<td>605</td>
</tr>
<tr>
<td>Cooling water demand at Delta T=10 K</td>
<td>m³ / h</td>
<td>12.4</td>
<td>26</td>
</tr>
<tr>
<td>Energy demand for cooling water supply</td>
<td>kWh</td>
<td>2.9</td>
<td>6</td>
</tr>
<tr>
<td>Energy costs per year with 5,000 h</td>
<td>Dollar</td>
<td>180,000</td>
<td>305,000</td>
</tr>
<tr>
<td>Energy saving per year</td>
<td>Dollar</td>
<td>125,000</td>
<td>90,000</td>
</tr>
</tbody>
</table>

Savings are based on calculation data, actual results may vary, energy costs at 10 ct/kwh
COMPRESS PLUS – Objective Achieved

- Reduction of the energy requirement
- Faster pressure build-up
- Increase of the closing speed
- Improved ease of use
- Saving of the energy consumption by means of a newly developed press drive system
- Achieved by shorter pressure build-up times
- Effectiveness with faster closing speeds (1,200 mm/s) at a total stroke of > 1,500 mm
- Development of the new short stroke system.
- Increase of the technical availability.
COMPRESS PLUS - a High Performance Hydraulic Press

- Pressing force 30,000 kN
- Table size 3,600 x 2,400 mm
- Velocities
  - closing/opening 800 mm/s
  - pressing 70 mm/s
- Pressure build-up value 0,4 sec
- Double-cavity molding
- Total cycle time 20-30 sec
- Active parallel levelling system
- Disconnectable ram guiding system
- Hydrostatic ram connection
- Data analysis system
- PC control
LFT-D-ILC Compression Molding Technology
Production and quality monitoring system

- Data acquisition and analysing system for statistic evaluations and allocations of relevant parameters
- Acquisition and presentation of machine and processing data with variable time grids (e.g. velocities, positions, forces (variance values) etc.)
- Max. 40 channels at the same time
- Max. 4000 measuring values per channel and cycle
- Hard disk capacity of approx. 70 MB for analysing system
LFT-D-ILC Compression Molding Technology
Production and Quality Monitoring System

- Trend development of the production process (process stability)
- Part-related statistic evaluations of the acquired process values with allocation by means of a barcode printer
- Separation of rejects
- Logging and presentation of cpk and cmk values

Presentation of the trend development of the production process

Evaluation of process data with Gaussian Distribution Curve
LFT-D/ILC – Superset PC Line Control System

- Production line control of complete production unit integrated into the PC control
- Recording and evaluation of machine and process relevant data with a variable time grid
- Display of set and actual values of recorded data
- Interface to statistical process control (SPC) and production data control (PDC)
- Supervision and acquisition of all relevant parameters for quality assurance including barcode identification of each part
LFT-D-ILC Technology
Highly Economical Process

- Production Example:
  - VW underbody shields PQ 46
  - Dimensions 1650 x 450 mm
  - Weight 1500 g
  - Production Double mold
  - Cycle time 22 s
  - Production rate 1,400,000 parts/ year
  - Based on:
    - 220 days / 22 hours / day
    - 85% efficiency

- Comparison vs. injection molding
  - Production Single mold
  - Cycle time 50 sec.
  - Production rate: 300,000 parts / year
  - Based on:
    - 220 day / 22 hours a day
    - 85% efficiency
LFT-D/ILC - Efficiency of Compression Molding

Data and cycle times of a production line for under covers

**Line data**
- **Hydraulic press**
  - Press force (kN): 30.000
  - Table sizes (mm): 3.600 x 2.400
  - Closing + opening time (s): 7
  - Cooling time (s): 8
  - Pressure build up time (s): <0.5

- **Extrusion line**
  - Capacity (kg/h): 600

- **Automation**
  - Part-/material handling (s): 5 included

- **Punching**
LFT-D/ILC - Efficiency of Compression Molding

<table>
<thead>
<tr>
<th>Production capacity</th>
<th>LFT-D/ ILC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cavities</td>
<td>2</td>
</tr>
<tr>
<td>Cycle time (s)</td>
<td>20</td>
</tr>
<tr>
<td>Productivity (parts/min)</td>
<td>6</td>
</tr>
<tr>
<td>Production rate (parts/year) based on</td>
<td>1.600.000</td>
</tr>
<tr>
<td>220 days,</td>
<td></td>
</tr>
<tr>
<td>3 shifts 7,5 h</td>
<td></td>
</tr>
<tr>
<td>Up time 93%</td>
<td></td>
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</table>
Dieffenbacher „Engineering Area“

- Hydraulic High Speed Press 36,000 kN with active parallel levelling system
- LFT-D Plant
- Conveyor and dosing plants for various plastics, granules and recycled materials
- Adjustable die for tailored plastificates

Research and Development

- Development of new process technologies and modifications suitable for the processing of long fiber-reinforced polymers
- Simulation of Mold filling by Fraunhofer ICT
- Matching and prototype production
- Material development in cooperation with ICT
Closing Words

The In-line Compounding-Compression Process is an established technology for long fiber reinforced components which offers a high development potential for future applications especially for structural and semistructural parts as well as for car body parts aiming at class „A“ surface quality.

www.dieffenbacher.de
www.ict.fraunhofer.de