Transfer machines: state of the art and future evolution
January 24th 2007

The company history

1963: Riello Macchine foundation as Riello Macchine Utensili, evolution of RIELLO BURNERS tooling room
1995: Start of Flexible Transfer Machines production (Vertiflex)
2000: acquisition of Mandelli S.p.A.
2001: acquisition of Burkhardt & Weber in Germany
2003: Starting of operational activities on the site in Shanghai
2005: acquisition of TriWay in Canada

Actual organization of RIELLO SISTEMI S.p.A. group, is based on 4 geographical areas (RIELLO SISTEMI Italia, RIELLO SISTEMI Germany, RIELLO SISTEMI North America e RIELLO SISTEMI Shanghai) with 4 production plants
Design and building of machining centers, Flexible Production Cells, Special Purpose Machines and Rotary Table Transfer Machines
Riello Sistemi Group

Brands

riello macchine

mandelli

BURKHARDT WEBER

TW TRI-WAY
Turnover Riello Sistemi Group
(million euro)

Final result 2005: 102.5 million
* Budget 2006: 110 million

Turnover Riello Sistemi Group
by market

Energy & Systems
15.39%

Automotive
33.22%

Miscellaneous
7.94%

Tractors & Big Engines
1.00%

Aerospace Ind.
15.04%

Manuf. Ind.
9.79%

Brass & Steel Fittings
12.85%
Production plants

RIELLO FACTORY  
Minerbe (Verona) – Italy  
→ Overall area: 50,000 mq  
→ Covered area: 10,000 mq

BURKARD+WEBER FACTORY  
Reutlingen – Germany  
→ Overall area: 39,000 mq  
→ Covered area: 14,100 mq

MANDELLI FACTORY  
Piacenza – Italy  
→ Overall area: 20,300 mq  
→ Covered area: 19,000 mq

TRI-WAY FACTORY  
Windsor – Ontario Canada  
→ Overall area: 9,325 mq  
→ Covered area: 3,393 mq

Riello Macchine product lines

3 different product lines, with the same market target: high volume production

- TTR rotary table transfer machines: 2÷30 s
- VFX flexible transfer machines: 25÷90 s
- MC4 2/4 spindles machining center: 60÷300 s
Typical transfer application

Transfer main features

• Customer oriented solution
• Highly tailored machine configuration
• Mix of standard and special component
• Quality and reliability are given but every machine is a prototype
Market evolution: key points

- Outsourcing of machining from typical transfer users
- Logistic cost reduction (just in time, stock reduction)
- Volume broken into many small batches
- Volume reduction: needing to saturate production machines with different components and machine changeover
- Shortened life cycle of product

Production outsourcing

Subsuppliers have more and more restrictions:
- Job is not warranty for long time (prices revision every year)
- Probability of modification of the component to be machined (no constraint for the customer related to internal equipment modification - it’s a supplier problem) and consequent modification to dedicated machinery
- Machine reusability for other job/customer (reconfigurability)

Equipment requirement:
- Easy setup and changeover
- Reduced downtime of the machine for setup operation
- Machine adaptation to geometrical shape modification of the parts to be machined
Transfer machines main features

- Customer oriented solution, highly tailored machine configuration
- Up to 14 stations, with 3 main spindles in every station
- Many tools contemporary working (up to 36 if directly fixed to the main spindle or even more with multispindle unit)
- Mix of standard and special component
- Every spindle has normally 1 or 2 axis, but may have up to 4
- Dedicated to a single component or to a family of similar component, often with special devices integrated
- Very high production rate with the best performance as cost per part
- Low space occupation in workshop

Transfer machines evolution

From rigid to flexible machines through control system modification:

- Gradual evolution from wiring to programmable sequence
- Adoption of CNC control
- Development of HMI more and more easy-to-use

Application of devices to modify the geometry of working spindles:

- Linear or angular slides manually operated to allow machine reconfiguration
- Evolution to CNC operated slides to decrease setup downtime
- Implementation of rotary axes
Transfer machines evolution

Integration of tool changes devices:

- To allow 2 or 3 short operations with the same spindle when the accumulated cycle time is still within the longest operation time

Integration in the machine of CNC machining centers:

- Complex path operation like of 2 or 3 axis interpolation
- Easy setup for machine changeover
- Easy reconfiguration for optional features in different batches

… a hard job:

- The space allowed inside the main frame to accommodate cross or angular slides is always a problem
- Protection from coolant and chips is an issue (several spindles working close each other projecting chips i.e. during a tool change inside the machine)
- “Not working time” is dramatic: needing for high acceleration (speed is not an issue) and low idle time
- … but shocking of the main frame due to moving mass must be avoid

… and an expensive and time consuming job:

- Every “reusable” device must be standardized to contain costs and reduce the time-to-market of the machine
- Machine composition become a mix of well-known components with some special application
Some modular component

Trunnion machine frame
Unit head
Cross slide
Rotary table

Some application

Angular adjustable unit head
Self centering chucks with CNC controlled rotating jaws
Some application

2 axis turning unit head

Inside the machine

Some application

Complex transfer machine

3 axis module
Transfer reconfiguration: an example

Scenario:

- Customer needs special equipment to produce 3 different parts
- Part A: 1,000,000 pcs/year – no change in the future
- Part B and C: 500,000 pcs/year each for 18 months – then product change with same volumes B, C → D, E

Part B and C
→
Part D and E

Transfer reconfiguration: the layout

Line 1 (part. A)  Line 2 (part. B, C)
Transfer reconfiguration: the process

Line 2 - first machine – original process

Line 2 - first machine – modified process

Line 2 - second machine – original process

Line 2 - second machine – modified process
Transfer reconfiguration: the modification

Machine 1 frame top view
Transfer reconfiguration: the modification

Machine 1 frame
bottom view

Machine 2 frame
top view
Transfer reconfiguration: the modification

Machine 2 frame
bottom view

The flexible transfer machine
Vertiflex
A new approach to flexibility and reconfigurability requirement of transfer machine came from Riello in middle '90 with the Vertiflex line:

- A standard machine where the unit heads are replaced by dedicated 3 axis machining centers
- Main rotary table accommodating 4 or 6 rotary axis
- Up to 8 machining centers with revolver type tool changer; up to 8 spindles contemporary working with a maximum of 48 tools
- Modular concept allow to accommodate a variable number of machining centers in the same frame or to add more spindles in the future
- Suitable for every component within 400 mm cube. Possibility to produce small batches of machines
- Less fragmentation of the cycle: this leads to higher cycle time compared with a traditional transfer machine (productivity is directly proportional to the number of contemporary working tool)

Flexible transfer features:

As standard machine has many advantages:

- Shorter delivery time (planned production – not on sold)
- Reduction of costs (batch production)
- Higher reliability both on mechanics and electronic
- Spare parts always available from stock

... with some disadvantages:

- Machine is more complex and more expensive
- Balancing of cycle time more difficult
- Require high skilled personnel for new part programming
Flexible transfer component

The Vertiflex 300 machine

VFX frame

3 axis module with revolver tool change

Main table & satellite B axis

Flexible transfer features

The Vertiflex 450 layout
Flexible transfer pictures

Inside the VFX 300 machine

Inside the VFX 450 machine

More requirements from the market

Further market needings:

• Gradual ramp-up of production influence the investment scalability – start production with simple machining centers and gradually increase the number of machines replicating the process (more expensive but safe)
• Poor availability of good technician – need to have simple machines

There is the needing for another type of machine, simpler, less expensive even if less productive
New market areas

- Traditional transfer machines and flexible transfer machines cover high and medium-high production volumes (areas A and B).
- Medium-low volumes require flexible transfer machines with a small number of spindles, less attractive because:
  - Higher cost compared with lower productivity
  - Number of tool may be not sufficient for complex component

Last development: MC4 line

MC4: multi spindle machining center
MC4 is the new line of machine from Riello:

- 4 or 5 axis machining center
- 4 independent spindles and 2 working station
- In each station the two spindles can operate as single spindle with a chip-to-chip of 1s or as double spindle or as combination of the 2 modality
- Pallet changer with 4 position to allow parallel operation on the 2 working station or sequence
- Double loading station – parts are loaded during machine operation
- Wide working area not just to increase the dimension of the component to machine but also to allow multiple clamping fixtures

MC4 main features

- Productivity comparable to a Vertiflex machine with 4/5 machining centers but less expensive
- 4 independent electrospindles with tool change and 30 places magazine each spindle (total 120 tools)
- Direct drive technology on rotary axis
- High productivity through idle time reduction (chip-to-chip less than 1s – acceleration and rapid performance not exasperated to warrant long time operation trouble free)
- High flexibility, comparable to a standard machining center, and easy-to-use
### Production rate comparison
Vertiflex – MC4

<table>
<thead>
<tr>
<th>Part description</th>
<th>Machine type</th>
<th>Cycle time [s]</th>
<th>Production rate (@ 100%) [pcs/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum pump support</td>
<td>VFX 450-4/300/2V</td>
<td>56.7</td>
<td>127</td>
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<tr>
<td></td>
<td>MC4 combination of single and double spindle - 2 parts x fixture</td>
<td></td>
<td></td>
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<tr>
<td>Vacuum pump body</td>
<td>VFX 450-4/300/2V</td>
<td>56.5</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td>MC4 single spindle + pcs x fixture</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MC4 double spindle + pcs x fixture</td>
<td>97.3</td>
<td>149</td>
</tr>
<tr>
<td>Aluminum gear box case</td>
<td>VFX 450-4/250</td>
<td>46.3</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>MC4 single spindle + pcs x fixture</td>
<td>52.5</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>MC4 double spindle + pcs x fixture</td>
<td>117.5</td>
<td>121</td>
</tr>
<tr>
<td>Aluminum gear box case</td>
<td>VFX 300-4/300/2V</td>
<td>89.3</td>
<td>60</td>
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<tr>
<td></td>
<td>MC4 single spindle + pcs x fixture</td>
<td>240.9</td>
<td>26</td>
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<td></td>
<td>sequence machining</td>
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<tr>
<td></td>
<td>(ST A) and 2 pcs x fixture</td>
<td>125.4</td>
<td>26</td>
</tr>
<tr>
<td>Distributor transmission FORD Trans 3C3P-7E34-AZ (ST1)</td>
<td>VFX 300-6/500/2V</td>
<td>89.3</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>MC4 single spindle + pcs x fixture</td>
<td>240.9</td>
<td>36</td>
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<tr>
<td></td>
<td>parallel machining</td>
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<td>What in the future?</td>
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<tr>
<td>• Transfer machines will always be unbeatable for high volumes</td>
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<tr>
<td>• Automotive, fittings and other market will continue to use rigid transfer machines but the high volume market will decrease</td>
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<tr>
<td>• Flexibility and reconfigurability can be obtained with less dedicated machines</td>
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<tr>
<td>• The strategic key point is the capacity to supply a “production system”, tailored to the customer needing, no matter the type of the machine</td>
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Thanks for your attention