

Introduction of Product

Introduction of High-speed Linear Servo-press-line (HLS) Product

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HLS (High-speed Linear Servo-press-line) of a new concept merging the productivity of transfer presses, and formability and versatility of servo-presses has been developed. This introduction of product explains the background to its development and technology of the new product, and introduces the above described product.

**Key Words:** HLS, Flexible, Space saving, Energy saving, Phase difference operation, Reference clock system

1. Introduction

Presses driven by a servomotor are diverse, ranging from small to large presses, and have been accepted in the market for high evaluation of their formation, energy saving and other performances. As products, this paper introduces transport machines that operate tuned (synchronized) to compact servo-presses of multiple processes and significantly enhance productivity compared with conventional robot tandem lines. The tuning (synchronization) principle of the transport machines in operation with presses is introduced.

2. Aims of Development

Plotting high precision and flexibility on the axis of abscissas and high productivity on the axis of ordinates, Fig. 1 shows where each machine stands. Conventional tandem lines (manual lines) are flexible, but general-purpose robots are installed and conversion into transfer presses is needed to enhance productivity. However, transfer presses have die constraints and their forming performance deteriorates due to eccentric die loads. Flexibility also deteriorates. The newly developed HLS (High-speed Linear Servo-press-line) merges

Market changes: Labor saving, high speed → High speed, high precision, flexibility

Objectives: High-speed production, high precision, low die cost

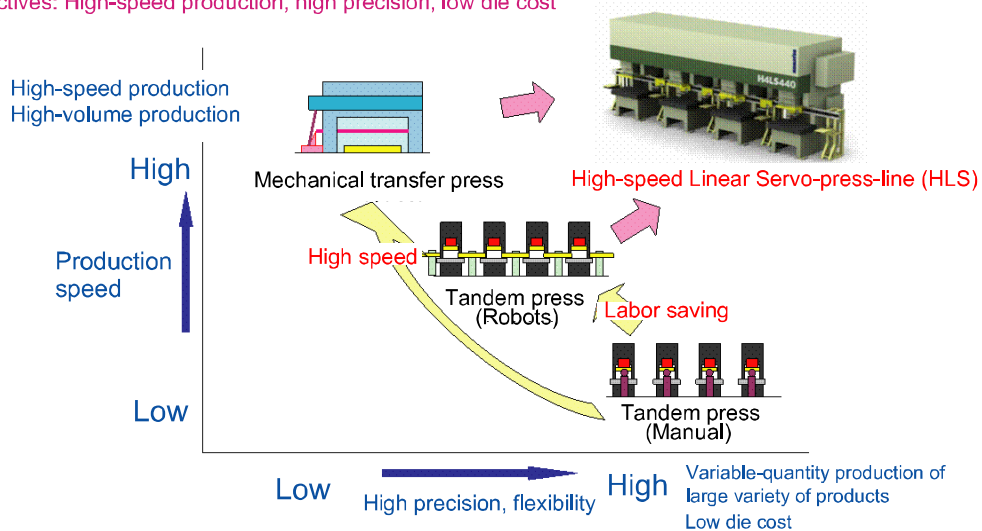


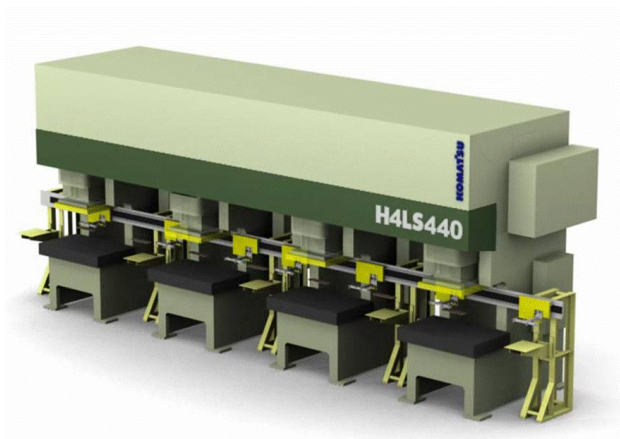
Fig. 1 Concept of HLS

the productivity of the transfer press and formability and flexibility of the tandem press.

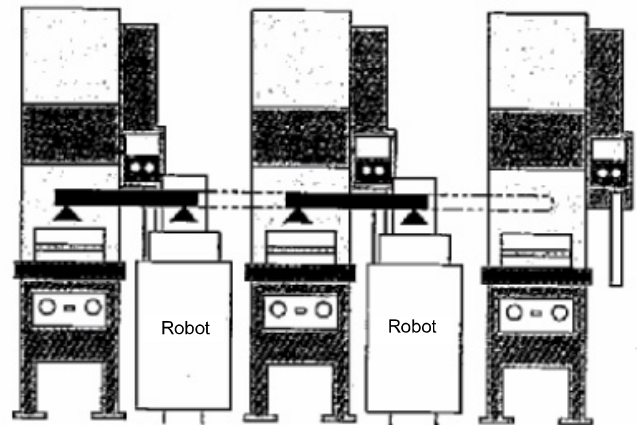
### 3. Composition

The full view of the HLS is shown in **Fig. 2**. The HLS consists of servo-presses for multiple processes (capacity 110 to 200 tons) and transport robots shown in **Photo 1**. The number of processes can be increased in accordance with production process requirements. Transport machines between presses are multiple carriers, each of which can be provided with a vacuum cup attachment (electromagnetic magnet can also be mounted in place of a vacuum cup attachment) to hold a work. The carrier houses a linear motor to drive the carrier in the flow direction and a servomotor to vertically move the attachment. The motors enable vertical two-dimensional operation of an attachment that transports a work.

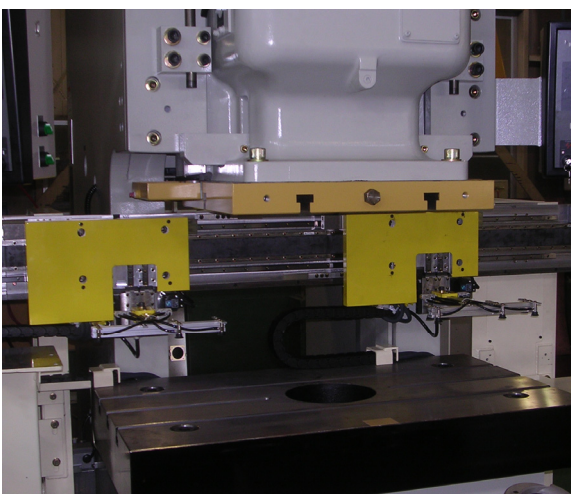
The linear motor improves the rigidity of the drive system and reduces vibration during the transport of works, ensuring stable transport of works. A prominent difference compared with conventional robots is that this structure allows individual carriers to move independently so that operations between processes can be set independently in accordance with die operation. **Figure 3** shows the structure of conventional robots. Structurally, two processes are driven by one drive equipment and the heights of the dies have to be adjusted to the same height. The HLS changes attachment motion in accordance with the die so that dies can be more flexible in it.



**Fig. 2** Full view of HLS



**Fig. 3** Structure of conventional transport robots



**Photo 1** Full view of linear robot

## 4. Characteristics of Product

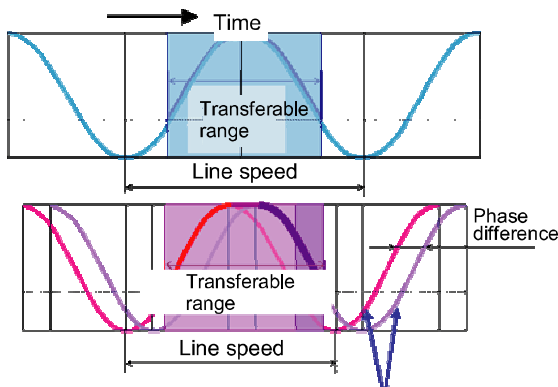
### 4.1 High productivity

The largest characteristic of HLS is productivity. The highest production speed is 35spm (if feed is 900mm), accomplishing a speed about twice that of a conventional robot tandem (18spm). This is made possible by perfectly synchronized operation of transport machines with presses, and by phase shift difference operation of presses.

In existing robot lines, presses and transport machines operate alternately. A transport machine transports a work after a press performs one cycle of operation and stops at its top dead center. This process is repeated and wasteful time of stopping and starting is generated, causing the low productivity. The only method available to address this issue is to make adjustment, such as increasing the speeds of the presses and robots and to operate transport machines immediately before the presses stop their operation.

In the HLS, the press slide is continuously operated and transport machines are operated synchronized to the press slide, to achieve continuous line operation. This eliminates wasteful time of stopping and increases the productivity. The principle of line tuning (synchronism) is described later.

Another means to accomplish a high productivity is phase shift difference operation of presses. Its principle is illustrated in **Fig. 4**, indicating that the line speed can be increased by providing a phase shift difference to presses even though the transport time is the same.



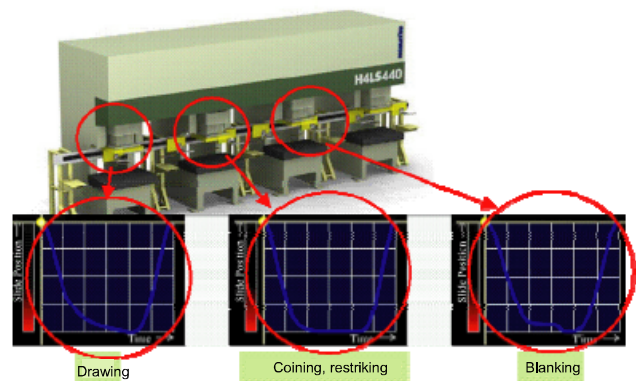
**Fig. 4** Principle of phase shift difference operation

When presses operate in the same phase shift as shown in the illustration in the top part of **Fig. 4**, the line speed is decided by transportable time +  $\alpha$  (depends on capacity of transport machine). However, when presses are operated by providing a phase shift difference between presses, a transportable time is gained and the cycle time of presses can be shortened for the phase shift difference time. As a result, the line speed can be increased.

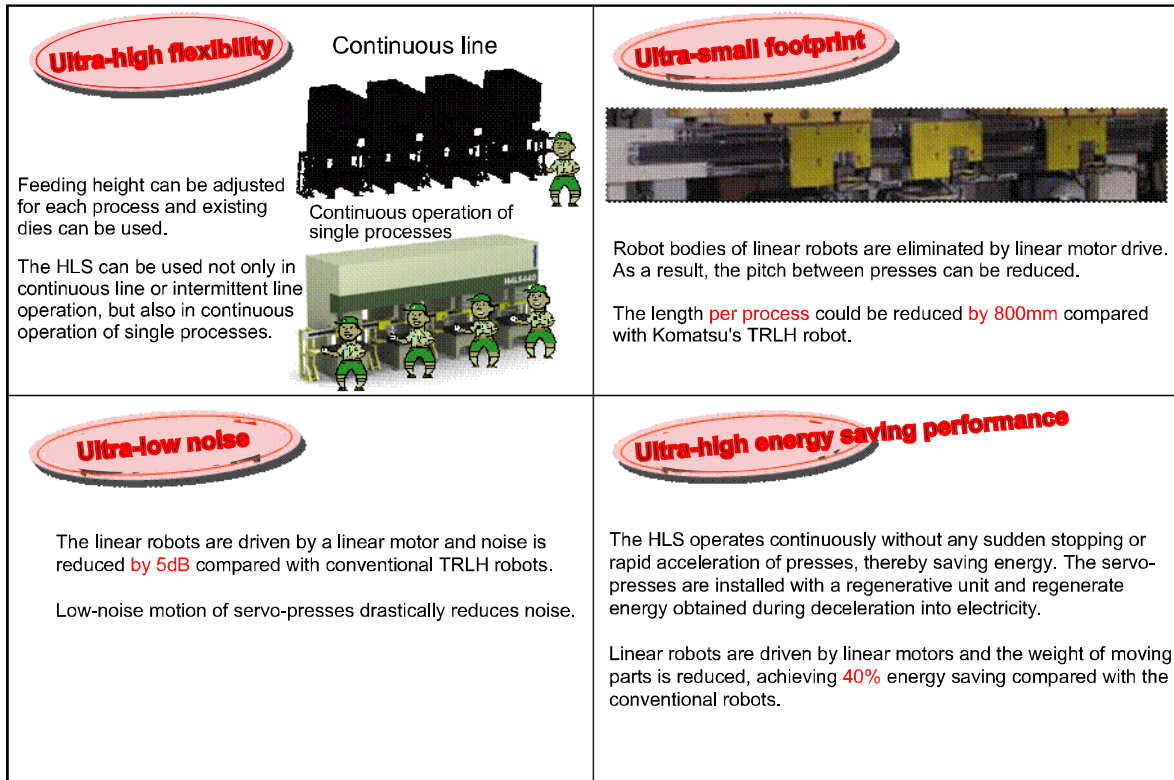
### 4.2 High formability

The second major characteristic of the HLS is a high formability and high precision. Generally, a transfer press is chosen if a high productivity is desired. However, the transfer press forms works by mounting plural dies on one slide and one bolster, sometimes causing an eccentric load. Therefore, the formability of some processes sometimes cannot be ensured. In this case, high-level die correction or adjustment of a shim or a die will be necessary.

On the other hand, the HLS is a servo-press with plural slides and can achieve high forming performance for each of its processes as shown in **Fig. 5**. The height of a bottom dead center of the slide can be corrected automatically for each process, allowing adjustment of precision and maintenance of high precision. The other characteristics of the HLS are summarized in **Fig. 6**.



**Fig. 5** Selection of forming motion



("Linear robots" appearing in the diagram are the names of transport machines and are registered by Komatsu as a trademark.)

Fig. 6 Characteristics of the HLS

### 4.3 Principle for tuning (synchronizing) servo-press and transport machine

The tuning system for transport machines is different for mechanical presses and servo-presses. First, the system to tune to a mechanical press is explained using a transfer press system as an example.

A transfer press of the mechanical drive equipment (press) houses a transport machine (mostly driven by a servomotor) for follow-up operation with a mechanically driven press. In this case, a table defining phase correlation between the press angle and position of the transport machine is defined in the control of the transport machine. The transport machine constantly detects the press angle at an interval of 1 to 3m/s and indexes the position command of the transport machine by looking up in the foregoing command table the position of the transport machine to the press angle. This position command controls the position of the servomotor of each axis of the transport machine. As a result, operations of the transport machine follow operations of the press.

Next, the system for the HLS (servo-presses) is explained. The HLS consists of plural presses and plural transport machines. Therefore, when the foregoing principle is applied, the transport machine of a process must alternately follow two

presses in the upstream and downstream, making the system complex. In an extreme case, the motion of a servo-press stops during its operation. Therefore, the transport machine may stop in the principle in which the transport machine operates by looking up the press position.

The HLS employs the reference clock system shown in Fig. 7. The reference clock system has a virtual clock as a reference for the operation of each equipment and each equipment is made to operate following this reference clock. When all equipment accurately follows this clock, the entire line can operate in tune (in synchronism). Each equipment can be operated free from concern about other equipment and the system can be simplified even if a system has equipment for many processes.

The notion of a reference clock system is not new. However, this system could be realized because the presses are driven by servomotors and can be operated accurately as planned. Theoretically, this system can be applied to mechanical presses. The follow-up performance of mechanical presses with a clock, however, is poor due to their structure (flywheel driven), causing an interference risk between presses and transport machines. Komatsu is not using the reference clock system with mechanical presses.



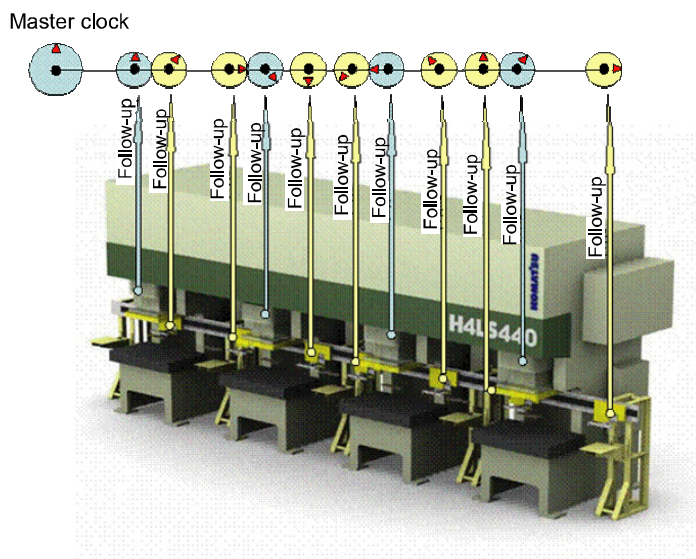


Fig. 7 Concept of reference clock system

## 5. Conclusion

The main feature of the HLS series is a press line that ensures productivity and that makes high-precision production of forming panels possible. Tuned operation between presses and transport machines made this press line feasible.

A linear servo mechanism is used in driving the HLS in the feed direction for the first time for this class, paving the way for simplification of the structure of transport machines and a reduction in the weight of moving parts. These results have contributed to energy saving and low noise. A further increase in productivity will be targeted in the future by improving set-up performance.

## Introduction to the writers



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## [A few words from the writers]

The HLS of a new concept employing the linear motor technology accumulated since the days of H\*TL has been introduced in the market as transport machines for the H1F and OBS lines. In the hope that the HLS technology will be evaluated highly by its users in the future, efforts will be continued to develop transport machines of a new concept matching the global market.