Development of linear motor driven Double-Column Machining Center incorporating a thermal displacement compensation system

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Introduction

Because of today's global competition, in the field of press molds for the automobile industry, there is an ever increasing demand for vertically starting up molds with the same quality all over the world. Therefore, it is necessary to reduce as much as possible the steps of manual finishing that can vary depending on the skill of the workers, and also to reduce the mold matching time.

In this technology development, we realized the high performances of "1/2 Finishing time" and "1/5 dimension accuracy stability with room temperature change" that revolutionizes the productivity of mold manufacture by developing the new concept of linear motors and adopting high accuracy thermal displacement compensation system.

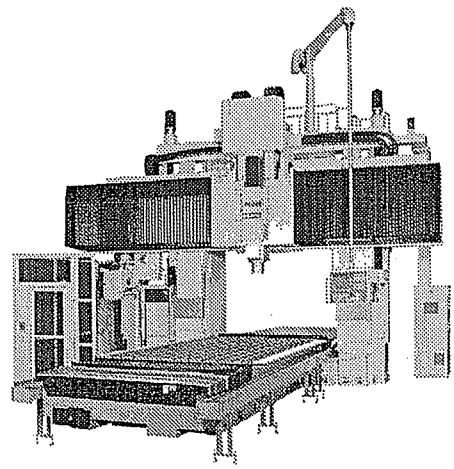


Fig. 1 External view of the developed linear motor driven double-column machining center

Description of Technology

(1) Development of linear motor

We used linear motors developed originally in our company in order to realize high accuracy and high speed contour machining in X and Y axes having large mass of the moving body.

The new linear motor does not have permanent magnets on the stator side, but merely has the structure of multiple layer steel plates with grooves. On the slider side, there are several permanent magnets affixed on the side surface, and coils placed surrounding them.

Because of this, the usage of magnets that are made of rare metals has become 1/10th of the conventional ones (**Fig. 2**).

In addition, because of the development of the thrust ripple suppressing technology for mutually canceling the thrust ripples of linear motors that are a problem in precision positioning, it was possible to reduce the thrust ripple up to 40% (Fig. 3).

(2) Development of thermal displacement compensation system

The structure of the columns is complicated in a double-column machining center, and the columns lean due to changes in the environmental temperature resulting in adverse effects on the dimensional accuracy and surface quality of the machined work. In view of this, we carried out experiments and analysis by changing the environmental temperature, and based on these results, performed development of a method of designing a thermal equilibrium structure that minimizes the thermal displacements of the columns.

At the same time, we developed a technology of estimating accurately the spindle thermal displacement in the transient state, and a technology of estimating accurately the thermal displacements of different parts of the machines with respect to changes in the environmental temperature, and realized stable dimensional accuracy even after machining for long hours by compensating the thermal displacement of the relative positions of the tool and the work piece over the entire surface of the table (Fig. 4).

Conclusions

Because of the technology developed this time, it was possible to realize high capacity, high accuracy, and high quality machining in a stable manner. This not only increased the productivity in the field of large sized press molds, but also reduced the dependence on experienced workers.

In addition, because of the thermal displacement compensation system, it became possible to maintain high accuracy machining even if the equipment is not placed in a factory having air conditioning facility maintaining almost constant temperature. This technology provides an environment friendly production means to a great extent by reducing the cost of air conditioning facilities.

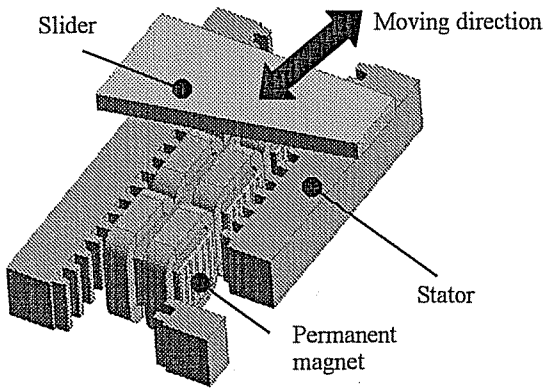
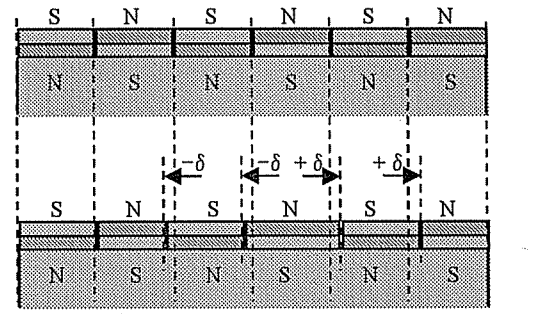


Fig. 2 Structure of the linear motor



Top row: No ripple suppression measure (equidistant)
Bottom row: Ripple suppression measure present (not equidistant)

Fig. 3 Placement of permanent magnets in the linear motor developed by us

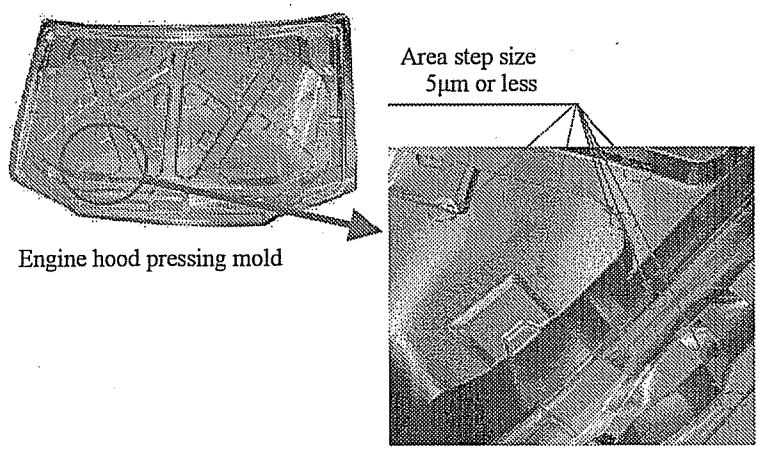


Fig. 4 Size of step between shaped surface and cornering after 42 hours of machining