# Progress of the Turbo Molecular Pump

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## Forward

Turbo Molecular Pump (TMP) is rather new kind of vacuum pump among the other vacuum pump. It becomes major pump of vacuum equipment with many recent improvement items. This paper reports process of the developments and improvements, and views future trend of the TMP.

## Birth of the TMP

Molecular Drug Pump which was invented by Geade (Germany) in 1912, originated molecular pumping principle. In 1958 Becker (Germany) invented similar structure of the present TMP that has th multiple stage of turbine rotor blades and stationary blades. This pump realized mechanically high pumping speed with smaller size attained ultra high vacuum.

## Rotor bearing

Pumping principle of TMP requires ultra high speed rotation. Generally, rotor rotates 20 000 to 90 000 rpm giving 300 to 350 m/s peripheral speed at maximum diameter of turbine blades. In early generation, liquid oil lubricated ball bearing was adopted for rotor bearing, but suffered from short life and vibration due to high speed rotation.

In 1976, Leybold Heraus A G (Germany) developed totally magnetic levitated (5 axes controlled) TMP. This pump was the first product of really oil free contact less TMP, but too early for the industrial demand pick up. Only hundreds of pumps are manufactured.

In 1983, Seiko Seiki (Japan) introduced magnetic bearing TMP with 3 axes control into the market. This model combined the merits of TMP and magnetic bearing features small size, low vibration, low acoustic noise and completely oil free. These merits of TMP with magnetic bearing are widely recognized in applying to scanning electron microscope (SEM), analytical instruments and accelerator.

By this successful introduction, about a half of TMP sales quantity in Japanese market is magnetic bearing model.

## Rotor configuration

The figure of the turbine is similar to the electric generator tubine composed of 10 to 20 stage sets of rotating and stationary blades. With this configuration, pumping effect is only limited in molecular flow region (lower than 0.1 Pa or 1 milli-Torr). In early generation, application field of TMP is limited to SEM, analytical instruments, accelerator etc. by the turbine configuration.

In 1986, Osaka Vacuum Ltd.(Japan) developed tubine and screw compound molecular pump that is able to be operated in higher pressure range. With this rotor structure, TMP came to be operated up to the medium flow range (hundreds Pa). This medium flow range TMP expanded TMP market share in the all kind of high vacuum pump by being applied large number to the semiconductor manufacturing equipment such as dry etcher, sputter etc.

**Application for semiconductor manufacturing**

Huge deposition of the chemical react product from aluminum dry etching on the pump components was the serious problem. The problem was happened every one month after the pump installation to this process. The countermeasure for this problem, temperature control system which control pump components rather high constant temperature, saves deposition phenomenon and avoids problem up to 2 years after the installation.

Cryogenic trap is attached for pump up time shortening or lowering ultimate pressure from 1990. This trap has a part of cryogenic pump, is attached to the inlet opening of the TMP, improves pumping efficiency for water molecule. This TMP with cryogenic trap is applied mainly for sputtering process in semiconductor manufacturing.

**For extremely high vacuum**

It is believed that ultimate pressure of the TMP is limited down to 10 nano-Pa (0.1 nano-Torr). To break this barrier, TMP's tandem structure was developed with compression ratio increment and saving out gas from the internal component of the pump. Industrialized tandem model's ultimate pressure is 1 nano-Pa (8 pico-Pa), 0.13 nano-Pa (1 pico-Pa) is recorded by prototype.

**Views for the future trend**

TMP with magnetic bearing will be in the main stream of the high vacuum pump, by these improvement. Recently several improving items which eliminates back up battery for the black out, shrinks electronics size by half and adds various control function using microprocessor, will be finished and introduced in the market in 1993.

Turbo molecular pump will keep and raise its important position in the high vacuum pump with operational and functional improvements in the future too.