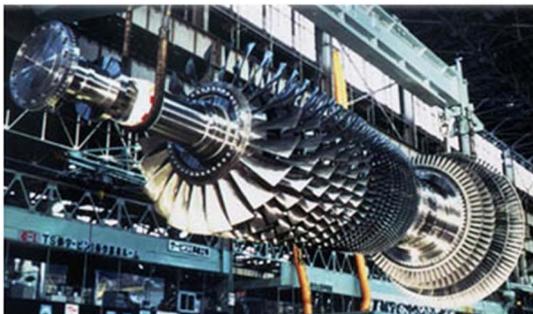


Large-sized Special-purpose Machines for Turbine Parts



Equipment & Machinery Sales Group
Sales Department, Machine Tool Division
Machinery, Equipment & Infrastructure

Large special-purpose machines are tools optimized in terms of their processing functions in compliance with the material, shape and machining details of large workpieces. Mitsubishi Heavy Industries, Ltd. (MHI) is one of the world's few machine tool manufacturers handling large special-purpose machines, and its Machine Tool Division provides products to those industrial sectors manufacturing large-sized parts such as for power system equipment (power plants), aircraft and construction machinery, thereby gaining a high reputation. In addition, MHI is well-known as a leading global manufacturer of power system equipment and aircraft, and this division has supported its in-house manufacturing sectors for more than 20 years, thereby accumulating abundant experience, technologies and expertise concerning machining of large workpieces.

This paper introduces a large special-purpose machine to process turbine rotors and gas turbine rotor disks as key components of power system equipment, i.e., side-entry processing machine, chain broaching machine and disk coupling grinder.

1. Side-entry processing machine

The side-entry processing machine cuts grooves on the vane of an integrated turbine rotor by milling (**Figure 1**). The lower right of Figure 1 is the shape of the milling tool that is manufactured and sold by this division. The workpiece placed in the center is supported by a hydrostatic journal support and indexed in the rotational direction by a face plate chuck on one side to cut grooves one by one. We have so far manufactured a variety of side-entry processing machines, and the largest corresponds to a workpiece of 3 600 mm in diameter, 13 600 mm in length and 300 tons in weight.

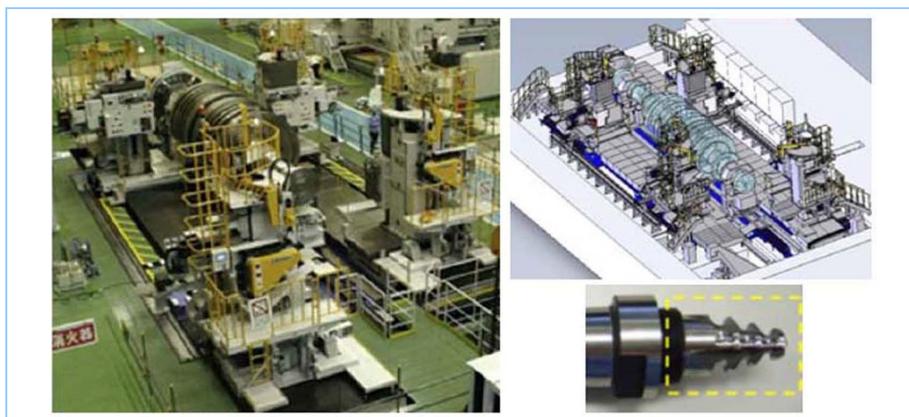


Figure 1 Side-entry processing machine and shape of milling tool (lower right)

The following are the advantages of our side-entry processing machine.

(1) High-efficiency machining

Simultaneous machining with opposite four spindles promises high-efficiency tasks. Nevertheless, 2- or 1-head machines are also delivered to users with many workpiece models unsuitable for simultaneous machining with multiple heads.

(2) Stable cutting

This machine has high damping properties owing to its casting structure and thus permits stable cutting.

(3) Design concept of ‘protecting expensive workpieces!’

The price of large workpiece material is extremely high. A number of highly reliable monitoring/detecting devices are therefore equipped to minimize the damage incurred by a workpiece due to unexpected abnormalities.

- A tool locus monitoring device
- A scale-duplicated face plate index monitoring device
- A chuck slip detecting device
- An AE sensor-system tool breakage detecting device

(4) User friendliness measures

Specifications were added for the analysis of customer work procedures to alleviate the burden on workers. This has realized easier preparatory and centering operations for a 300-ton workpiece.

2. Chain broaching machine

The chain broaching machine cuts grooves by broaching the vane of a gas turbine rotor disk (**Figure 2**). The workpiece is mounted on a tilting table – known as a cradle – that is equipped with a horizontal slide table and index table. A broaching tool attached to each of the pallets connected together by a chain is precisely guided to the cutting position for broaching, and then returns to the original position after making a circuit. The largest machine we have ever manufactured corresponds to a workpiece of $\Phi 2500$ mm in diameter and 12 tons in weight, and a final-stage workpiece with a shaft can also be machined. The broach’s maximum pull-out force is 35 tons and the maximum broach edge length is 15.47 m with 17 pallets (0.91 m per pallet).



Figure 2 Chain broaching machine for gas turbine rotor disk processing, and state of broaching (lower right)

The following are the advantages of our chain broaching machine.

(1) High-efficiency machining

The machining efficiency is higher than that of a normal ram-sliding broaching machine due to the fact that return motion of the broach is unnecessary.

(2) Space saving

As the machine only requires half or less the typical longitudinal floor space, a great deal of space can be saved.

(3) Multi-model compatibility

The machine was structured so that the index table for three different diameters ($\Phi 380$, $\Phi 744$, and $\Phi 1180$) is interchangeable, making it compatible with multiple workpiece models with diameters ranging from $\Phi 400$ to $\Phi 2500$.

3. Disk coupling grinder

The disk coupling grinder shapes by grinding curvic couplings to connect one gas turbine rotor disk to another (**Figure 3**). The cup-type grindstone is trued by the NC dressers installed on both sides, and grooves are plunge-ground two at a time in parallel with the indexing of the

workpiece on the index table. The lower right of Figure 3 shows how an actual workpiece is ground. The maximum diameter of the workpiece is 2500 mm and the maximum weight is 18 tons.

The following are the advantages of our disk coupling grinder.

(1) Compatibility with a workpiece with a shaft

A 1000 mm-diameter through-hole is bored on the index table so even the turbine's final-stage workpiece with a shaft can be machined. The indexing accuracy of this index table is as high as ± 2 seconds.

(2) Interactive automatic programming system

NC programs that include truing can be automatically developed from nothing more than simple entries such as grindstone and coupling specifications, and compensation entries are also easy for the detection of contact with the master coupling.



Figure 3 Disk coupling grinder and state of grinding (lower right)

4. Future development

In the future, MHI will continue to share the issues and efforts to consider solutions with customers toward the realization of machining accuracy and efficiency exceeding what is possible with general-purpose equipment. In addition, we will propose and provide completely new-concept machine tools that have never existed, meeting market needs as they arise.