The Double "L" Machine Base

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Purpose and Our Intention

ENS Cortesi and Prof. Slocum have jointly developed a new type of lathe for grinding ceramic parts to their finished dimensions. The purpose of the Double "L" structure described here is to serve as the main structural element for the lathe.

We intend to pursue this research at MIT as part of ENS Cortesi's PhD thesis in Mechanical Engineering. We are trying to entice US companies to fund research to develop the idea further. We would like the US Government to assign its rights to MIT, otherwise the research contract process will not be manageable, and the research will be dead on arrival. The result is we will publish it as is, and then Chinese/Japanese/Korean machine tool builders will pick up on it, and US producers will lose big time.

US producers will basically fund nothing and have nothing to do with non-protectable ideas, because they say, justifiably, when they develop new technology, unless it is protectable where they can have an exclusive license, the idea will be stolen by their competitors (foreign or not).

Background

Traditional machine tool structures come in a wide variety. Few of them are designed to move the center of motion of the carriage to a point where the Abbe (motion errors) are reduced to zero for certain directions of roll, pitch or yaw of the carriages. NONE of them incorporate the carriage as part of the structural loop in such a way to increase the machine stiffness. These lower resonant frequencies are easier to excite and reduce machine accuracy.

Description and Operation

The figure 1, below, shows the basic layout of the lathe. The workpiece carriage has the spindle that holds and spins the ceramic workpiece. It moves back and forth on a pair of rails. These rails are attached to the Double "L" structure. The grinding carriage has the grinding wheel assembly that is used to shape the ceramic workpiece. It too moves on a pair of rails attached to the Double "L" structure.

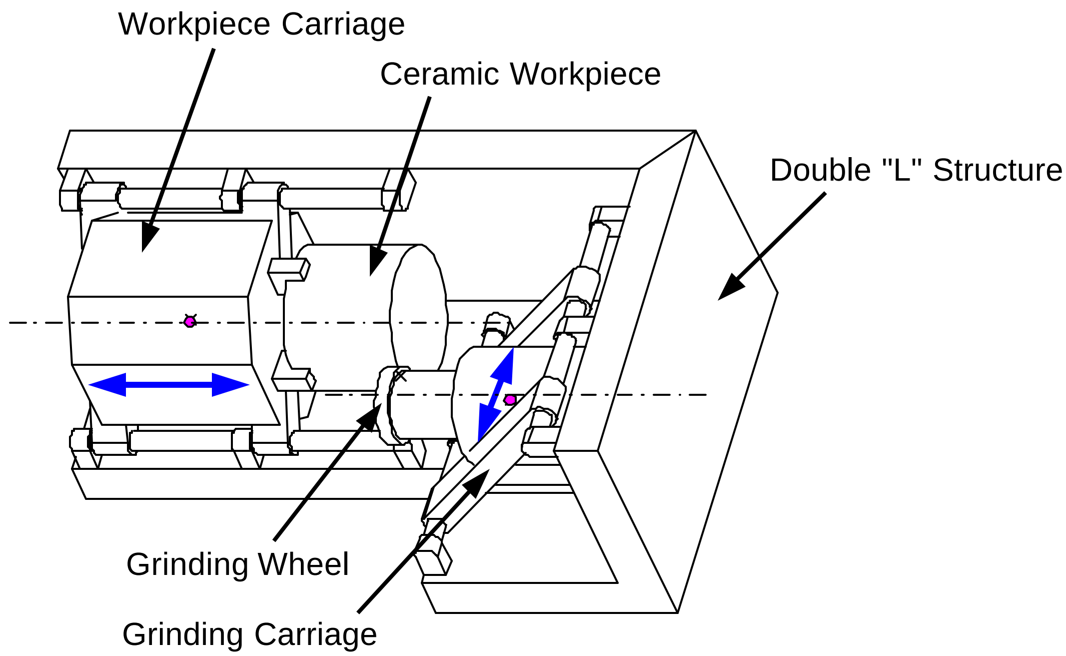


Figure 1 The basic layout for the Lathe. The purple dots are the center of motion for each the carriage, notice they pass thought the rotational axes of the workpiece and grinding wheel.

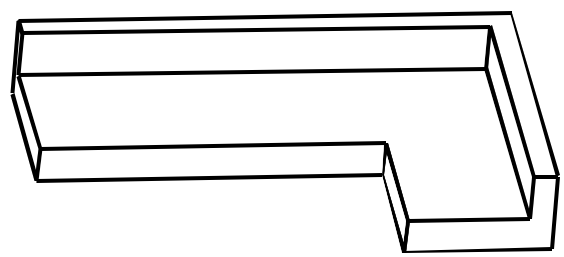


Figure 2 The Double "L" Structure without the rest of the machine components.

Advantages and New Features

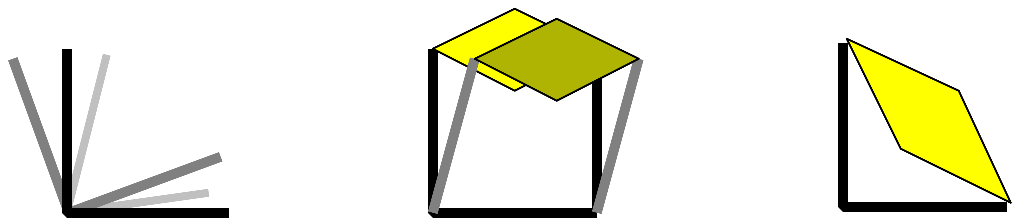
1. Elimination of Some Abbe Errors

The rails that support the workpiece carriage are position so that the carriage's center of motion (purple dot in figure 1) is on the ceramic workpiece's axis of revolution (dashed-dot line in figure 1). Any error due to workpiece carriage roll will not cause errors in the workpiece. This is particularly convenient because carriage roll is the most difficult of the error motions to map and cancel out with the control system.

The grinding wheel carriage uses a similar concept. Again, the carriage's center of motion (purple dot in figure 1) is on the grinding wheel's axis of revolution. In this case carriage pitch will have no effect on the position of the spinning grinding wheel and therefore, it will not cause any errors on in the finished part. The carriage's center of motion is positioned by putting the grinding wheel's axis of revolution in the center of the four bearings that support the carriage on the rails. The Double "L" Configuration makes this possible.

2. Increasing the Resonant Frequency of the Machine

The unique innovation of the Double “L” design is that it increases the resonant frequencies of the machine. This allows parts to be made with greater accuracy. The carriage completes the structural loop as the third side of a triangle. This makes the machine much more rigid, increasing the resonant frequency of the machine.



An end view of the Double L w/o the carriage installed. The horizontal and vertical pieces are free to vibrate independently of each other. THIS IS BAD

The traditional box structure for including the carriage in the structural loop. This configuration would also eliminate motion error in the same way that the Double "L" does. However, the box shape is inherently not rigid as shown by the deflection above. THIS IS BAD

The Double "L" configuration prevents the horizontal and vertical wall from vibrating independently from each other, and it prevents the structural deflection that would occur in a box configuration.

Figure 3 Illustrations showing how the Double “L” configuration increases machine stiffness and the resonant frequencies.

Finite Element Analysis (FEA) confirms these results. The table below shows the improvement in the first two non-solid body vibration modes. Figure 4, below shows the graphic results of the most recent FEA.

Mode	Frequency	Improvement over base alone
7	179 Hz	+64 Hz
8	263 Hz	+98 Hz

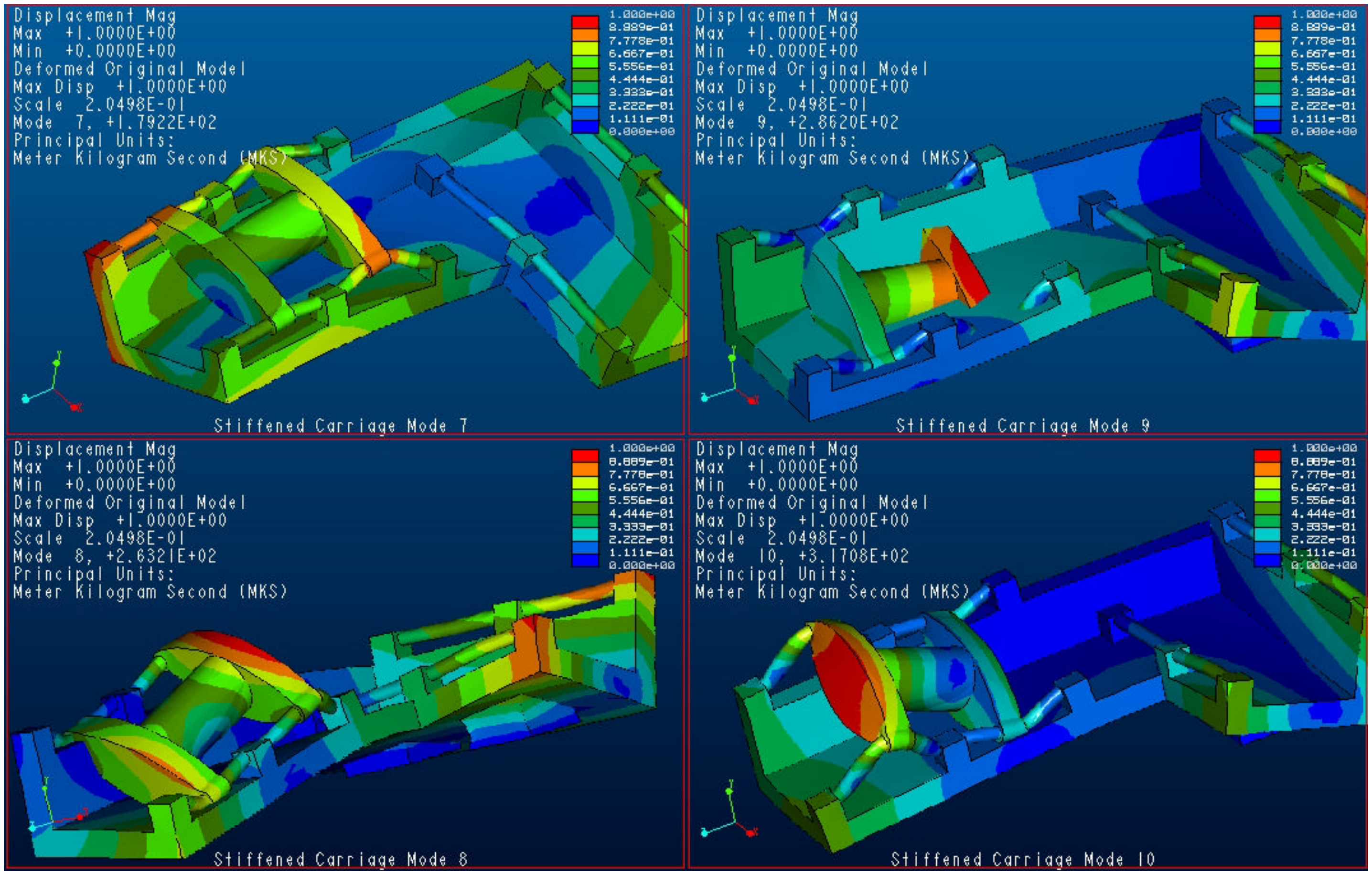


Figure 4 Results of the FEA model showing the direction and frequencies of the first 4 non-solid body modes of the Double "L" structure and the workpiece carriage. The magnitude of the deflections is greatly exaggerated to allow the direction of the vibrations to be observed.