# 여러가지 냉각냉매 적용 볼 스크류 냉각효과에 관한 연구

# Study on the Cooling Performance with Various Coolants of a Ball Screw

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## 1. Abstract

The demand for higher productivity and tight part tolerances requires machine tools to have faster and more accurate feed drive system. As tried and tested technology, ball screw drive systems are still used in majority of machine tools due to their low cost and high stiffness. A high speed ball screw system generates more heat naturally and resultant more thermal expansion, which adversely affects the accuracy of positioning. Therefore, a center hole cooling system was set in ball screw shaft in this paper to dominate the thermal error and achieve temperature equilibrium faster.

With the aim to achieve temperature equilibrium faster on the ball screw system to improve the positioning error, a simple structure and low-cost air cooling system was set in the ball screw shaft. The main idea of the air cooling method is that through ball screw center hole air injection to obtain more convection heat loss, so the heat gain-loss balance will be achieve faster which produces a position error directly.

In this paper, a liquid/air-cooling system was set in a bulk production center hole ball screw drive system to achieve cooling effect. Circulation and forced cooling methods were employed to perform ball screw shaft cooling to guarantee the positioning error.

## 2. Experimental

### 2.1. Experimental set up

A schematic diagram of the air cooling experimental set up is shown in Fig. 1, containing a ball screw system(ball screw shaft, ball screw nut and support bearings), driving unit(motor and coupling), data gathering unit(thermal sensors and computer), control unit(controller and limit sensor) and cooling system(air compressor). A ceaseless advance and return movement of ball screw happened in the range of 500 mm. And it has 20 mm lead, 41 mm BCD and 1025 mm total length. The data gathering unit consisted of 4 thermal sensors and a displacement sensor, and recorded data every 100 seconds.

A schematic diagram of the liquid experimental set up is shown in Fig. 2, containing a ball screw system(ball screw shaft, ball screw nut and support bearings), driving unit(motor and coupling), data gathering unit(thermal sensors, displacement transducer and computer), control unit(controller and limit sensor) and cooling system(liquid tank, pump, seal housings and plastic pipes). Here, controller can control the motor to execute ball screw advance and return movement and the computer can collect the data which thermal sensors gathered. The liquid coolant flows through pipe, airtight clutch and screw center hole to achieve cooling effect.

### 2.2. Specimen

A two lines, exposure tube, four point contact type ball screw and ball bearing with 62 OD and 30 ID were used as specimen in this paper as shown in Fig. 3 and Fig. 4. And the main specimen parameters were shown in table 1.

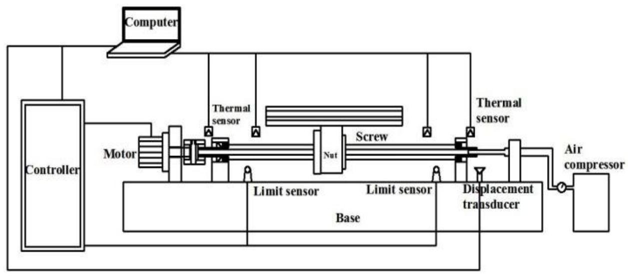



Fig. 1 Schematic diagram of the air cooling experimental set up

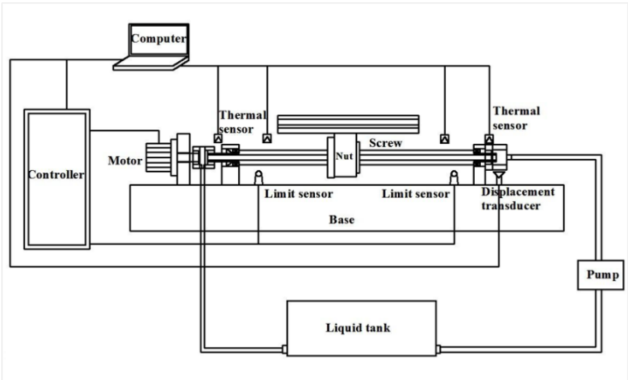
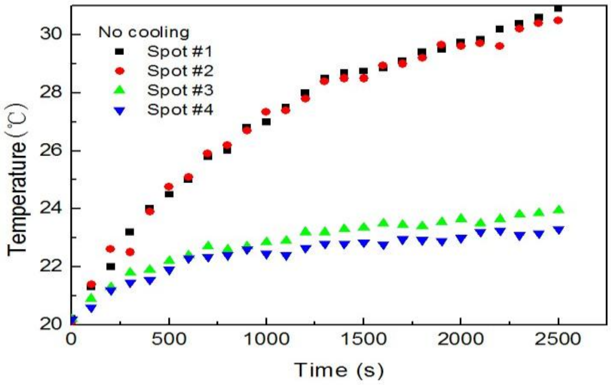


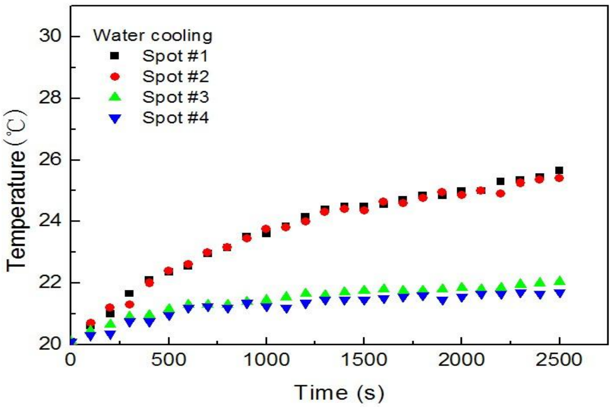

Fig. 2 Schematic diagram of liquid cooling experimental set up

Fig. 3 Ball screw used in this paper

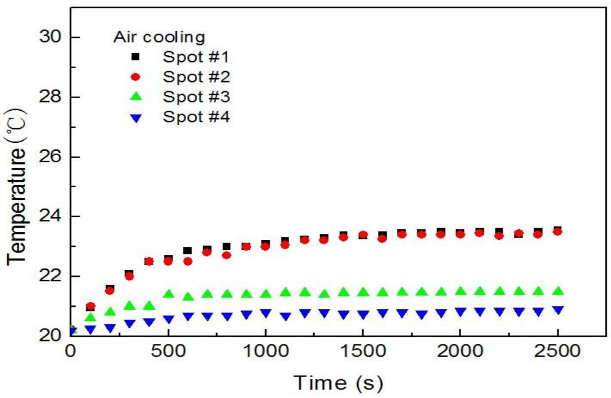
Fig. 4 Ball bearing used in this paper



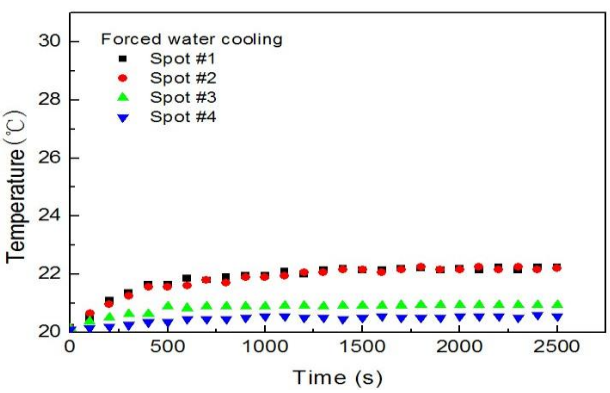

(a) No cooling




(b) Water cooling




(c) Air cooling




(d) Forced cooling

Fig. 5 Test results of test spot temperature variation, (a) no cooling case, (b) circulation water cooling case, (c)air cooling case and (d)forced water cooling case

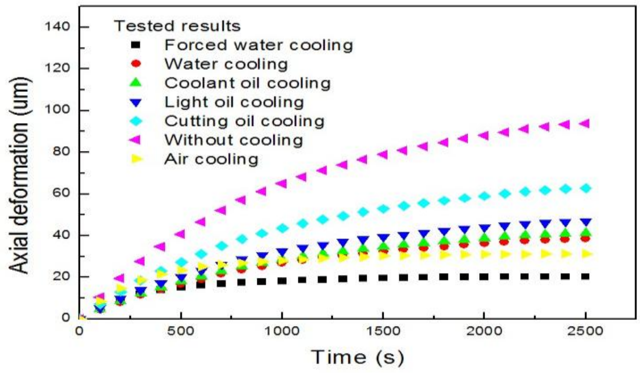



Fig. 6 Test results of variations in axial deformation

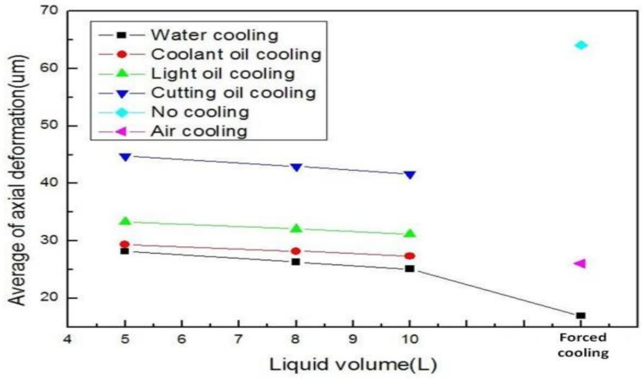



Fig. 7 Cooling performance variation according to coolant volume

## 3. Results

Through a series of experiments with the above set up and method, we obtained thermal deformation data and temperature variations at the 4 spots on the ball screw shaft surface shows the variations of thermal deformation at 500 rpm for the six cooling conditions. Temperature variation at the four measuring points is also significantly less with each of the cooling methods than without cooling, as clearly seen in Fig. 5 and Fig. 6. Fig. 7 shows thermal deformation and screw surface temperature changes according to coolant volume during the variations in cooling performance. Cooling performance improved as circulation liquid coolant volume increased.

## 4. Conclusion

In this paper, with the aim to effectiveness of the cooling system, a series of tests was done. The thermal deformation through the cooling in comparison with no cooling method is substantially reduced and the temperature variation on the four measuring points through the cooling methods in comparison with no cooling method is substantially reduced.

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