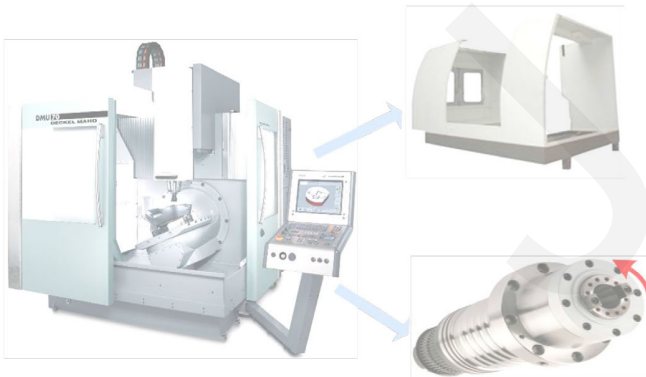


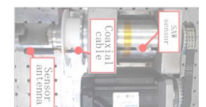
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Research on transmission performance of a surface acoustic wave sensing system used in manufacturing environment monitoring

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Key words:
Transmission performance, Surface acoustic wave,
Sensor, Manufacturing environment, Monitoring

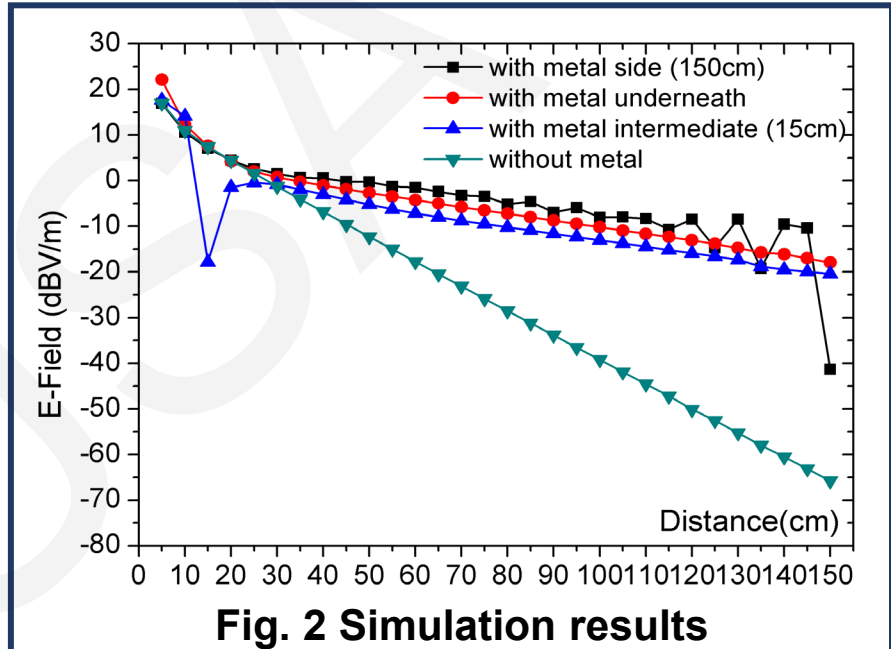
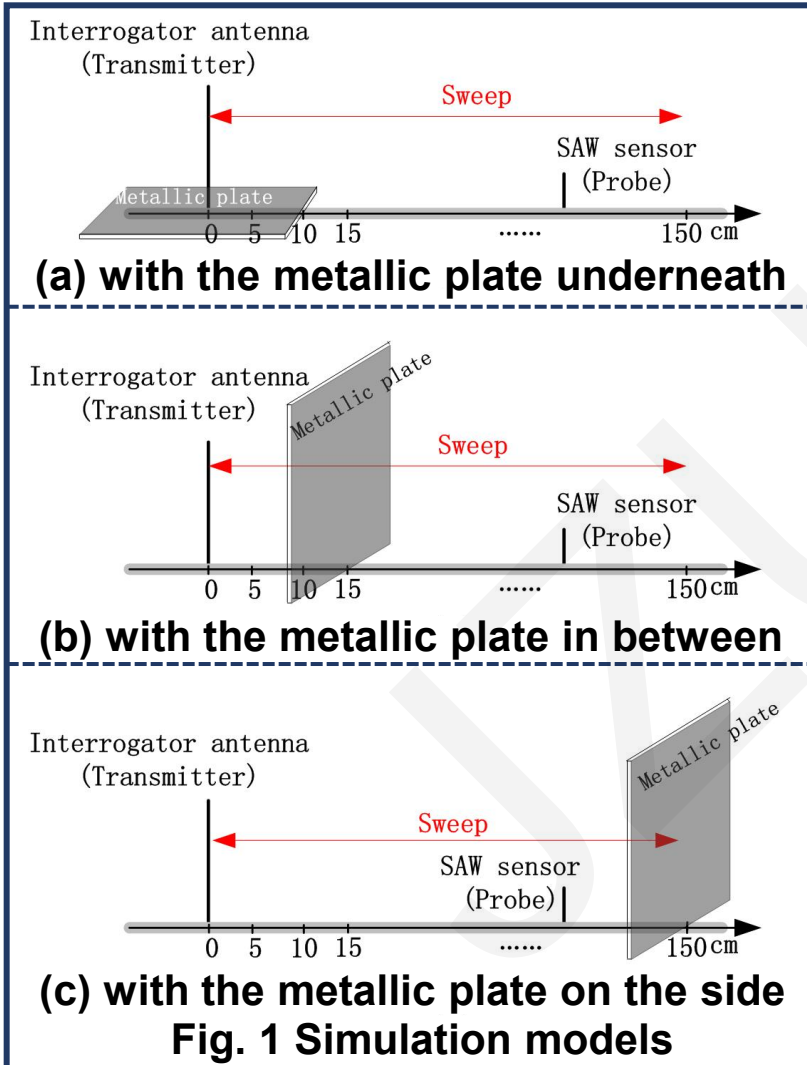


Introduction



- Integrating **advanced sensor systems** into machine tools enables improved understanding of the **process conditions** and facilitates optimization and control of the **quality of the formed part**
- Due to the necessary intrusion of the rotating process, **wired sensors** are typically **not feasible** for monitoring spindle units
- Enclosure structure of the spindle unit poses a **challenge** for the **power supply to wireless sensors**
- Surface acoustic wave (**SAW**) **sensors** have emerged as favorable **alternatives**, due to their **passive operation**, **wireless installation**, **freedom from maintenance**

Simulation with CST

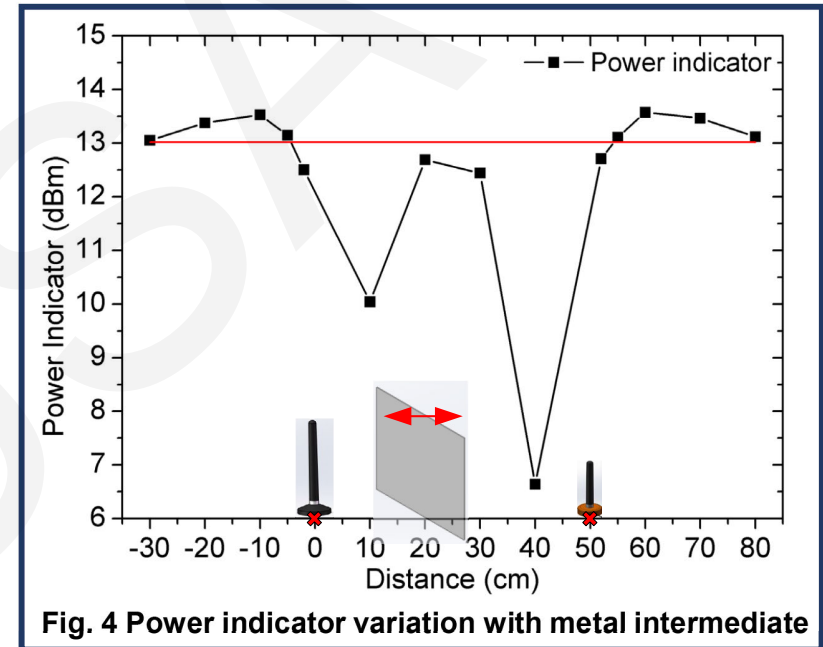
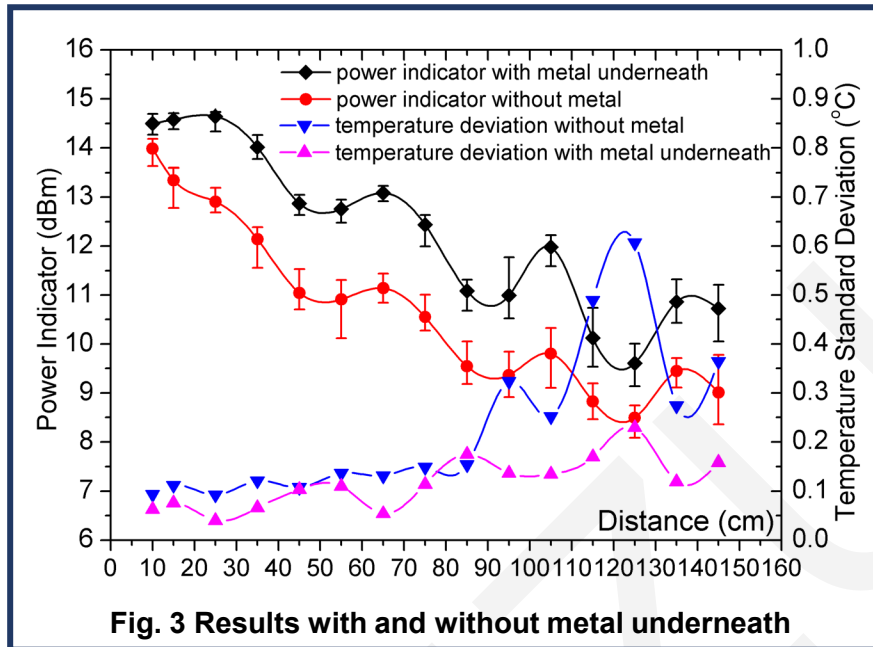


$$10 \lg P_r = 10 \lg P_u + 10 \lg \left(\lambda^2 / 4\pi \right) + 10 \lg G_r$$

Possible explanations

- Metal reflective effect
- Electromagnetic induction effect
- Metal shielding effect

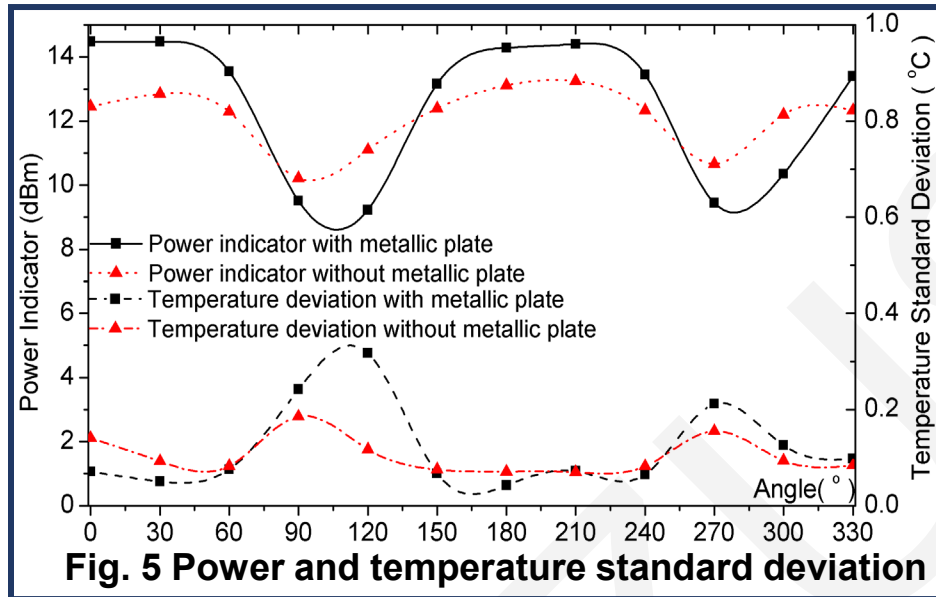
■ Experimental verification



□ Results

- Metallic plate could strengthen the E-field when it was placed under the interrogator antenna.
- Power strength decreased in the distance of 0~50 cm and increased in the other distances except -2 and 52 cm.

Antenna angle influence



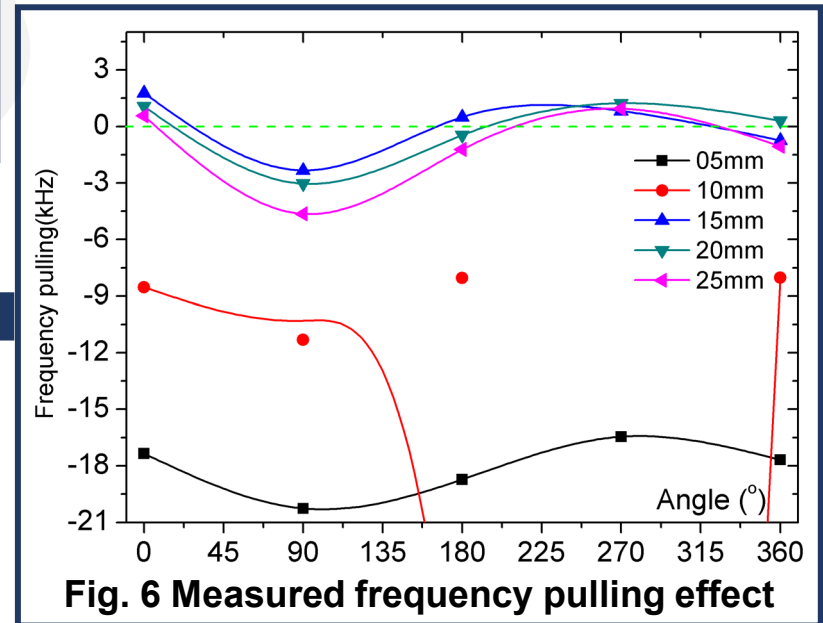
Results

- Power strength decreased with an increase of antenna angle in the range of 0~90° and increased in the range of 90~180°.
- Metallic plate is undesirable for temperature measurement.

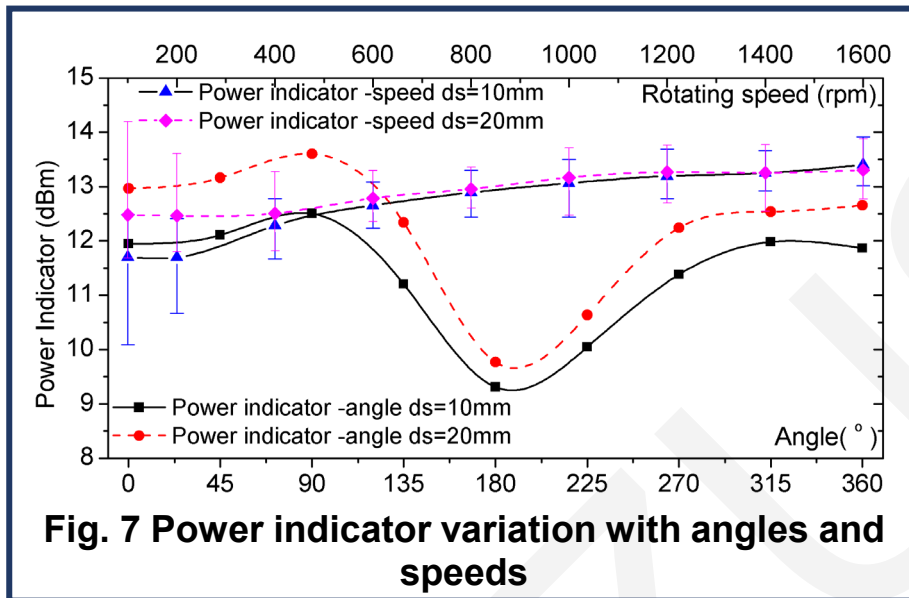
Antenna location influence

Results

- The observed pulling effect is related to both the angular position and the distance.
- Angular position has major influence when the distance is more than 15 mm.



■ Experiment with spindle model



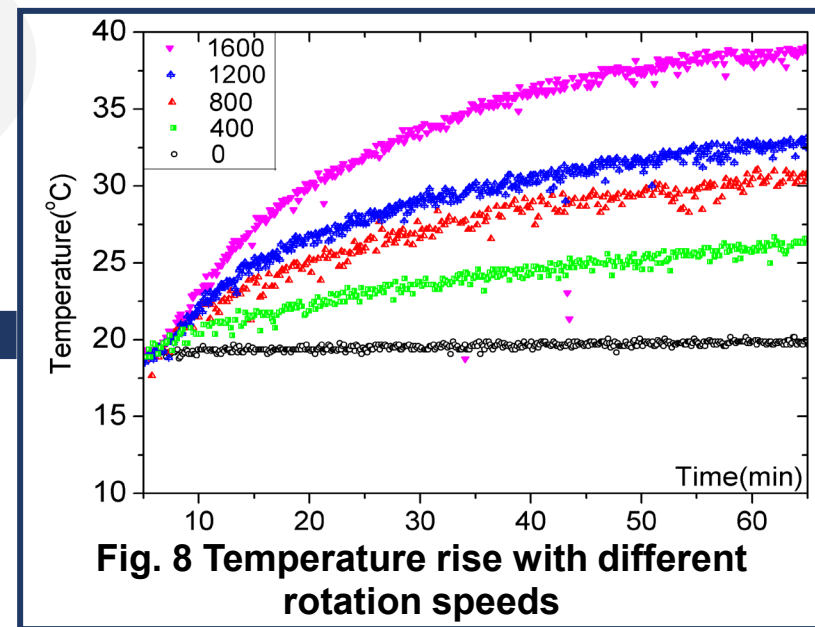
□ Results

- Average power increased slightly with the rotation speed
- Power indicator standard deviation decreased remarkably when the speeds were less than 600 r/min.

■ Temperature sensing

□ Results

- Temperature outliers occasionally occurred during spindle rotating.
- Fluctuations decreased with increasing rotation speeds.



- **Metal** can strengthen the power when it is placed below the interrogator antenna, but it can weaken or even block the power when it is placed beside the antenna
- **Angle** between the interrogator and sensor antennas should be considered for different types of antennas
- **Distance** between the sensor antenna and shaft affects the power and temperature measurement capability
- Dynamic experiments in a rotating spindle apparatus demonstrate that **using wireless passive temperature SAW sensor on spindle monitoring is feasible** but some large temperature fluctuations exist