[New Product]

Press Connect Spline Hub Joint

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In the automotive industry in the world, low fuel consumption is an important issue , the lightening to become one of the solution is demanded from every part constituting a car. **NTN** developed the lightening of a hub bearing and the CVjoint in order to meet these demands.

This report introduces "PCS-hub joint" which is lightening by connecting a hub bearing and CVjoint by "the press connect method" that is **NTN** original technology.

1. Introduction

High fuel economy is an important requirement in the automotive industry today. One of the solutions for achieving high fuel economy is a lightweight design, which is now required for all vehicle components.

In this article, we introduce the "Press Connect Spline Hub Joint (PCS-H/J)" which is 12% lighter than our conventional product and eliminates backlash of the spline joint by connecting the hub bearing (H/B) and the constant velocity joint (CVJ). **NTN**'s technology for the "Press Connect Method" does not require any change in the assembly process of the automotive manufacturers.

2. Structure and features

NTN has been developing the "V-Series Hub Joint (V-H/J)" [1] as an integrated unit of the H/B and CVJ connected with the "Press Connect Method", which uses a swaged CVJ outer ring stem (**Fig. 1b**) to assemble the third generation H/B+CVJ (**Fig. 1a**) where conventional H/B and CVJ are fastened together with a nut. H/B and CVJ are inseparable with V-H/J design and so the vehicle assembly process needed to be changed at the automotive manufacturers. To solve this problem, the newly developed "PCS-H/J" is designed to fasten the H/B and CVJ with a bolt which also assisted in reducing the spline pressure load (**Fig. 1c**).

2.1 Joint methods of components

The joint methods of H/B and CVJ are described using **Fig. 1** in the following:

a) Conventional structure (third generation H/B+CVJ)

Splines are provided on the outer diameter of the CVJ outer ring stem and on the inner diameter of H/B, which are then fit together to transmit torque. The transmission of torque from CVJ to H/B is conducted through the contact of the spline teeth. However, close contact of both components is difficult because of the machining accuracy (difference of pitch of the teeth between the splines). The resulting gap, as shown in the middle section of the figure, causes circumferential backlash. This prevents the torque to be borne by the entire spline, which requires the length of the spline engagement to be increased.

b) V-H/J

The CVJ outer ring stem is machined with special splines (teeth) that are thermally hardened and inserted into the H/B. This causes splines to be formed on the inner diameter of the H/B spindle ring with which CVJ and H/B are tightly connected. **NTN** calls this joint method the "Press Connect" method.

In this method, since the inner diameter of H/B is formed by elastic deformation, the recessed part of the H/B inner diameter and the raised part of the CVJ outer ring stem are tightly engaged. The input torque

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can be uniformly borne by the entire teeth area allowing shorter spline engagement length compared to the conventional structure **a)**.

Since the entire teeth area has to be formed, high power is required for the machining process including the use of machining equipment such as a press machine for the joint process, which is a challenge.

c) PCS-H/J

For PCS-H/J, splines are pre-formed on the inner diameter of H/B with smaller tooth width than the CVJ outer ring stem splines (**Fig. 2** shows an example of pre-formed splines). The CVJ stem teeth and the splined grooves of the H/B are gapped at specified distances to reduce the power required for the assembly process of the H/B and CVJ that are fastened together by a bolt. With this design, the vehicle production line at the automotive manufacturers does not required to be changed for assembling PCS-H/J.

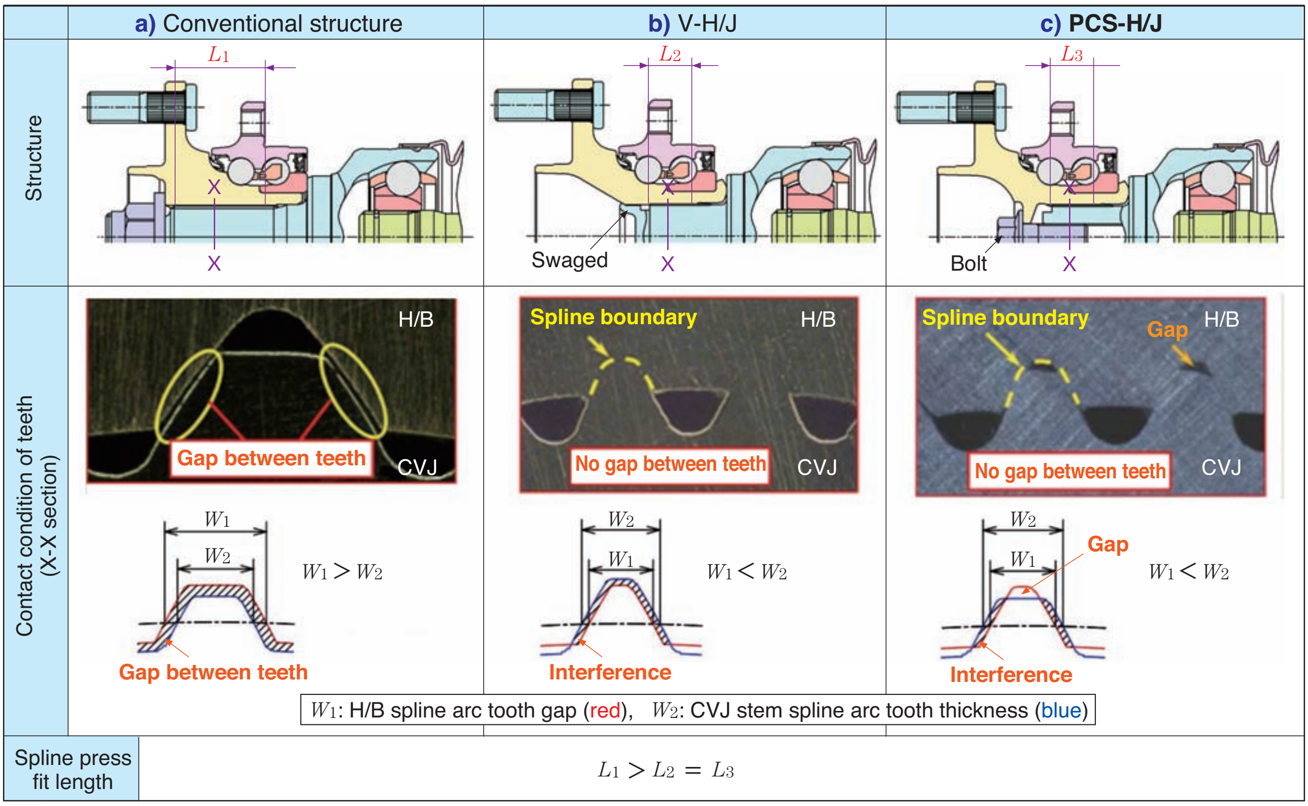


Fig. 1 Contact condition of teeth

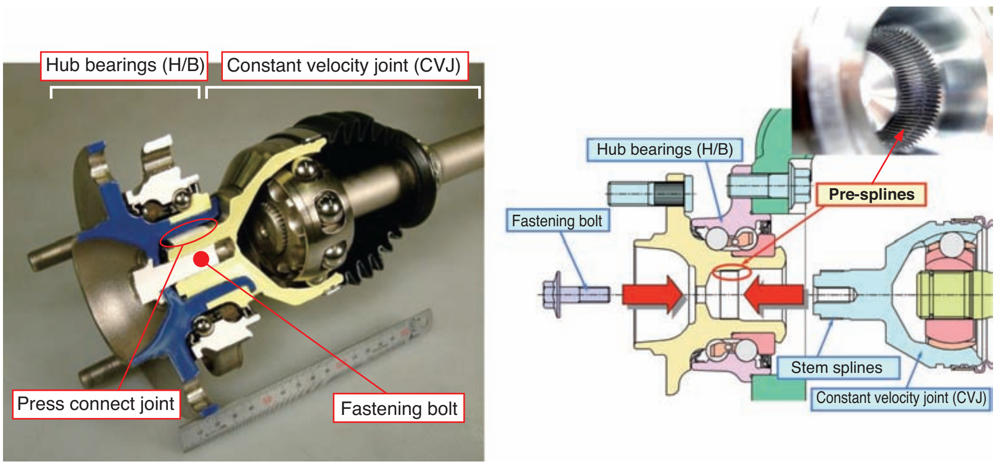
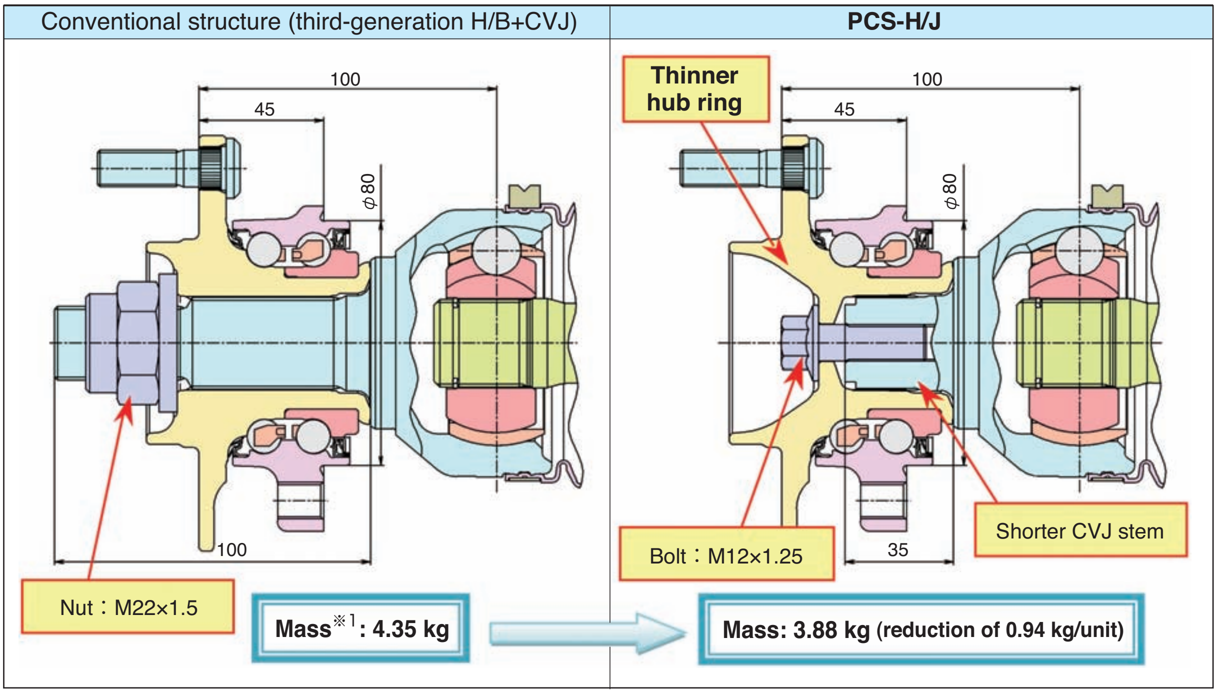


Fig. 2 Structure of PCS-H/J

2.2 Features

PCS-HJ achieved a significant lightweight and eliminated backlash on the splined area thanks to the adoption of the press connect method. **Fig. 3** shows an example of the trial application on a C-segment vehicle.

With PCS-H/J, input torque is borne by the entire area of the teeth as opposed to the conventional structure, therefore, the length of the CVJ stem can be reduced by approximately 65%. Furthermore, the weight was reduced to 0.94 kg/unit (approx. 12%) by thinning the inside wall of the hub ring and by using a bolt instead of a nut.



*1: Mass of H/B+Outboard CVJ outer ring+nut or bolt

Fig. 3 Example of the application of PCS-H/J

3. Functional test

3.1 Spline press-fit load

With PCS-H/J, the CVJ outer ring stem is assembled to the inner diameter of H/B by use of a bolt. **Fig. 5** shows the measurement results of the spline press-fit load using components with the upper and lower limits of the interference as shown in **Fig. 4**.

Fig. 5 shows that the spline press-fit load required for the upper and lower limits of interference is below the lower limit of the established axial force of the bolt which means that the H/B and CVJ can be assembled in all specified ranges of interference.

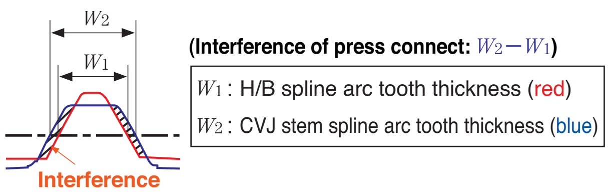


Fig. 4 Interference

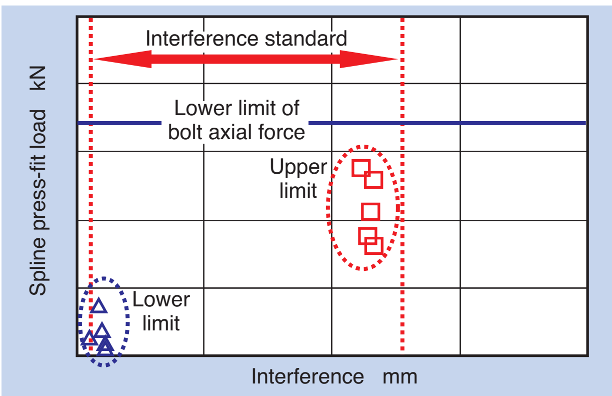


Fig. 5 Spline press fit test

3.2 Strength evaluation of the splined area

Static torsional and bi-directional torsional fatigue strength tests were conducted against the shortened splined area of PCS-H/J and had verified the strength was equal or better than the conventional unit.

3.2.1 Static torsional strength test

Static torsional strength test was conducted for breaking torque when torsional torque is applied in one direction. **Fig. 6** shows the test results.

Although the splined area is short, PCS-H/J has equal or better strength than the conventional units.

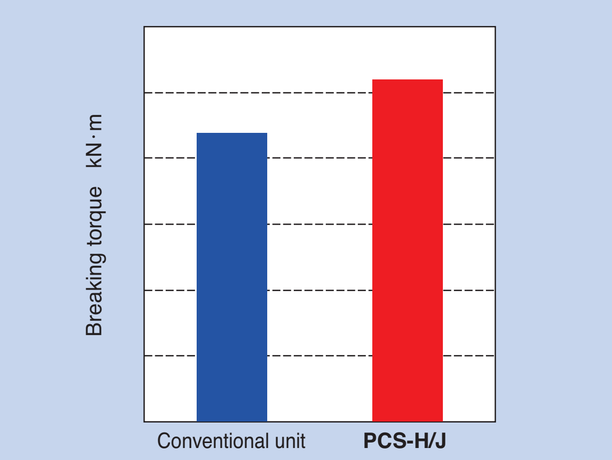


Fig. 6 Static torsional strength test

3.2.2 Bi-directional torsional fatigue strength test

A bi-directional torsional fatigue strength test was conducted where alternating torsional torque is repeatedly applied on the splined area and records the cycle count until the unit breaks. **Fig. 7** shows the test results.

Both high torque and low torque were applied repetitively for the evaluation with the assumption that high torque and low torque is what is normally seen on vehicles. PCS-H/J demonstrated to have sufficient fatigue strength over the guaranteed life values of the conventional products even if the splined length is shorter.

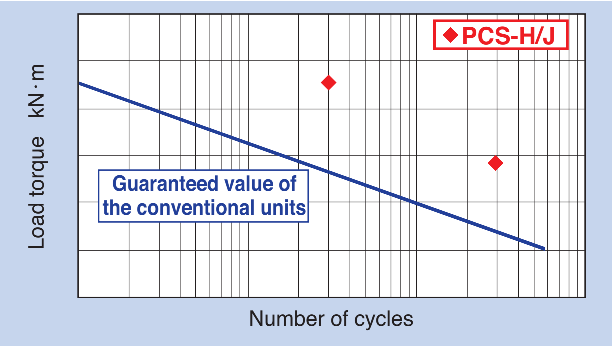


Fig. 7 Bi-directional torsional fatigue strength test

3.3 Disassembly/reassembly test

Service or replacement of the PCS-H/J components was studied. Disassembly of the H/B and CVJ was conducted and the spline press-fit load was evaluated when they were reassembled. The spline strength of the disassembly and reassembly unit was verified to be OK.

3.3.1 Measurement of spline press-fit load during reassembly after disassembly

In this test, spline press-fit load was measured with the combination of both new and reused H/Bs and CVJs, as shown in **Table 1**, and verified to see if interference still remained in the splined area of the reused components. **Fig. 8** shows the test results.

Table 1 Sample combination

		CVJ	
	Number of reuse	New	Reused 5 times
H/B	New	(1)	(2)
	Reused 5 times	(3)	(4)

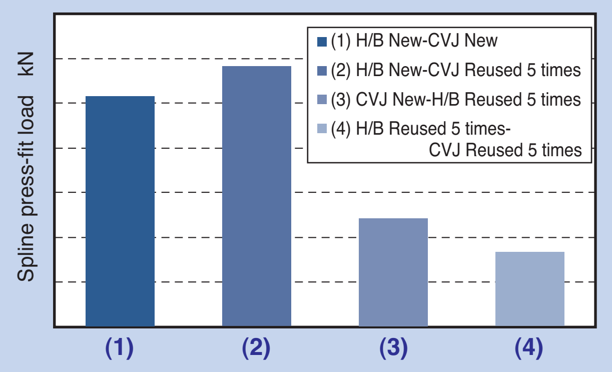


Fig. 8 Re-assembly load test

When only the CVJ was the reused component (**Fig. 8 (2)**), the press-fit load was almost the same as in the case of new components when comparing the spline pressure load of new components (**Fig. 8 (1)**). When only the H/B was the reused component (**Fig. 8 (3)**), the press-fit load was about half of the new component. The press-fit load decreased because the interference had been reduced as the H/B inner diameter was formed by the CVJ splines when the original CVJ was pressed in. When both H/B and CVJ were the reused components (**Fig. 8 (4)**), the press-fit load was approximately 1/3 of the new components.

Based on the above data it was revealed that when the H/Bs were reused, the press-fit load is reduced compared to the new components, however, the load is not zero and some interference still remained in the splined area. In addition, the reused components were verified to be fit without any backlash being observed in the joint.

3.3.2 Bi-directional torsional fatigue strength test of disassembled and reassembled units

In order to verify the strength of the splined area of the disassembled/reassembled PCS-H/J, samples which have undergone disassembly/reassembly 5 times were placed on the bi-directional torsional fatigue strength test of the above section 3.2.2. Fig. 9 shows the results.

They were evaluated with high torque and low torque, similar to 3.2.2. The disassembled and reassembled unit has the equivalent level of strength as the first assembled (new) unit.

Based on the above data it was observed that the reuse of H/B and CVJ exhibits no problem for assembly or strength.

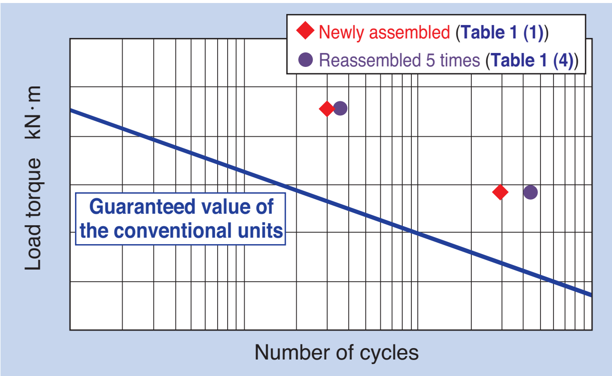


Fig. 9 Bi-directional torsional fatigue strength test

3.4 Verification of impact to H/B

Inspection of the raceway condition after bearings life testing was conducted to verify the impact of press connect on H/B.

3.4.1 Measurement of roundness of raceway

Roundness of raceway of the inner ring before and after press-fitting splines with upper and lower limits of interference (Fig. 4) was measured. Fig. 10 shows the results.

The roundness measurement value after press-fitting the splines increased by approximately 0.5 μm. No impact such as polygon strain was observed. Also, no difference between press connect interference was observed.

3.4.2 Turning life test with 0.8G

A load equivalent to 0.8G which simulates aggressive turning was applied to the PCS-H/J bearings so life testing could be conducted. Fig. 11 shows the results.

The bearing life was equivalent to the conventional products and no difference was exhibited.

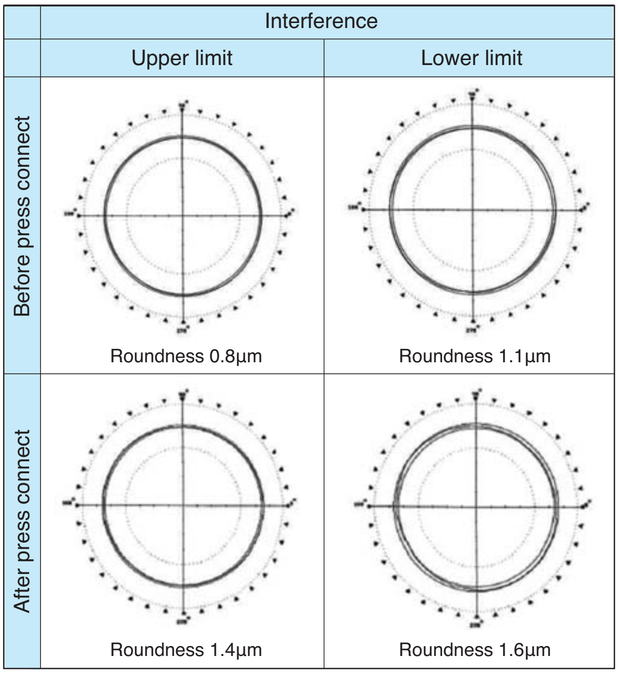


Fig. 10 Circularity measurement of raceway surface

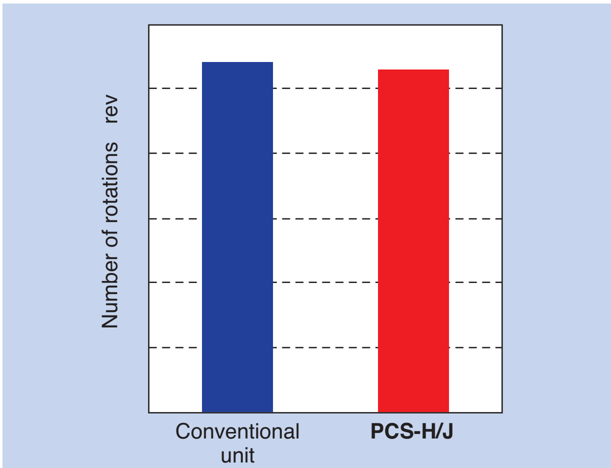


Fig. 11 Turning (0.8G) durability test

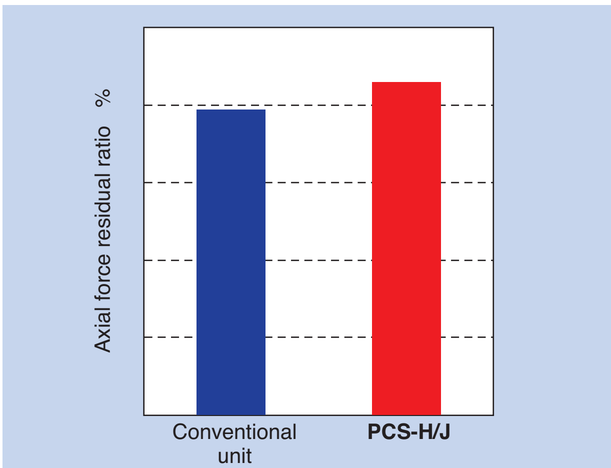


Fig. 12 Axial force residual ratio

3.5 Measurement of bolt axial force

Since the PCS-H/J uses a bolt for fastening instead of the conventional use of nuts (**Fig. 1**), loosening of the bolt during use in the field is a concern.

Bi-directional torsional torque was applied on the splined area of PCS-H/J for predetermined number of times and bolt axial force was measured before and after the test to verify if the bolt had loosened. **Fig. 12** shows the results.

No loosening was observed after the test and the residual ratio of the bolt axial force was 86% or more for PCS-H/J as opposed to the conventional nut fastening of approx. 80%. This is considered to be adequate for operational usages.

4. Summary

We have developed a lightweight PCS-H/J that has no backlash in the splined area by forming pre-splines on the inner surface of the H/B with smaller tooth width than the splines of the CVJ stem, and uses a bolt for connecting the H/B and CVJ.

PCS-H/J can be assembled within the existing assembly process in the vehicle production lines of automobile manufacturers. We have pursued weight reduction with PCS-H/J which is desired for the modern vehicles and believe it will significantly contribute to improved fuel economy.

We plan to expand this PCS-H/J into a family of product lines and continue developing modular units.

References

1) Mitsuru UMEKIDA, Yuuichi ASANO, “V-series Hub Joint”, NTN TECHNICAL REVIEW No. 77 p67-72, 2009

Photo of authors

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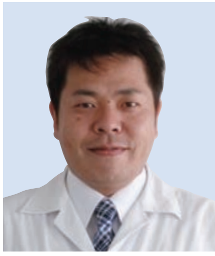

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