Proceedings of the 72nd World Foundry Congress
21-25th May 2016, Nagoya, Japan

The strength analysis in caulking fastening portion of automotive parts

Ryota Ueda[1], Kazumichi Shimizu[1] and Takafumi Funabiki[2]
[1]Muroran Institute of Technology,
27-1, Mizumoto-cho, Muroran-city, Hokkaido, Japan, 050-8585

In this study, we are focusing on the caulking for fixing the two metals. The method of fixing by plastically deforming the material is referred to as caulking fastening. This way, it is possible to low cost and shorten delivery time. However, since the weak rotational force at the junction, it has been reported that failure symptoms. Therefore, it is important to establish the strength evaluation method. So this time, we made a stress measurement of by the measurement and simulation of the slip torque in the two types of the miniature model and the full scale model. This model uses the shaft side and the ring side respectively FCD450, S45C tempering and quenching material. This analysis is intended to be to investigate the effect of the load applied in 1 second static structural analysis. Test in miniature model results showed a fixation for all interference. The results of shear stress, by tresca's theorem is shown that it's broken when fastening margin is 0.1 mm. Therefore, interference may be set to interference in the range of 0.1 ~ 0.05mm. This has been shown similar trend to full scale model.

Keywords: *caulking , fastening, fastening margin, slip torque, analysis*

1. Introduction

In this research, reported for caulking fastening method of the two parts. When joining the two parts, in the prior art is fixed by using bolts. However, there is a need for low-cost joining process from because it is costly. So, I will be paying attention to the caulking fastening. The method of fixing by plastically deforming the material is referred to as caulking fastening. This way, it is possible to low cost and shorten delivery time [1]. However, since the weak rotational force at the junction, it has been reported that failure symptoms. Therefore, it is important to establish the strength evaluation method. Therefore, in this study, analysis is performed for the purpose of practical use to the automotive products by swaging method of the differential case and ring gear. To the simulation analysis using the finite element method for the strength of the caulking fastening portion.

2. Analysis method and Experimental method

2.1 Analysis method

The torsional analysis using ANSYS a FEM analysis tool. It is intended to investigate the effect of load applied to one second. It shows the model to be used in the present analysis in Figure 1. Twist with adding a load to the key groove of ring side. In this analysis we use a complex model that was quenched FCD450 and S45C. However, it regard FCD450 as the shaft side and it treat S45C as ring side. Analysis object to investigate the stress analysis and contact of the crimped portion interference 0.1mm, 0.05mm, 0.025mm. To evaluate the strength of the caulked portion in the calculated shear stress. Also, friction coefficient of the contact surface is set to 0.25. Also, physical property values are as shown in Table 1.

2.2 Experimental method

In this study continuously performed to be twisted by the load on the ring of the key groove, and performs a torsional torque load test. It is shown in Fig. 2 the relationship between load and slip determination torque. Load will be 30~40% lower by value from the maximum slip torque. It is set as slip determination torque from the 2 percent lower value of torque at the start of the test. The test shall be conducted at ambient temperature. In addition, it will be when the number of repetitions is 10^6 times or slip and stop conditions. Also, physical property values takes a same value as the analysis.

Table 1 Each physical properties values

	Shaft	Ring
Material	FCD450	S45C
Longitudinal elastic modulus [GPa]	161	205
Linear expansion coefficient [1/℃]	1.05×10^{-5}	1.17×10^{-5}
Poisson's ratio [-]	0.3	0.25

3. Results and discussions

3.1 Analysis result

First, miniature model was set to the analysis object. It is observed after the analysis of the contact surface. There was no change in the state before and after the analysis in all of the fastening margin. Also, analysis results of the maximum shear stress that it is increased as the fastening margin increases. Next, full scale model was set to the analysis object. It is observed after the analysis of the contact surface. Analysis method is the same as a miniature model. Analysis result was a state of being fixed like the miniature model. In addition, the analysis result of the frictional stress and shear stress tended to analysis value increases with a large fastening margin. It was obtained the same tendency as miniature model. Analysis model is considered less likely to slip by a large fastening margin from the analysis result of the friction stress. Table 2 shows the Analysis results of shear stress in each model. The analysis result of shear stress is assessed by theorem of Tresca. Apply this to the analysis result as to whether or not it will be considered to break. In the case of 0.1mm, the shear stress should be set small fastening margin to exceed the allowable shear stress. Therefore, it is preferable that fastening margin is employed at between 0.1mm to 0.05mm.

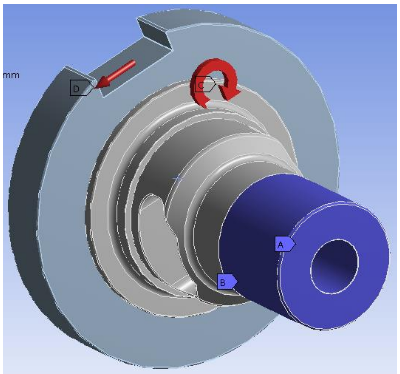

Fig. 1 Analysis model

Table 2 Analysis results of shear stress

Model	Element	0.1mm (MPa)	0.05mm (MPa)	0.025mm (MPa)
Miniature model	Shaft	296.90	148.59	68.27
	Ring	855.19	417.57	239.29
Full scale model	Shaft	273.10	138.78	127.75
	Ring	585.00	326.79	159.43

3.2 Experimental result

The slip torque is subjected to torsion test of the two kinds of specimens. It shows the value of the slip torque of slip torque in Table 3. As a result, specimens of 210 N-m was slip determination at 5498 rotation. Meanwhile, the test piece of 631 N-m were obtained the results that do not break even when repeatedly load 10^6times.

Table 3 Measurements results of torque and slip determination value in the each specimen.

Fastening margin [mm]	4.27×10^{-3}	12.8×10^{-3}
Slip torque [N・m]	210	631
Torque after fastening [N・m]	95	426
Slip determination [N・m]	93	417

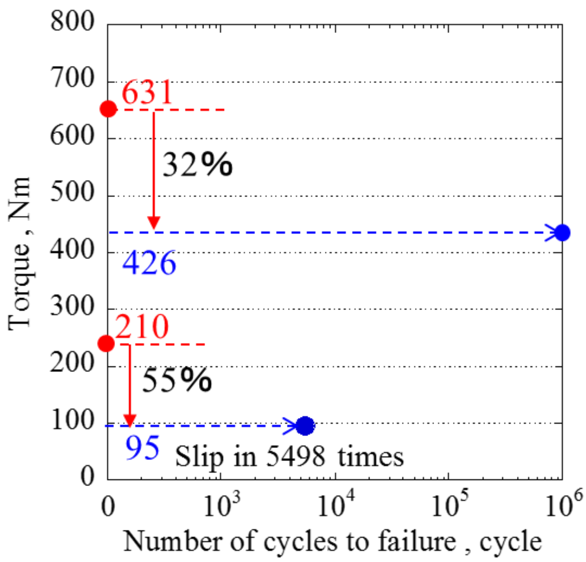

Fig. 3 The torsion fatigue test results of each specimen

4. Conclusion

This study was evaluated by simulation analysis the strength of the model that was produced in the interference of 0.1, 0.05, 0.025mm. Shear stress is evaluated by theorem Tresca, fastening margin is estimated to be broken at the time of 0.1mm. Therefor the interference it is preferable in the range from 0.1mm to 0.05mm.

References

[1] Kinoshita Hiroyuki, Nakanishi Tsutomu : Japan Society of Mechanical Engineers Proceedings 008-1(2000)73