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2023 年 8 月 22 日　Email: shutingnpu@yahoo.co.jp

Design and Strength Analysis of Cycloidal Gear Reducers

By Prof. Shuting Li

1． Abstract

Cycloid reducers are characterized by their high reduction ratio, high torsional rigidity, and high shock resistance, making them commonly used in industrial robot joints and machine tools. In this reducer, a trochoid curve is used as the tooth profile, and the pin serves as the tooth of the internal gear; meshing is achieved through the eccentric oscillation of the crank shaft. Mechanically, this reducer differs from involute-toothed gears, and as a result, strength analysis remains difficult at present.

To enable design calculations and strength analysis of this reduction gear, the author developed design calculation software through many years of research and proposed a numerical analysis method using the two-dimensional, finite element method (2D-FEM) to analyze the contact problems of this reduction gear. Furthermore, the author developed specialized finite element method software capable of analyzing the contact strength of this reduction gear. Here, the author presents the loads and contact surface pressures (contact stresses) on the gear tooth surfaces, center rollers, and bushes calculated using the developed software; for details on this research, please refer to Reference [(1)].

2． Development of Design Calculation Software for Cycloidal Reducers

The design software was developed using standard Visual Basic and AutoCAD VBA, respectively. Figures 1 and 2 show the input and output screens, respectively. As shown in Figures 1 and 2, once the gear parameters are entered into the software's "Input" section and the "Calculate" command is clicked, the calculation is completed immediately, and the mechanism diagrams on the right side of Figures 1 and 2 are generated instantly.

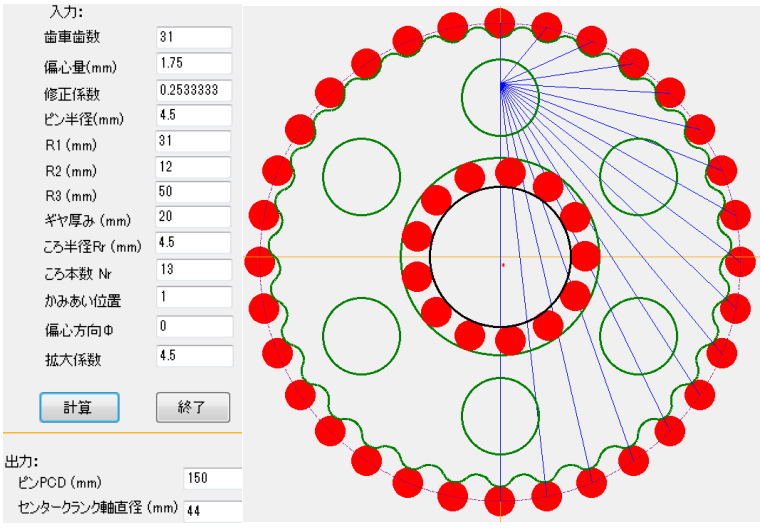

Figure 1: Design calculation software for cycloidal reducers

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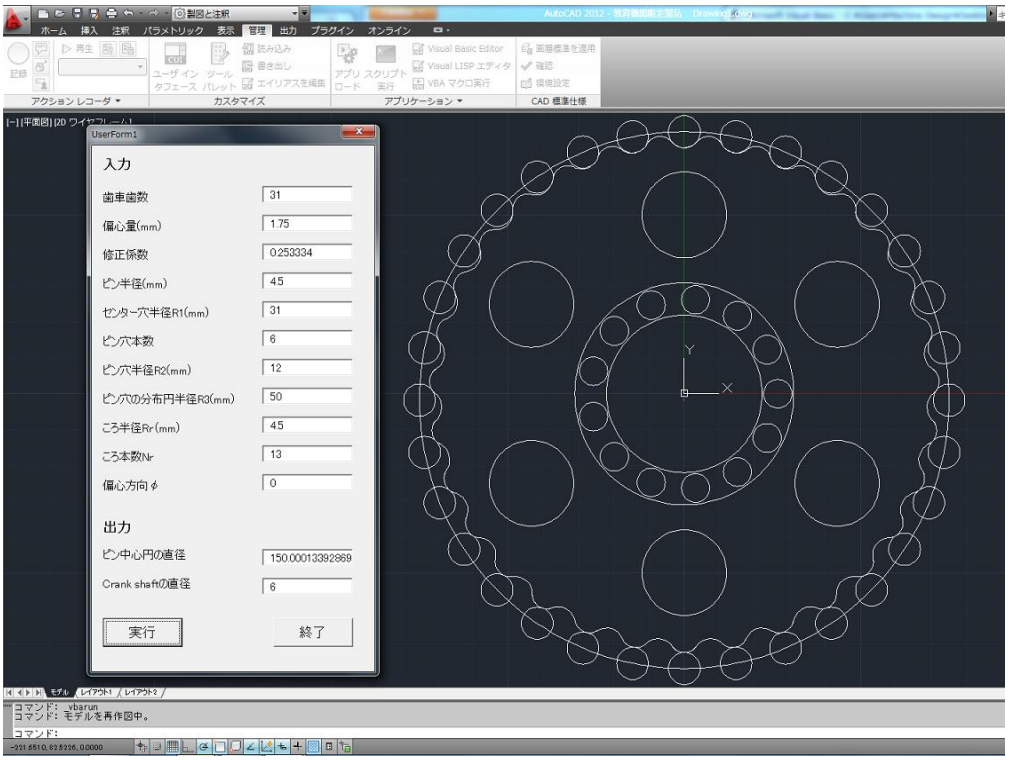

Figure 2: Design calculation software for cycloidal reducers developed using autoCAD VBA

Figure 3 shows the design calculation software developed for the inboard cycloidal reducer. In this inboard cycloidal reducer, the trochoid curve is used as the tooth profile for the internal gear, and the pin is used as the tooth profile for the external gear.

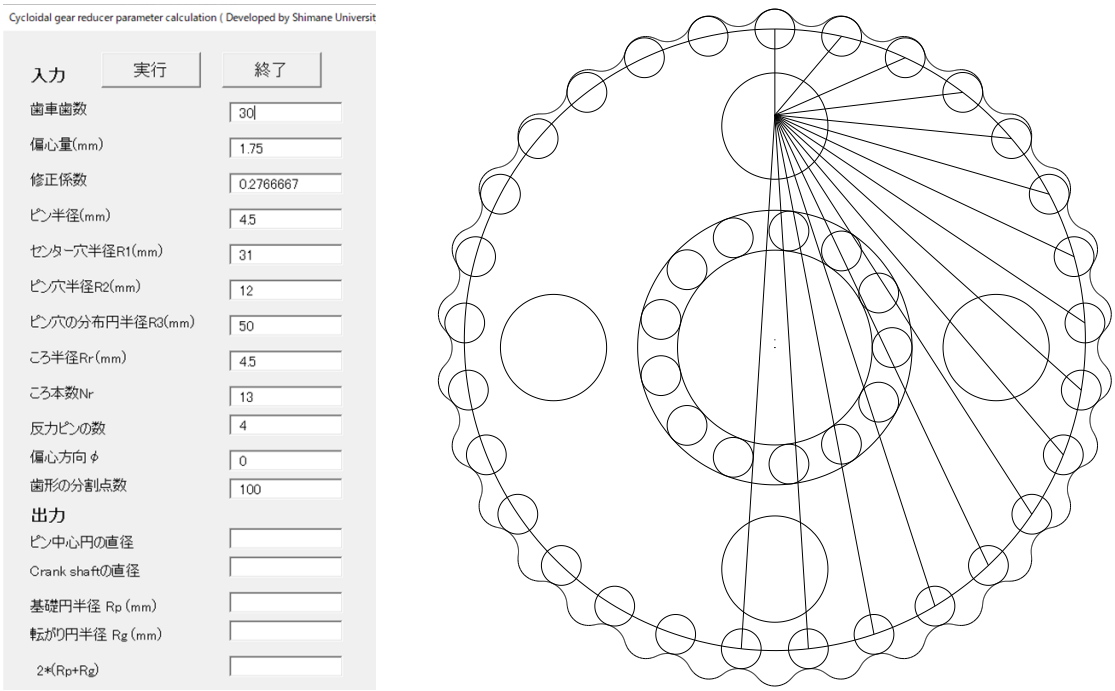

Figure 3: Design calculation software for inboard cycloidal reducers

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3． Contact Strength Analysis of Cycloidal Reducers

We developed a dedicated two-dimensional, finite element method (FEM) software to analyze the contact strength of cycloidal reducers. The results calculated using this software are presented below. For details on the analysis method and this research, please refer to Reference [1]. Figure 4 shows the cycloidal reducer subject to the strength analysis, and Figure 5 shows its FEM element mesh.

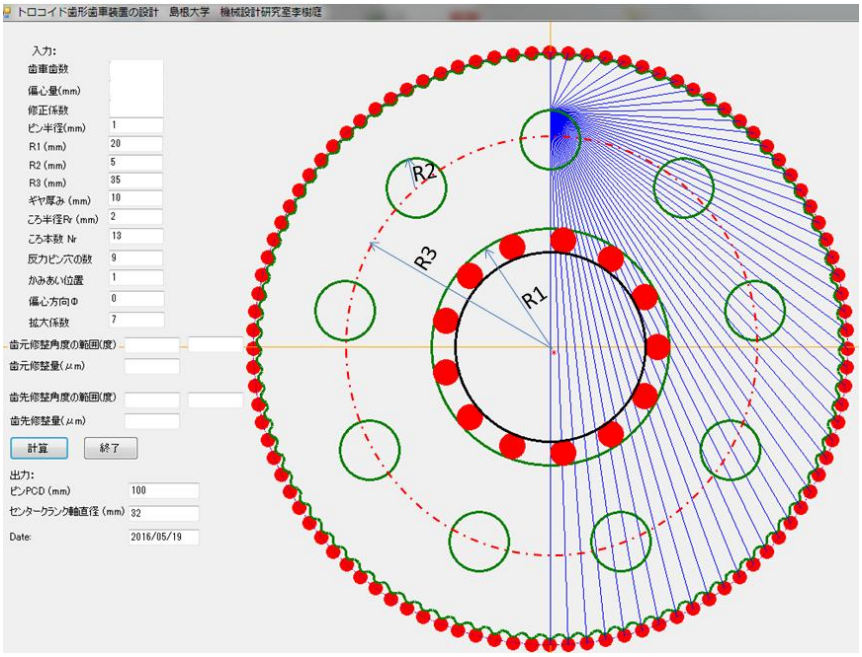

Figure 4: Cycloidal reducer subject to strength analysis

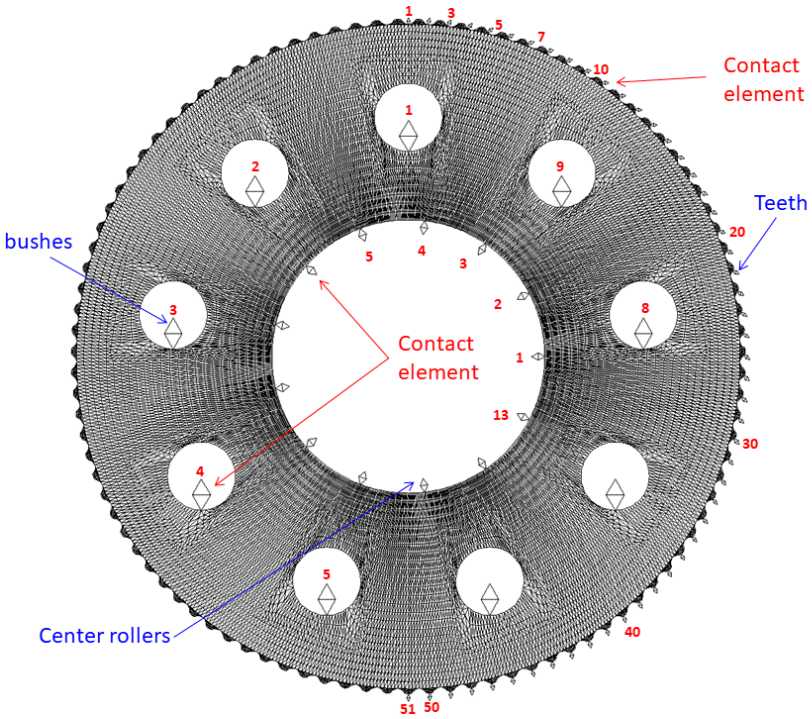

Figure 5: FEM element mesh for strength analysis

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Figures 6 and 7 show the load distributions on the tooth surfaces and on the center roller, respectively, while Figure 8 shows the load distribution on the bushes. Figure 9 shows the cycloidal gear after deformation.

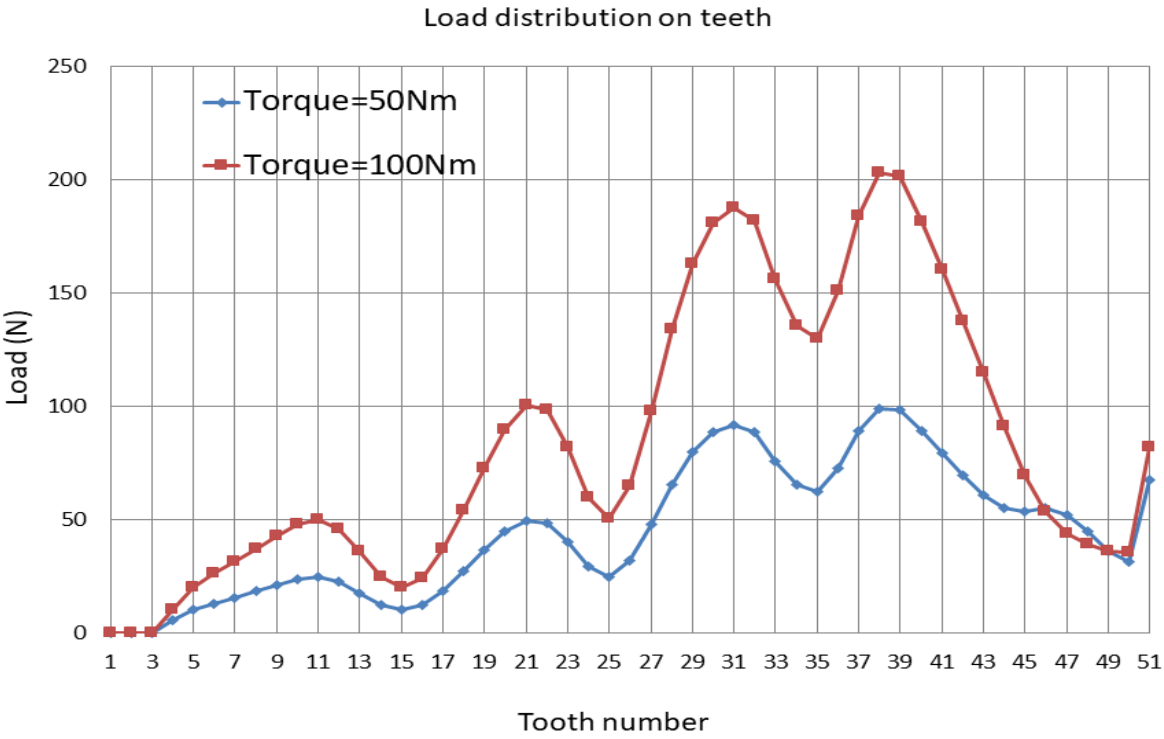

Figure 6: Load distribution on the tooth surface

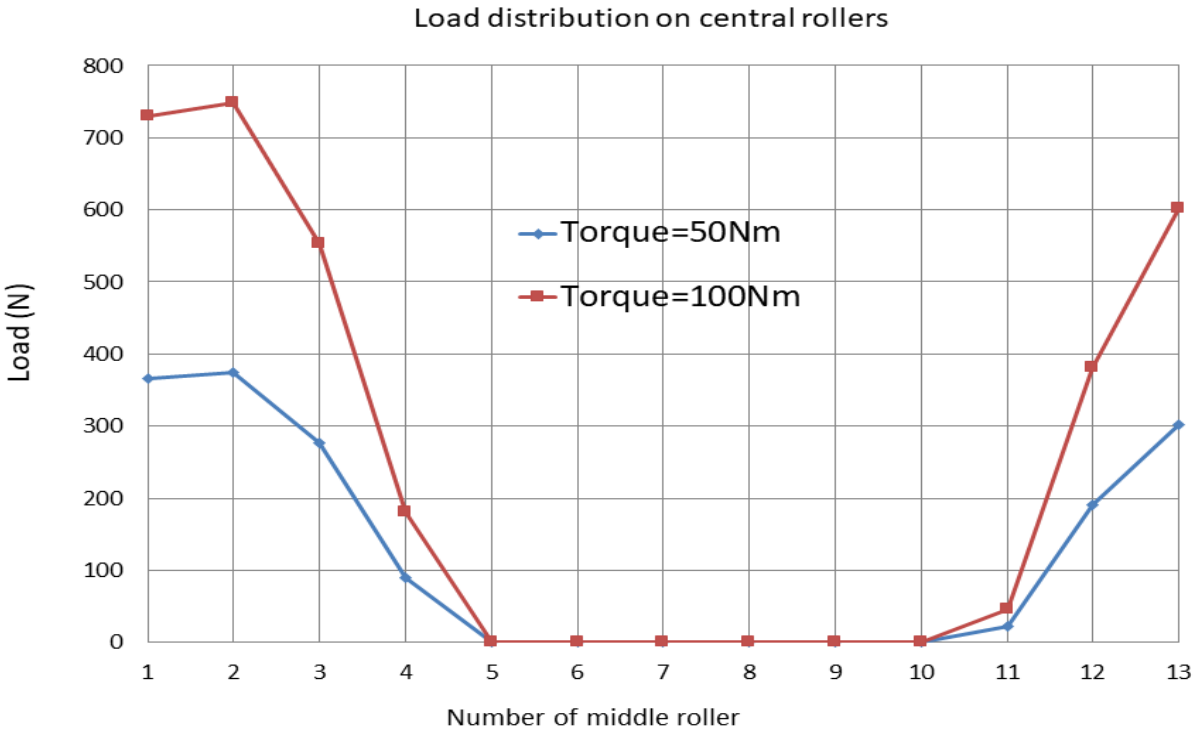

Figure 7: Load distribution on the center roller

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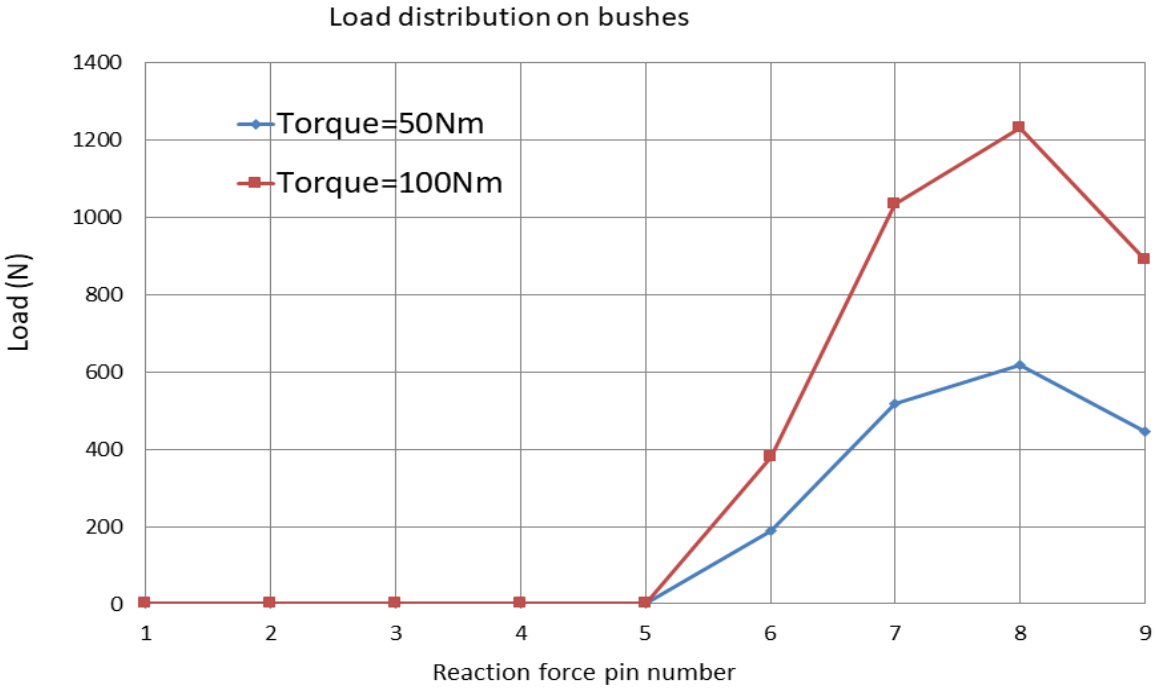

Figure 8: Load distribution on the bushes

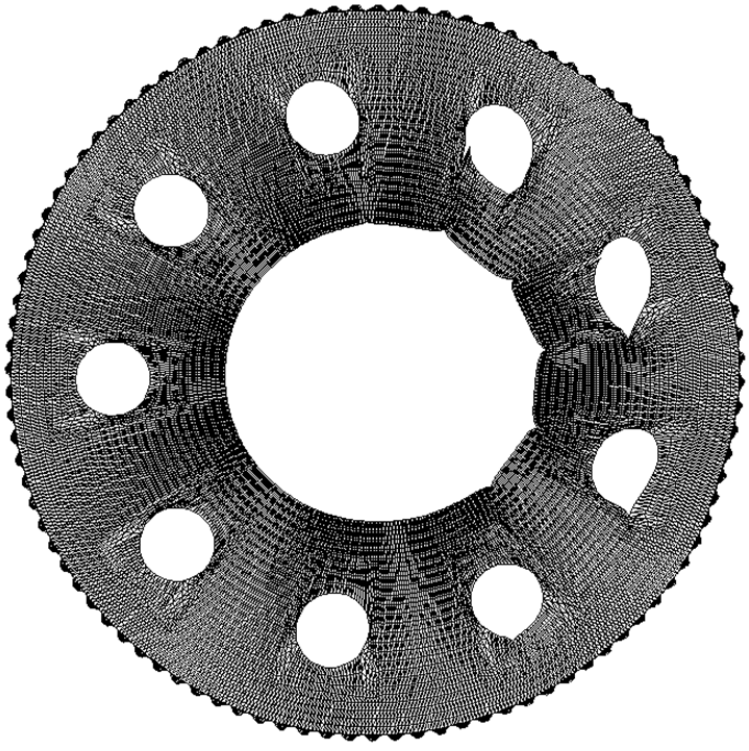

Figure 9: Deformed cycloidal gear

References：

(1) Shuting Li, “Design and strength analysis methods of trochoidal gear reducers”, **Mechanism and Machine Theory**, Elsevier Press, Volume 81, 2014, pp.140-154