Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Sensitivity analysis and optimization design of hypoid gears' contact pattern to misalignments

Xiao-le WANG, Jian-wei LU, Shi-qin YANG

Cite this as: Xiao-le WANG, Jian-wei LU, Shi-qin YANG, 2019. Sensitivity analysis and optimization design of hypoid gears' contact pattern to misalignments. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 20(6):411-430.

https://doi.org/10.1631/jzus.A1900021

Research object

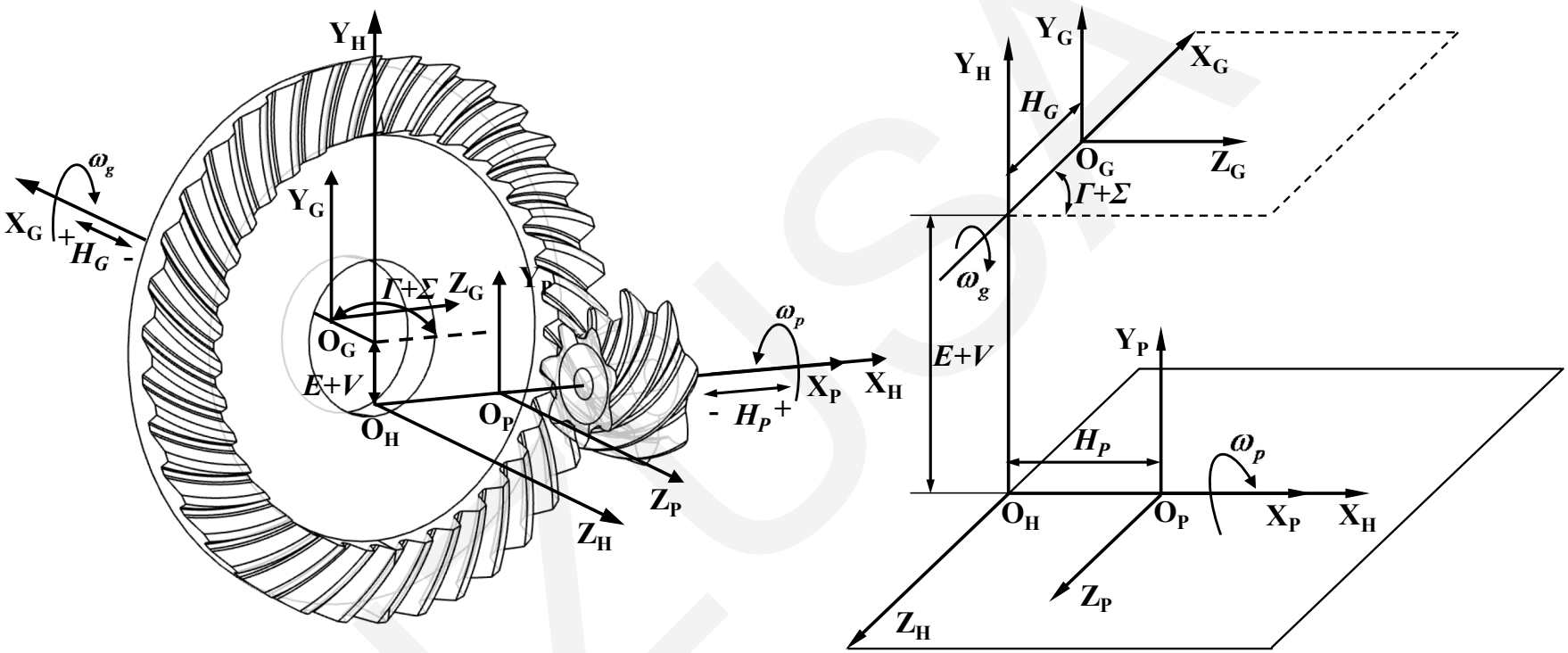


Fig. 1. Misalignments of a hypoid gear pair
(H_G: axial error of the gear; H_P: axial error of the pinion;
V: offset error of the gear pair; Σ: angular error of the gear pair).

Evaluation indexes

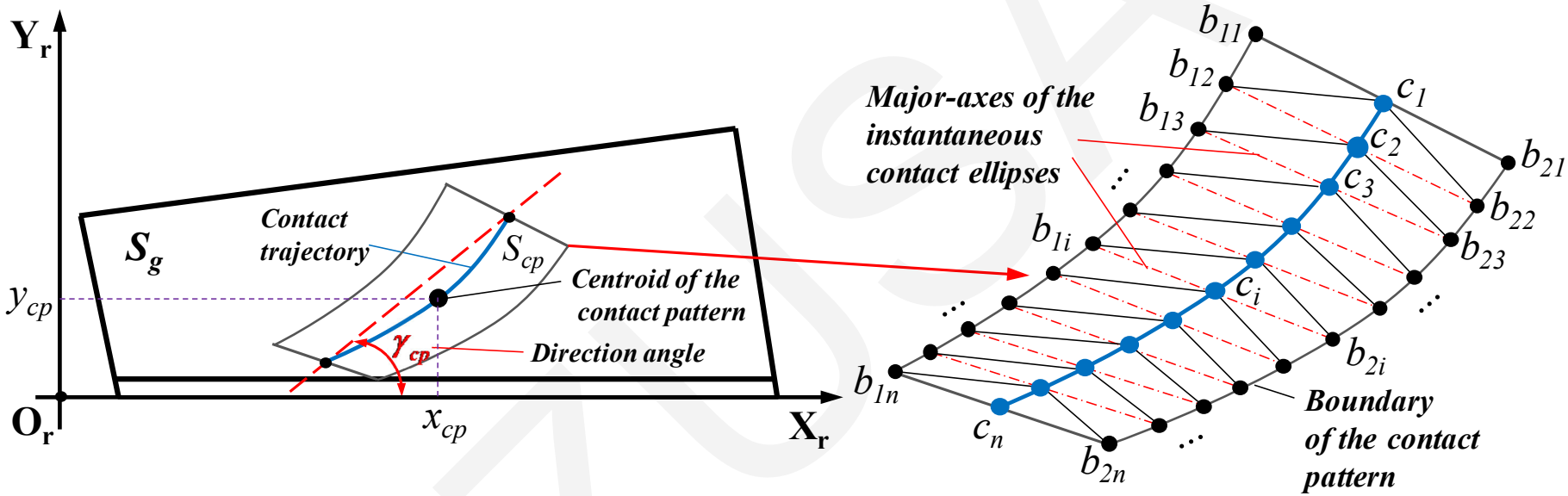


Fig. 2. Parametrization of the contact pattern on the gear surface.

- The area S_{cp} of the contact pattern on the gear surface
- The coordinate $[x_{cp}, y_{cp}]$ of the centroid of the contact pattern

Evaluation indexes

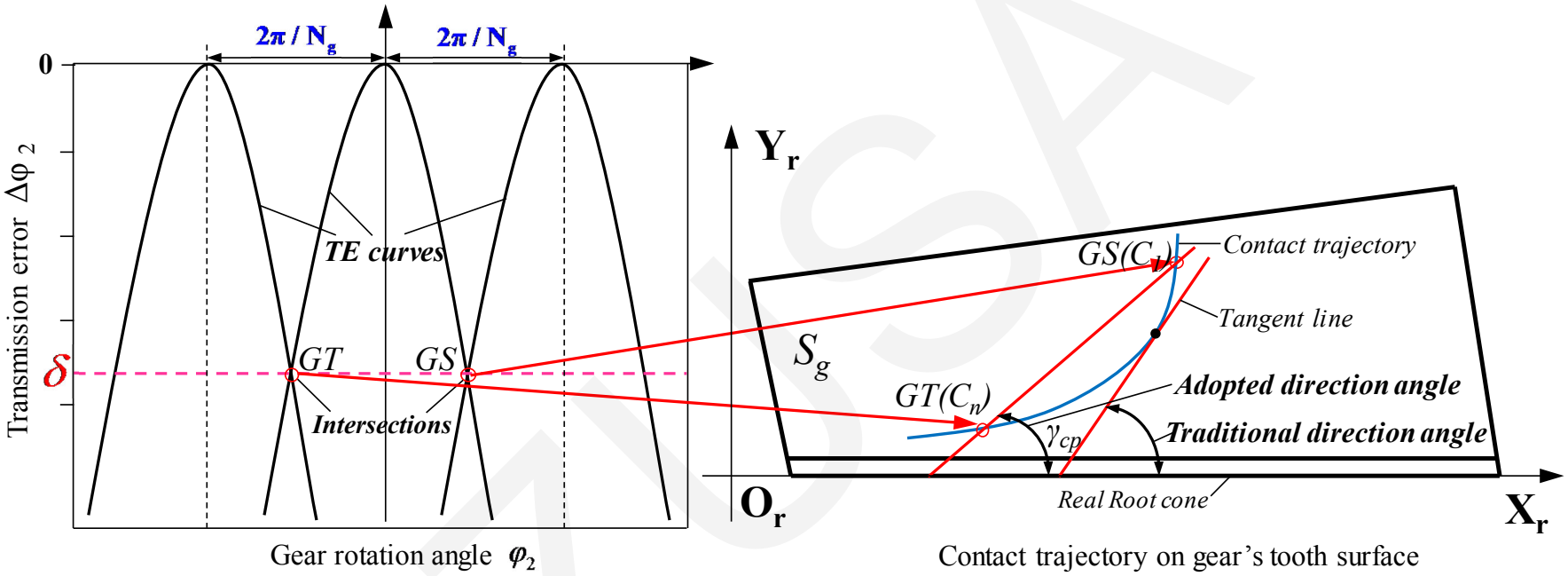


Fig. 3. The intersection of two adjacent TE curves and the direction angle of the contact pattern.

- **The direction angle γ_{cp} of the contact pattern**

Control objectives

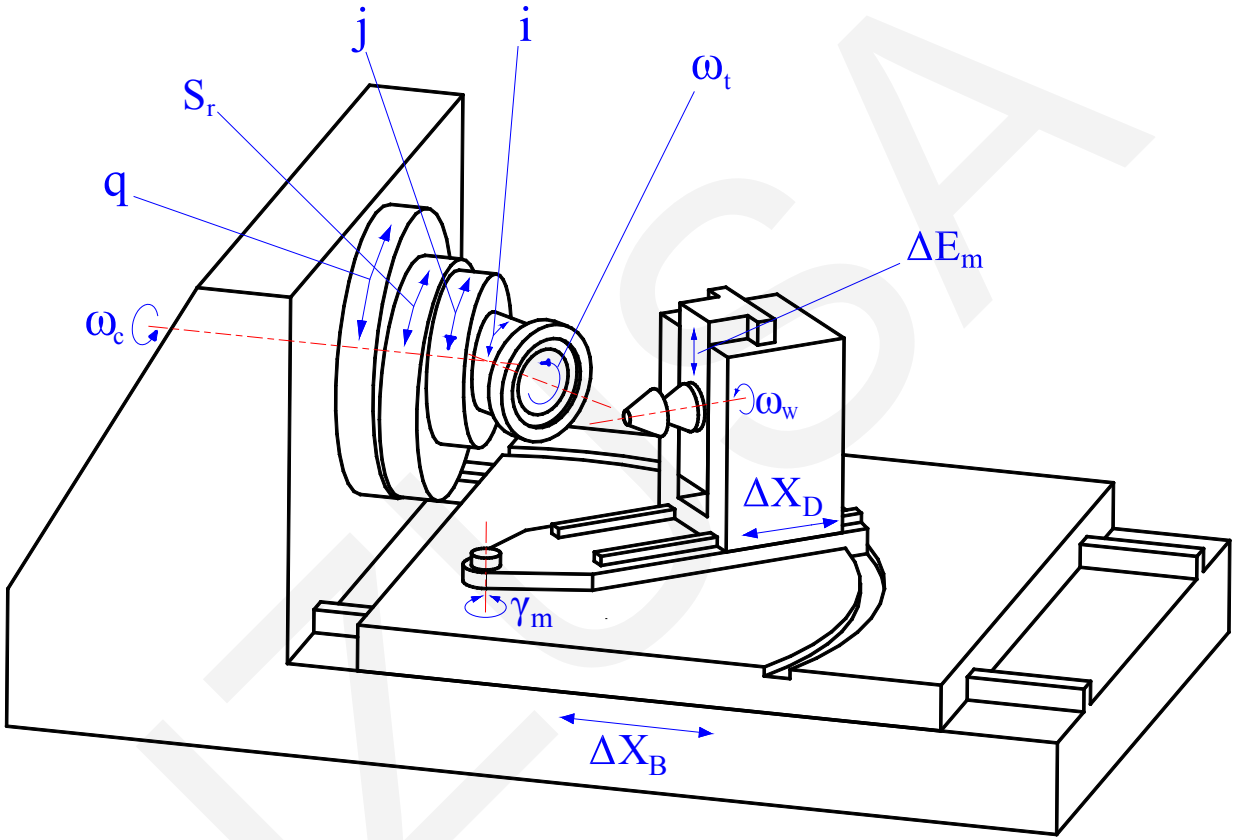


Fig. 4. The machine-tool settings of the universal machine tool for processing hypoid gears.

Constrains

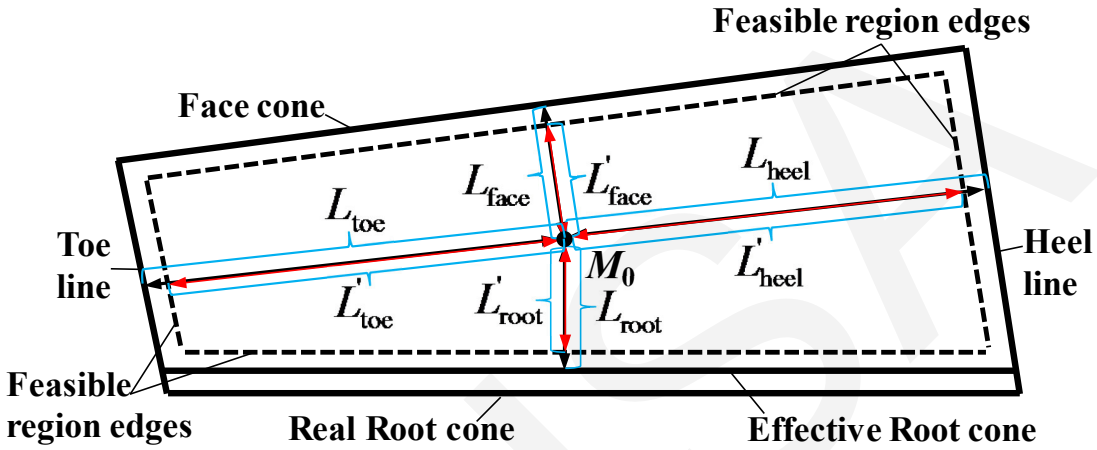


Fig. 5. The feasible region of the contact pattern.

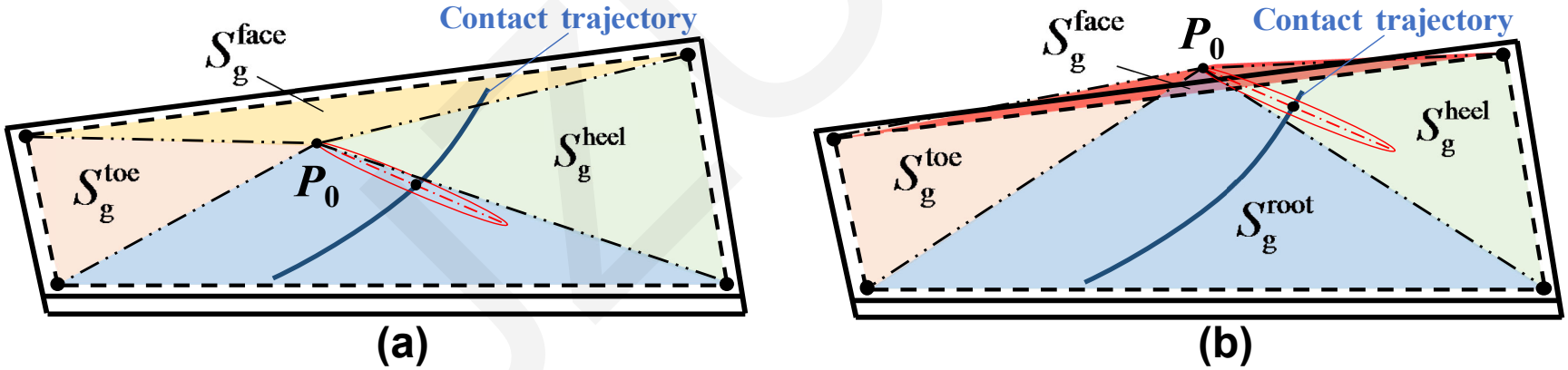


Fig. 6. Constraint strategy of the contact pattern
(a) Reasonable contact point; (b) False contact point.

Optimization flowchart

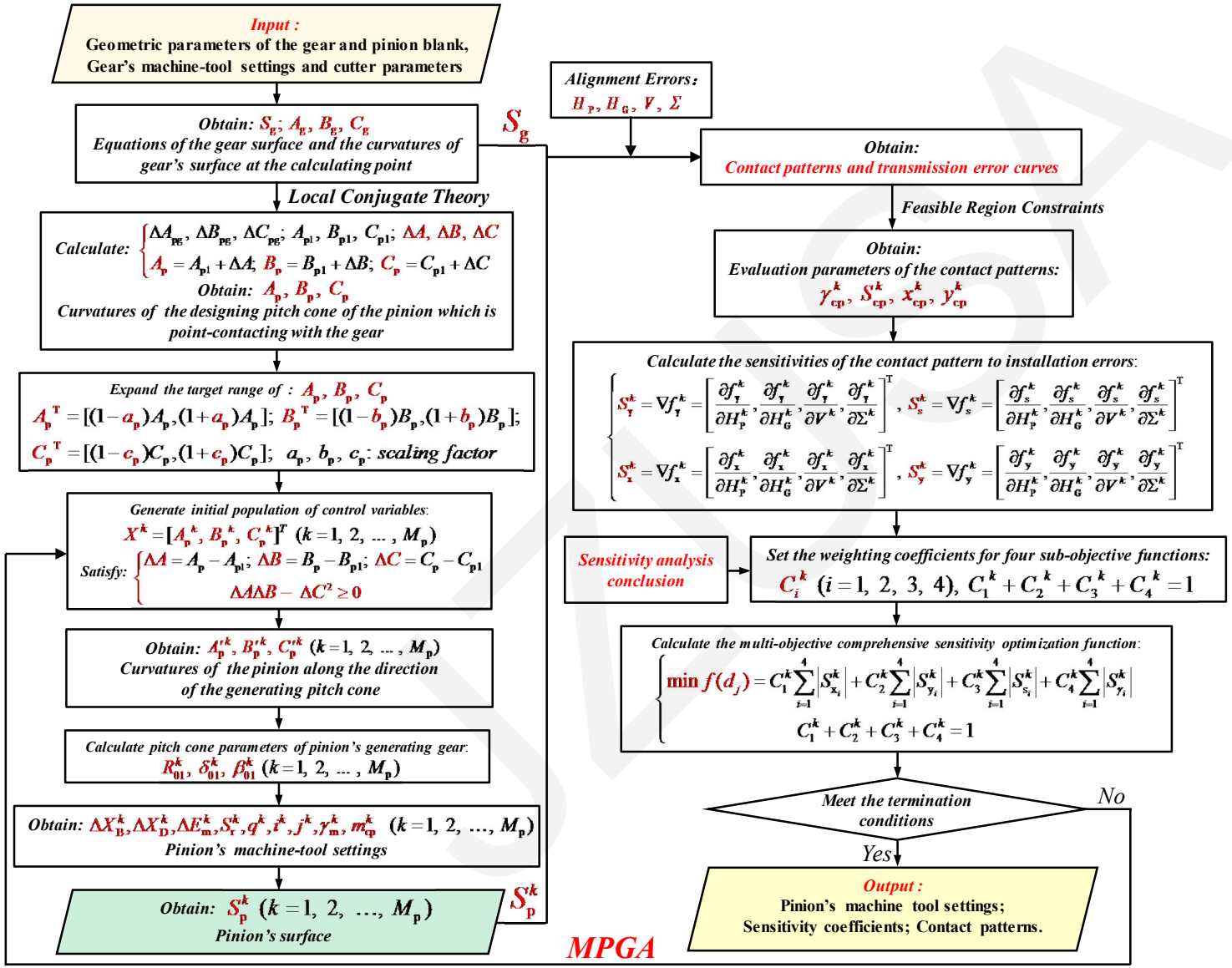


Fig. 7. Flowchart of the Optimization process.

Case studies

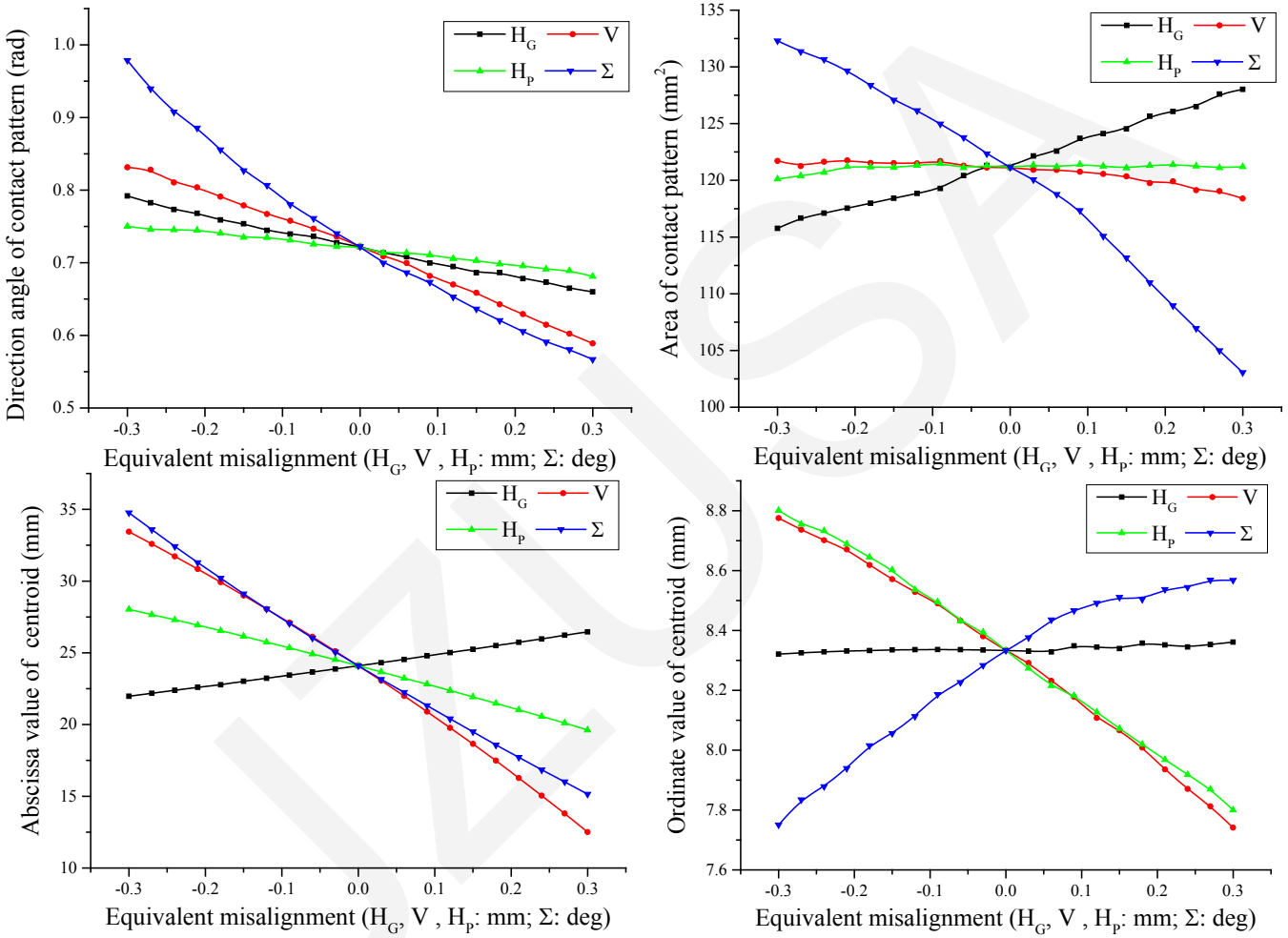
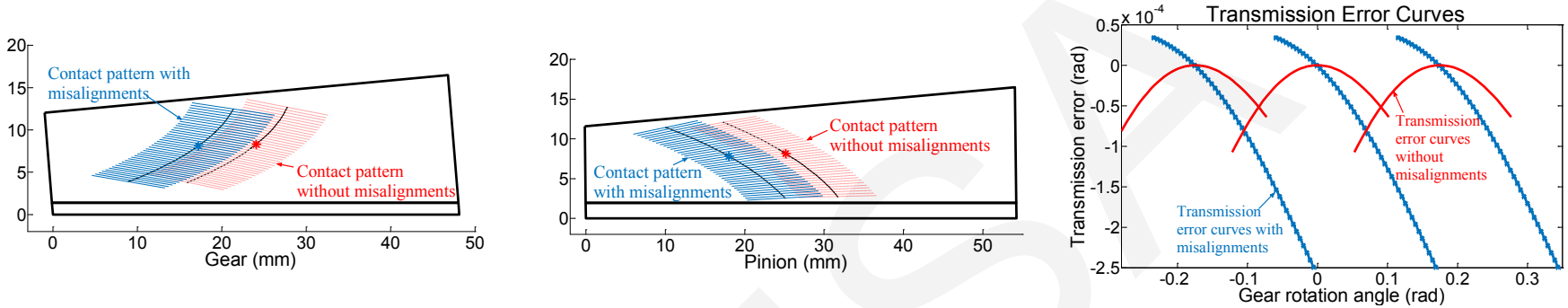


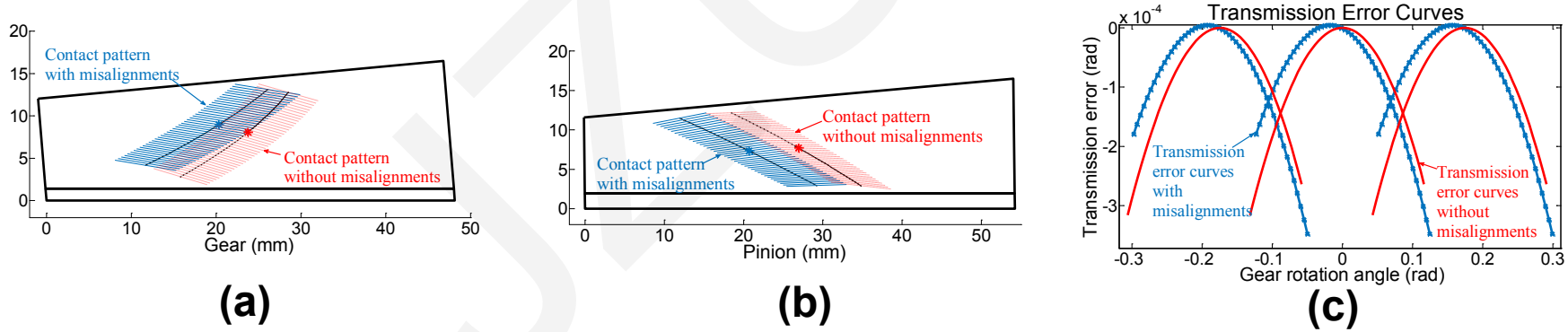
Fig. 8. Change rules of evaluation indexes of contact pattern. (a. direction angle of contact pattern; b. area of contact pattern; c. abscissa value of contact pattern's centroid; d. ordinate value of centroid).

Case studies



(a) (b) (c)

Fig. 9. Contact pattern (a), (b) and TE curve (c) of the original hypoid gear pair.



(a) (b) (c)

Fig. 10. Contact patterns (a), (b), TE curves (c) and fitness curves (d) of the optimized gear pair

Conclusions

- Parametric modeling of the misalignments and the contact pattern of hypoid gears is completed in this study.
- The evaluation indexes of the contact pattern are most sensitive to the angular error of the gear pair. The effect of the running offset error is also significant, while the impact of the axial misalignment of the gear is minimal, followed by the axial misalignment of the pinion.
- A comprehensive sensitivity optimization model of the contact performance to the misalignments is established. The improved MPGA algorithm can achieve the minimum sensitivity with a good convergence rate.
- By optimizing the sensitivity of the contact pattern to the four equivalent misalignments, the sum of the sensitivity coefficients of the evaluation indexes has been reduced, thereby improving the meshing stability of the gear pair.