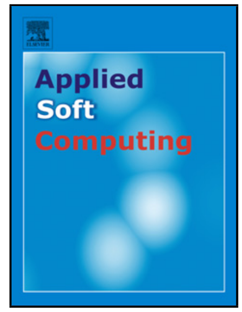
Accepted Manuscript




Title: Six sigma robust multi-objective optimization modification of machine-tool settings for hypoid gears by considering both geometric and physical performances

Authors: Han Ding, Jinyuan Tang


| | |
|---|---|
| PII: | S1568-4946(18)30322-3 |
| DOI: | https://doi.org/10.1016/j.asoc.2018.05.047 |
| Reference: | ASOC 4913 |

To appear in: *Applied Soft Computing*

| | |
|---|---|
| Received date: | 11-2-2018 |
| Revised date: | 25-5-2018 |
| Accepted date: | 28-5-2018 |

Please cite this article as: Han Ding, Jinyuan Tang, Six sigma robust multi-objective optimization modification of machine-tool settings for hypoid gears by considering both geometric and physical performances, Applied Soft Computing Journal https://doi.org/10.1016/j.asoc.2018.05.047

# Six sigma robust multi-objective optimization modification of machine-tool settings for hypoid gears by considering both geometric and physical performances

Han Ding[1,2]*, Jinyuan Tang[1,2]

[1]State Key Laboratory of High-performance Complex Manufacturing, Central South University, Changsha 410083, China

[2]School of Mechanical and Electrical Engineering, Central South University, Changsha 410083, China

*Corresponding Author: E-mail: dinghan0204@163.com (Han Ding).

Highlights

- 6σ robust optimization formulation to evaluate machine-tool setting modification.
- MOO modification mode considering the both geometric and physical performances.
- 6σ robust MOO machine-tool setting modification for the hypoid gears.
- A data-driven decision and optimization process to get the accurate computation.

**Abstract:**

With the increasing demands of low noise and high strength from gear transmission system in industry applications, a collaborative optimization considering both geometric and physical performances has been increasingly significant for high-performance complex manufacturing of the hypoid gears. More recently, the machine-tool setting modification has provided an important access to this optimization design. However, its data-driven robustness or reliability is of a great difficulty. To deal with this problem, this paper presents a six sigma (6σ) robust multi-objective optimization (MOO) modification of machine-tool settings. Firstly, the 6σ robust optimization formulation is applied in the numerical result evaluations. Then, a novel data-driven model for MOO modification of machine-tool settings is established by establishing the functional relationships between the machine-tool settings and the performance evaluations, respectively. They can be integrated into a 6σ robust MOO machine-tool setting modification for hypoid gears having higher quality requirements. Finally, with the decision and optimization process, an achievement function approach was applied to solve MOO modification for the Pareto front, and the sensitivity-based variability estimation is used to identify the robust solution. The numerical applications are given to verify the proposed methodology.

**Keywords:** hypoid gears; machine-tool setting modification; multi-objective optimization (MOO); six sigma (6σ) robust optimization; an achievement function approach.

**Nomenclature**

6σ six sigma
MOO multi-objective optimization
UMC universal motion concept
LTCA loaded tooth contact analysis
SGEs spatial geometric errors
TCA tooth contact analysis
UTCA unloaded tooth contact analysis
eTCA tooth contact analysis with errors
DTCA dynamic tooth contact analysis
SOA service-oriented architecture
DFSS design for six sigma
ppm parts per million
$\boldsymbol{S}_{\mathrm{Rob}}$ robust solution
$\boldsymbol{S}_{\mathrm{Opt}}$ optimal solutions
$\boldsymbol{S}_0$ the initial design
$\boldsymbol{S}_{\mathrm{i}}$ the *i*-th design
LSL lower performance specification limit
USL upper performance specification limit