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基于最优化思想的磁流变抛光驻留时间算法

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摘要：

基于最优化思想研究磁流变抛光驻留时间算法。将驻留时间反卷积运算变换成矩阵运算，以实际加工要求为约束条件，建立关于驻留时间的最优化数学模型，利用最小二乘逼近和最佳一致逼近数学解法器对优化模型进行数值求解。仿真结果显示：该算法收敛幅度大，计算效率较高，所求解满足数控加工要求。在自行研制的磁流变抛光机床上进行抛光实验，对有效口径为50mm的圆形平面工件，经过4.7min抛光，PV值从0.191λ降至0.087λ，收敛54.5%，RMS值从0.041λ降至0.010λ，收敛75.6%。

关键词： 磁流变抛光 驻留时间算法 反卷积 最优化数学模型

Dwell time algorithm based on optimization theory for magnetorheological finishing

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Abstract:

Magnetorheological finishing (MRF) is a deterministic polishing technique capable of rapidly converging to the required surface figure. This process can deterministically control the amount of removed material by varying the time to dwell at each particular position on the workpiece surface. The dwell time algorithm is one of the most important key techniques of the MRF. A dwell time algorithm based on matrix equation and optimization theory was presented in this paper. The previous mathematical model of the dwell time was transferred to a matrix equation containing initial surface error and removal function. The required dwell time was just the solution to the large, sparse matrix equation. A new mathematical model of the dwell time based on the optimization theory was established, which aims to minimize the 2-norm or ∞-norm of the residual error. The solution meets almost all the requirements of precise computer numerical control (CNC) without any need for extra data processing, because this optimization model has taken some polishing condition as the constraints. Practical approaches to find a minimal least-squares solution and a minimal maximum solution are also discussed in the paper. Simulations have shown that the proposed algorithm is numerically robust and reliable. With this algorithm an experiment has been performed on the MRF machine developed by ourselves. After 4.7 minutes'polishing, the figure error of a flat workpiece with a 50mm diameter is improved by PV from 0.191λ to 0.087λ and RMS 0.041λ to 0.010λ. This algorithm can be constructed to polish workpieces of all shapes including flats, spheres, aspheres and prisms.

Keywords: magnetorheological finishing dwell time algorithm deconvolution optimization model

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