Novel grinding control method for nanometric surface roughness for space optical surfaces

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Traditional bound abrasive grinding leaves the machine marks and subsurface damages ranging from 1 to few tens microns rms in height. These are removed typically by subsequent craftmen-based loose abrasive lapping, polishing and figuring. Using the multi-variable regression technique, we established a new automated grinding process control method for the removal of loose abrasive lapping from the traditional fabrication process. Three grinding variables - grain size, feed rate, work piece rotation - were used to achieve the target surface roughness(Ra) ranging from 90 nm to 20 nm at the Ra accuracy of better than ±20 nm in a series of controlled machining experiment. For each machining run, the control model uses a target Ra to compute a number of possible input values for each variable. It then determines a final set of numeric inputs for the variables following minimization of machining time (i.e. crucial indicator for delivery schedule and hence the fabrication cost) and predicted Ra accuracy (i.e. key acceptance condition by the customer). The machine run is followed by the measurement of surface roughness, of which the data is then added for updating the grinding control model. The next machining process is then commenced with a new target Ra which, in this experiment, was typically set to about 10 nm better than the target Ra of the previous machine run. This automated cyclic grinding control method shows an improvement in controllability and accuracy for precision grinding process for nanometric surface roughness. The process control model, the experiments details, the results and implications are presented.