ABSTRACT

A detail investigation on a proposed novel Strain Wave Generating (SWG) cam, to work with conventional Harmonic Drives (HD), is carried out to set its optimum design criterion. In HDs the external toothed pinion are generated on the free end of a thin cup shaped body, called as Flexspline (FS) cup. While an oval shaped conventional SWG cam rotates as input inside the cup (below the FS teeth), teeth contacts with the Circular Spline (CS) having two teeth more than FS teeth, occur at two places at the vertices of the cam's major axis. Availed transmission ratios are half the number of teeth of CS or FS when they are output keeping the other one (i.e., FS or CS) constrained to rotate about its own axis. As the FS teeth in contact with the CS teeth are on deformed (by cam) rim (FS cup end) the conjugate contact (with respect to that in cylindrical gearing) is lost. In case of the novel proposed cam, the FS rim maintains circular shape, identical as in undeflected cylindrical internal gearing, at two contact zones. Thus the conjugate teeth contacts are maintained and involute teeth can be used for the gear set. As a result the HD performance is improved both in torque capacity and elimination of kinematic irregularities. Essentially other portions at non contact regions the FS cup are stretched and get oval shaped. The deformed FS cup experiences more stresses than those with conventional cam with single oval shaped curve, at the zones where the novel SWG cam profile switches from the oval curve to circular arc and vice-versa. In the present investigation rigorous study is carried out on this aspect of design of the novel cam. In the dissertation flexspline (FS) is termed as flex gear (FG) and circular spline (CS) is termed as ring gear (RG) in HDs with novel cam, as the conventional gearing action is availed with the proposed novel cam. In designing the novel cam profile first of all a FG-RG gear set is chosen. For the cam profile the spread of the circular arcs at two contact zones at the two vertices of the major axis of the cam, transformation of circular arc to oval curve (ellipse is chosen in the present study) and relevant geometries are carefully considered satisfying all kinematic and other requirements. For the verification of the avoidance of teeth interferences, contact ratios and other geometric and kinematic conditions with corrected and uncorrected involute teeth of different pressure angles a generalized computer programme is developed using Matlab codes. To facilitate the assembly inside the FG cup the novel SWG cam is made split into two identical pieces about the minor axis. For the calculation of stresses first of all a CAD model of cam with split cam feature is developed in solidworks. This CAD model is directly imported into FEM (Ansys®) environment for stress analyses. All cases of the cam (36 in number with varying geometries in the present investigation) are considered to find the maximum stresses in the cup to select the best geometry of the cam for which it (stress level) is least among all. In next step rigorous stress analysis of the FG cup is done for the chosen best cam. For verification, two other cam geometries adjacent to the best one are also analyzed for cup stresses. The stress results are also verified experimentally. In experiments, stresses in FS cup with conventional cam and novel cam, both with no load and applied torque load, are measured. For conventional cam theoretical results (FEM analysis) and experimental results have very good agreement. However, in case of novel cam, qualitative similarities in stress results are highly satisfactory although at some places quantitative differences in stresses are there. It is established both by FEM and experiment that the location of relatively higher stresses in FG cup with proposed SWG than that with conventional cam is away from the teeth contact zone. On the other hand the stresses at the teeth contact zones in case of proposed SWG came are much lower than that with conventional cam. In summary the detail method of designing the proposed novel cam for improved performance of HD is established.