Presently modeling of surface fatigue crack growth for residual life assessment of structural elements is almost entirely based on application of the Linear Elastic Fracture Mechanics (LEFM). Generally, it is assumed that the crack front does not essentially change its shape, although it is not always confirmed by experiment. Furthermore, LEFM approach cannot be applied when the stress singularity vanishes due to material plasticity, one of the leading factors associated with the material degradation and fracture. Also, evaluation of stress intensity factors meets difficulties associated with changes in the stress state along the crack front circumference. An approach proposed for simulation the evolution of surface cracks based on application of the Strain-life criterion for fatigue failure and of the finite element modeling of damage accumulation. It takes into account the crack closure effect, the nonlinear behavior of damage accumulation and material compliance increasing due to the damage advance. The damage accumulation technique was applied to model the semi-elliptical crack growth from the initial defect in the steel compact specimen. The results of simulation are in good agreement with the published experimental data.