During machining operation, fixtures are used to locate and constrain a workpiece. In any manufacturing operation, a certain amount of deformation will occur in the workpiece due to clamping and machining forces. So the dimensional and form errors will occur in the workpiece. A good fixture design minimizes workpiece geometric and machining errors by limiting the workpiece elastic deformation. An ideal fixture design exhibits minimal deformation while machining and it consists of optimal fixture layout, optimum clamping forces and optimum number of fixturing elements such as locators and clamps. Hence, in this research work, the machining fixture layout, clamping forces and number of fixturing elements optimization problems are considered with an objective of minimizing the workpiece elastic deformation caused during machining.

In this machining fixture layout optimization problem, the workpiece is treated as elastic model and fixture elements are treated as rigid to predict the workpiece elastic deformation, which influences the dimensional and form errors of the workpiece. In this research work, Finite element solver ANSYS has been used to determine the workpiece elastic deformation caused due to machining and clamping forces. The following
machining fixture layout and clamping forces optimization methods have been used for minimizing the workpiece elastic deformation:

- Mathematical approach for machining fixture layout and clamping forces optimization

- Machining fixture layout optimization using Artificial Neural Networks (ANN)

- Machining fixture layout optimization using combined ANN and Design of Experiments (DOE)

- Machining fixture layout optimization using Genetic Algorithm (GA)

- Machining fixture layout optimization using combined GA and ANN

- Number and positions of machining fixture elements optimization

The proposed mathematical approach for optimum fixture layout and clamping forces is based on the equilibrium condition of forces and moments acting on workpiece to minimize the overall workpiece deformation. The ANN based procedure utilizes a hybrid scheme of
nonlinear finite element analysis and ANN. First, the ANN is trained with sufficient fixture layouts and their corresponding workpiece deformations which are obtained from FEM, and then the trained ANN is able to predict the state of maximum elastic deformation of the workpiece. Then, along with ANN, DOE is introduced as another optimization tool to find the solution regions from the wide range of design variables.

To compare and identify the most suitable machining fixture layout optimization method, GA based and combined GA and ANN based fixture layout optimization methods are presented and results are compared with other methods. The objective function of GA is minimization of moment values at all locators and clamps. Finally to optimize number of fixture elements, 3-2-1, 3-2-2 and 3-3-1 locating schemes are used and performances are compared.

All the above methods have been applied in the case studies and the obtained optimal fixture layouts and their workpiece deformation values conclude the following:

The artificial neural networks, genetic algorithm and design of experiments are suitable tools for the fixture layout optimization problems towards minimum workpiece deformation. Comparison of performances of mathematical approach, artificial neural networks and genetic algorithm in
the fixture layout optimization problems concludes that ANN and GA yield better results than mathematical approach. The overall performance shows that either combined GA and ANN approach or combined ANN and DOE approach is better suited for fixture layout optimization problems. The comparison of the performances of 3-2-1, 3-2-2 and 3-3-1 locating schemes in fixture layout optimization methods concludes that the 3-3-1 locating scheme yields better results than other locating schemes and suitable for constraining the movement of prismatic components while machining. Workpiece elastic deformation has been minimized by using the optimum value of clamping forces and optimum clamping forces have been found using stick/slip condition and Coulomb’s friction law.