Friction Stir Welding (FSW) produces higher quality welds with fewer defects like porosity, and cracking and material properties closer to the parent metal as compared to most other welding processes. A solid state process which is particularly suitable for welding aluminum is Friction Stir Welding (FSW) as it can overcome the difficulties in conventional welding of aluminum alloys. A non-consumable tool is used to generate frictional heat in the abutting surfaces. A shoulder and a pin are the important parts of the tool. This tool makes weld without conventional defects with good mechanical properties and is especially suited for defence applications. In addition, because friction stir welding is performed below the melting temperature, protection requirements are greatly reduced. These reasons make this welding process suitable for many applications in aerospace industries. The scope for welding of aluminum alloys using FSW has increased in the recent past. The process of welding lower temperature materials by friction stir welding (FSW) is extended to weld SS and Titanium. Tool design for friction stir welding determines the joint properties and microstructure, and hence it is one of the most important and critical parameters that influences the FSW process. Tool pin profile, axial force, tool rotational speed, and welding speed are a few of the other important parameters that decide the weld quality.
FSW process is carried out on aluminum alloy plates where, the critical process parameters are identified as Axial Force (F), Tool Profile (T), Weld Speed (WS) and Tool Rotational Speed (TRS). Tools are fabricated to weld aluminum alloys. For this, five profiles (cylindrical pin, tapered cylindrical pin, threaded cylindrical pin, square pin and triangular pin) are considered, and among the five tools, based on the mechanical properties used to obtain the FSW joints, three tools i.e. tapered cylindrical, threaded cylindrical, and square tip tool profile are used to conduct the experiments in this work. Physical FSW tools for all the five profiles are manufactured using H13 (Chromium hot worked steel). Using each tool, friction stir welding process is carried out on three base materials AA6082, AA6351 and AA6061. Tensile strength for each weld joint is obtained using UTM, in which the square profiled tool resulted in joints with the highest tensile strength for the weld joint obtained by FSW. The various process parameters are optimized by using the Design of Experiments (DOE) approach. Using optical microscope, weld microstructures in various zones are analyzed, and micro hardness measurements are conducted on the cross sections across the welds.

As the stirring is the important phenomenon in the FSW, the quality of weld depends on how optimally the material is melted at the joint. A modified tool is designed and fabricated, which resulted in obtaining a better weld joint for the same combinations of parameters.
The results obtained with the actual tool and modified tool are compared, and it is found that the results obtained by using the modified tool are much better. In the second phase of the project, for analysis and simulation between FSW parameters, an Artificial Neural Network (ANN) model is developed. Among the parameters, weld speed and tool rotational speed have got more effect on the mechanical properties of the weld. The input parameters of the model considered for study consist of weld speed (WS), tool rotational speed (TRS) and axial force (F) as they have comparatively major effect as per the ANOVA. The tensile strength is the output parameter of the ANN model. Good agreement between the results of the ANN model and the results obtained from experimentation is observed. The model can be used to calculate the tensile strength of welded plates as function of weld speed (WS), axial force (F) and tool rotational speed (TRS), as the performance of ANN model is satisfactory. The measured data is compared with the calculated data and both are found to be in good agreement.