

# INVESTIGATION OF HYDRAULIC EXCAVATOR USING DFMA

## Abstract

Excavators are the most commonly used equipment for various purposes in construction activities. The operation of booms, arms and buckets for pushing, pulling, lifting and digging/lowering in excavators are carried by hydraulic cylinders. Based on the quality issues during assembly and in the field, as reported by the manufacturers, on hydraulic cylinders and front axle assembly of excavators, the present research work has been carried by analysing the components of hydraulic cylinders and front axle assembly using DFMA (Design for Manufacture and Assembly) in two separate case studies.

Hydraulic cylinders are the linear actuators used in applications such as industrial, agricultural and construction equipment like excavator. The backhoe of an excavator can dig with enormous force and its movement are carried out by hydraulic system. The piston movement, from rear to front end, swings the backhoe in seconds and if it is not slowed down at the end, the swing stops suddenly with an impact, resulting in metal-to-metal contact causing jerk, vibration and bounce due to inertia effect. This leads to failure of seals and other components causing higher maintenance cost. To reduce the sudden impact, end cushioning in hydraulic cylinders is provided. The size and profile of the cushion nose plays an important role in slowing down the piston movement. Hence in this work, an attempt was made to investigate the cushioning effect by changing the size and profiles of the cushion nose based on DFMA and to analyse the pressure variation with respect to piston movement using CFD. In addition, analysis was carried out using DOE to find the most significant factor that affect the back pressure and smooth transition of pressure. The effect of varying hydraulic oil viscosity on the back pressure and end cushioning is analysed using CFD. The effect of outlet flow path shape with tapered entrance and an additional flow path is compared with the existing outlet flow path on the back pressure and end cushioning using CFD analysis. Stress analysis on the hydraulic cylinder was carried out to find the impact at various angles of the arm/boom during loading and digging process.

From the CFD analysis and from the experimental study, it is found that the curved internal profile provides better results as compared to the existing taper design and also with the other profiles in comparison.

The front axle assembly of a hydraulic excavator consists of front axle, stub axle and thrust bearing. The front axle assembly carries the weight of the front part of the vehicle as well as facilitate steering and to absorb shocks due to road surface or terrain conditions. A nominal assembly gap has to be maintained in the front axle assembly for better performance and for easy manoeuvring of the vehicle during operation. A

typical value ranging from 0.1 mm to 0.5 mm is required for one particular model being manufactured by the local industry. It was reported by the industry that there are a greater number of assembly rejections in maintaining the said gap which lead to higher cost and downtime due to rework or interchange of parts. To reduce this, DFMA analysis was carried out using the concept of stack up tolerance to reduce the rejections and improve the performance of front axle assembly without affecting the manufacturing. Based on the above results cost and time analysis was also carried out to compare the processing cost of the assembly with the existing and modified tolerance. A stress analyses on the assembly at various gap levels were carried out and compared.

From the DFMA analysis by tolerance stacking, the cost estimation and assembly time analysis were carried on components with modified tolerance. It resulted in total cost saving of Rs 59.58 and a saving of 11.44%

in assembly time per assembly. The probability to maintain the assembly gap within the range of 0.1mm and 0.5mm is reduced by 18.4% that contributed to increased assembly efficiency.