Academic Guru Publication House

Research and Development
In Engineering Technology
Volume 1
Year: 2021

AG PH Books

A REVIEW ON DESIGN ANALYSIS AND OPTIMIZATION OF FRONT AXLE FOR COMMERCIAL VEHICLE

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Abstract

To remain competitive in today's market, it is critical for manufacturers to provide new products to consumers at a lower cost and quicker than their competitors. The Front axle beam accounts for up to 40% of the vehicle's load-carrying capability. The existing measuring system shows quite a poor acceptability for the proposed design of the cross pin, except for the micrometer. A review is presented here on design analysis and optimization of cross pin. Literature is also studied of researchers and presented here on the same topic.

Keywords: Front Axle Beam,Cross pin; .Lean manufacturing; Design for manuifacturing.

1. INTRODUCTION

When it comes to manufacturing, there is a vast range of disciplines and skills involved, and a large range of gear, tools and equipment with a variety of automation levels like computers and robots. There are a variety of demands and advances that must be taken into consideration when it comes to manufacturing.[1]

* ISBN No. 978-81-953278-9-8

Apart from that, future technicians must be familiar with the fundamental requirements of workshop routines, such as the number of people, tools and materials needed to do the job properly as well as the various methods, revenue streams, and other infrastructure conveniences that must be properly positioned for optimal shop or plant layouts and other support solutions in the field or industry within a “properly planned manufacturing firm”.[2]

1.1. Machining

Machined products are made by cutting material (typically metal) into a specific form and dimension by using a controlled material-removal process. Subtractive manufacturing refers to procedures that use controlled material removal as a common theme, whereas additive manufacturing refers to methods that use controlled material addition. Although the exact meaning of the word "controlled" in the term is up to interpretation, it usually invariably connotes the use of machine tools (in addition to just power tools and hand tools).[3]

In addition to metal items, machining may also be used to create products from materials such as wood and plastic as well as ceramic and composites. A machinist is someone who specialise in machining. The term “machine shop” refers to a space, a facility, or an organisation where machining is carried out. “Computer numerical control (CNC)” is used to control the movement and functioning of mills, lathes, and other cutting equipment in most contemporary machining operations. Machine businesses save money on labour expenses by using a CNC machine that works without a human operator. [4]

1.2. Front axle

The front axle bears the weight of the vehicle's front end, as well as providing steering assistance and absorbing road shocks. Even though they're considered “dead axles”, tiny automobiles with compact designs and four-wheel drive have “live front axles”.

This axle, located in the front of the car, helps with steering and absorbs road stress. The beam, swivel pin, track rod, and stub axle are the four primary components. Carbon steel and nickel steel are the most common materials for front axles since they are both very durable.[5]

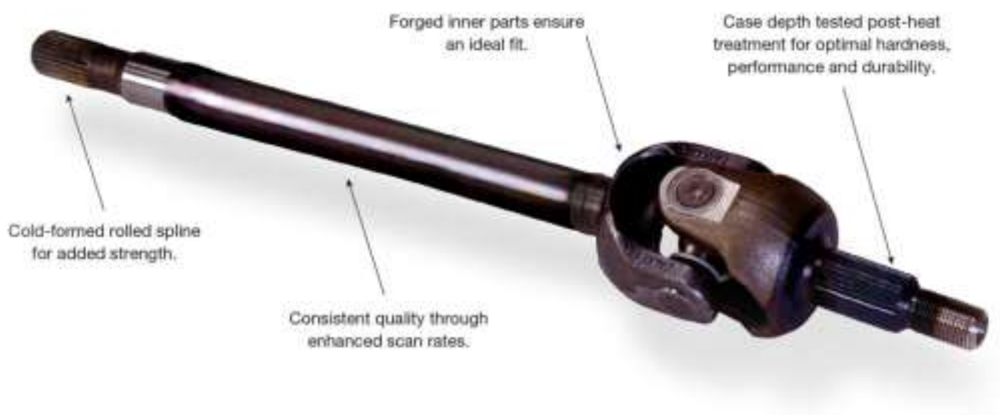

Figure 1: Front Axle Shaft

Front axle are responsible for ascending vehicles of the front wheels [6]:

a) Posterior part of the vehicle is supported by front axle.
b) It provides steering facility.
c) Due to the irregular road surface, shock is absorbed by front axle.
d) While applying brake on vehicles torque is applied.

There are two types of front axles:

i. Dead front axle:

The term “dead axle” refers to an axle that solely serves to keep the wheels on the ground. Neither power nor torque is transferred to the wheels. There are two ways to operate a vehicle: front wheel or rear wheel. In both cases, the rear axle is considered dead, while the front axle is considered precious. The dead front axle bears a great amount of weight, yet it does not spin. Its ends are shaped so that they fit snugly over the stub axles on each side. [7]

ii. Line front axle:

Line axles are used to transmit power from gear box to front wheels. Line front axles although, front wheels. Line front axles although resemble rear axles but they are different at the ends where wheels are mounted.

1.3. Design for Manufacturing (dfm)

A part's or product's design may be optimised to make it easier and more cost-effective to manufacture, known as “Design for Manufacturing (DFM) or Design for Manufacturability (DFM)”. “Design for manufacturing (DFM)” is the process of reducing manufacturing costs by designing or engineering an item more effectively at the product design stage. This enables a manufacturer to detect and avoid errors or anomalies.

Five principles are examined during a DFM. They are:

1. Process
2. Design
3. Material
4. Environment
5. Compliance/Testing

Ideally, DFM should take place from the beginning of the design phase, before any tooling has ever been made. All the players, from engineers to designers to contract manufacturers to moldbuilders to material suppliers must be included in a successfully implemented DFM. "Cross-functional" DFM is designed to question the design, examining the design at all levels, from components to systems to the whole. This is done to guarantee that the design is optimised and does not include superfluous costs.[8]

1.4. Lean manufacturing

To improve production efficiency and total customer value while simultaneously reducing waste, many industrial organisations and enterprises have adopted a set of ideas, tools, and procedures known as Lean, sometimes known as “Lean Manufacturing (LM), Lean Enterprise, or Lean Production”.

Lean is a theory that may be applied to any industrial organisation, not only manufacturing and supply chain management. The major goal of LM is to make higher-quality goods more affordable to a wider range of customers. As a result, it finally leads to a better quality of life for everyone (Melton, 2004). An LM-based manufacturing system is critical to the success of a company. The most important aspects of LM are as follows:

i. Reduce production-line waste.

ii. Lower production costs by integrating quality into the manufacturing process.

iii. Develop and create tools that improve the operational performance of the company.

As a result of lean's emphasis on constant improvement, there are five distinct stages to implementing it in the workplace:

i. Analysing and documenting the existing process and evaluating its efficiency and effectiveness.
ii. Determining the value and the network of the value stream with precision.
iii. A third part of the process is identifying and proposing modifications to remove the causes of undesired impacts.
iv. Achieved performance is measured
v. Applying the suggested improvements

1.5. Principles of lean manufacturing

When it comes to lean manufacturing, the aim is to reduce waste—the non-value-added components in any process. There is always some waste in a process that hasn't gone through lean several times. Lean has the potential to reduce costs and increase competitiveness by reducing waste, increasing productivity, reducing cycle time, and reducing the amount of material used in the production process. Consider the fact that lean is not just applicable to manufacturing. There are a number of ways it may enhance teamwork, inventory management, and customer relations.

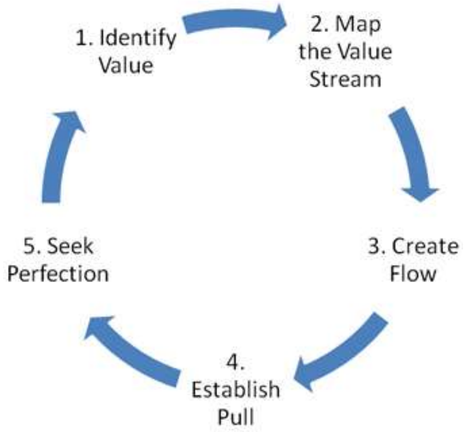

Figure 2: Process of lean manufacturing

1.6. Standardization of product and processes

It is the purpose of standardisation to guarantee that certain industrial practises are consistent. As a result of standardisation, the production of products, corporate operations, technology, and particular mandatory procedures are all standardised. Even in the car business there has been a dramatic increase of product varieties over the last several years, according to Ulrich [9]. Customization is the only way businesses can meet the many and diverse needs of their consumers. According to Ulrich (1995), modularization is a way for increasing product diversity. It is possible to standardise components and to use the same ports in several products if they perform the same purpose [10]. The use of modular design improves the likelihood that components can be used in a variety of products. In terms of cost, performance, and product development, product standardisation is a tremendous benefit in the manufacturing sector. It is also possible for production processes to be standardised, which is the largest facilitator of consistent performance when it comes to standardised goods [11].

Standardization also aids in the security, interoperability, and compatibility of manufactured items. Involved parties include end-users, government agencies and companies, as well as standards bodies.

2. LITERATURE REVIEW

(Soyusinmez et al., 2021) [12] In this study, the kingpin parts are examined with optical microscopy, Scanning Electron Microscopy (SEM), hardness tests and %C potential analysis in order to determine the potential causes of the crack formations. By the help of the analysis, the presence of cracks became clear. There are no signs of hydrogen embrittlement. The exact outcome of the fracture could not be determined. It is seen that heat treatment of the parts is not homogeneously obtained throughout their surfaces or desired volume, and therefore fractures occur. With the present structure, it can be expected that even a low dynamic load can lead to breakage. As a result, the investigations suggest that the parts were exposed to inappropriate heat treatment parameters.

(S. H. Kim & Shin, 2020) [13] An examination of the steering pull's sensitivity is presented in this research. As part of the process of creating a steering pull model, many types of pulling forces on the tyres must be taken into consideration. These include plysteer and conicity forces as well as lateral forces resulting from slip angle and cast and kingpin lifting forces. Steering systems are also modeled since the resultant pulling forces are dampened as they are passed via the steering systems. Steering components are modeled and then assembled into a system that includes the lower body linkage and the rack and pinion gear, universal joint and the steering column with electric power steering (EPS) system. Once these two models have been combined, the final steering pull model is created. A vehicle's steering pull is approximated using a model and then compared to experimental data to ensure accuracy. We may examine the impact of several parameters, including kingpin and rack friction force and anti-rattle spring (ARS) stiffness, on steering pull using the steering pull model.

(Marcomini et al., 2016) [14] When the kingpin was installed in a fifth wheel of an off-road vehicle, it was found to be defective at the outset of use. The truck was utilised in a quarry for three months until the kingpin failed. Due to overheating, burning, and cavitation, poor grain structure may result in hot forged products. SEM investigation of the failing component revealed the presence of cavitation, which was detected by the method. Even while cavitation was shown to be a contributing factor, failure analysis findings showed that it was not the primary factor in the fracture.

(Vargas-Arista et al., 2013) [15] Fatigue Crack Propagation in AISI 4140 Steel Shielded Metal Arc Weldings is the focus of this article. Normalizing at 1200 °C for 5 and 10 hours after welding produced different austenitic grain sizes. A decrease in fracture toughness and critical crack length, as well as a transgranular brittle final fracture with an area fraction of dimple zones linking cleavage facets, were seen in three-point bending fatigue testing on pre-cracked specimens along the HAZ. The fracture length reduced as the normalization time rose, according to a fractographical examination. Zone II fatigue crack propagation was also shown to be affected by river patterns, and the ultimate brittle fracture was seen due to "transgranular quasicleavage". The fatigue resistance of the HAZ was reduced as a result of larger grains.

(Triantafyllidis et al., 2009) [16] There are two instances of steel pin joint failures that are discussed here. There were 90 mm pins, and the failures resulted in long repair wait times. An impact fatigue fracture developed after the initial failure, which was produced by "a combination of bending and twisting fatigue". Optical metallography and scanning electron microscopy/ electron dispersive x-ray analysis (SEM/EDS) analysis provided a better understanding of the failure mechanism of the two steel pins, since these particular components exhibited excellent fatigue characteristics in both mating fracture surfaces.

(D. H. Kim et al., 2007) [17] The static friction torque of the tyres, which is impacted by tyre loads, kingpin axis geometry, such as camber, caster, and kingpin offset, is the most critical component in estimating steering effort. Effort and rack-bar force are calculated as a function of tyre contact patch friction torque in this study. There is a good connection between calculated rack-bar force and steering effort and the observed results from a vehicle test.

3. CONCLUSION

After studying the literature review, it was observed that the existing measuring system shows quite a poor acceptability for the proposed design of the cross pin, except for the micrometer. As such, there may be need for purchasing new more sophisticated and precise measuring equipments. While, the process capability indexes of the system are within the acceptable limits for most of the characteristics of the cross pin for which the process is capable of manufacturing parts within the specified tolerance limits with very few defects, for certain characteristics it shows a poor capability.

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