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Evaluation of using high strength low alloy steel for design of knuckle joint.

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ABSTRACT: The rapid growth of modern design technology in recent decades has led to the reduction of cost, weight of materials, stress reduction, accident reduction and ultimately leading to safer environment. knuckle joint has become popular in industry as well as in research. This paper describes the procedure for evaluating (17HMBVA) high strength steel grade to design knuckle joint under tensile load for the avoidance of potential failure in the long run. The new grad of high strength steel helps to increase the efficiency of designer's work by enhancing the level of automation in the design process . Good results were obtained in the selection of materials for engineering applications.

KEYWORDS: Knuckle joint, tensile strength, allowable stress.

I. INTRODUCTION

The main purpose of the 'Design' is to create things which will meet certain customer requirements in an innovative way. Over the last years, the continuous evolution in technologies allowed to reducing stress and strain. The effective design of any mechanical device or assembly demands the predictive knowledge of its behaviour in working conditions. It has become a necessity for the designer to determine the forces and stresses generating during the operation [1].Today, many machines elements require high power. Knuckle joint has to designed with a great strength and stiffness, but it must be lighter in weight and size. The development of machine elements is based on various factors such as the weight of the linier and angular parts steering arm, tie rod, pitman arm etc. The overall performance of the connecting system is affected by higher inertia forces. It, therefore, should always be investigated to avoid any potential failure of the vehicle in the long run [2]. As shown in figure 1, Knuckle Joint has mainly three components:- the eye, fork and pin. The eye is formed on one of the rods and fork is formed on the other. The eye fits inside the fork and the pin is passed through both the fork and the eye.

The new grade of higher strength steels, 17HMBVA (500 up to 700MPa) are usually produced by the quenching and tempering route and have traditionally been used to resist the hard tensile application [3] .Tong had presented a novel dynamic modelling wizard for 3D standard part library [4]. Pantazopoulos and others [5] have studied the failure of a knuckle joint of a universal coupling system, and reported that wear of material due to severe friction leading to delaminating wear. A. K. Mishra, [6] further reported that knuckle joint, which is used in steering mechanism of racing car, is dealt with and analysed for optimization of weight, because weight is the important parameter which affects transmission efficiency of a device .Several investigators of failure mechanism of knuckle joint reported that shear and tensile failure due to tensile and torsional loading were the normal failure mechanism in many engineering components [7]. The present study investigates the procedure of using a new high strength steel grade, 17HMBVA, in designing knuckle joint to avoid potential failure under tensile load was investigated.

II. MATERIALS AND PROCEDURES

The proposed material of high strength steel grade (Q &T) 17HMBVA has many advantages over other materials. It helps to increase the strength-to-weight ratio of movement systems, reduction in the cost of materials, and construction schedules due to reduced amounts of welding. The hardenability and the composition related carbon equivalent values

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increase have a significant influence on yield strength. The results of mechanical properties of high strength low alloy steel grade 17HMBVA are given in table 1belwo.

Table 1. Mechanical properties of high strength steel grade 17HMBVA.

Mechanical properties of high strength steel grade 17HMBVA				
Tensile Strength MPa	Yield Strength MPa	Shear strength MPa	Reduction Area Zo %	Elongation Ao %
869	798	480	59.4	12

It is assumed that the diameter of the rod is equal to the diameter of the pin (d = d1) , and d2 = 2d , d3 = 1.5d , t = 1.25 d, t1 = 0.75 d, t2 = 0.5 d. Also, the applied load is 100 KN and, the factor of safety (4), and the yield strength compression is equal to yield strength in tension.Figure.1shows the parts of knuckle joint and figure 2 shows three key components of knuckle joint in which (1) is fork, (2) eye and (3) pin. For the design and calculations of three components, the following assumptions for stress analysis of Knuckle Joint were considered: - The rods are subjected to axial tensile load, the effect of stress concentration was neglected due to holes, and the force is uniformly distributed in different parts.

A knuckle joint may be failed as the result of the following three modes; (1) Shear failure of pin (single shear), (2) Crushing of pin against rod, and (3) Tensile failure of flat end bar stresses in tension, Compression and shear values are given by σt, σc and τ..

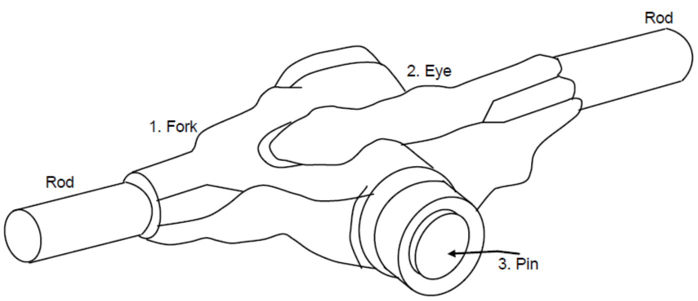
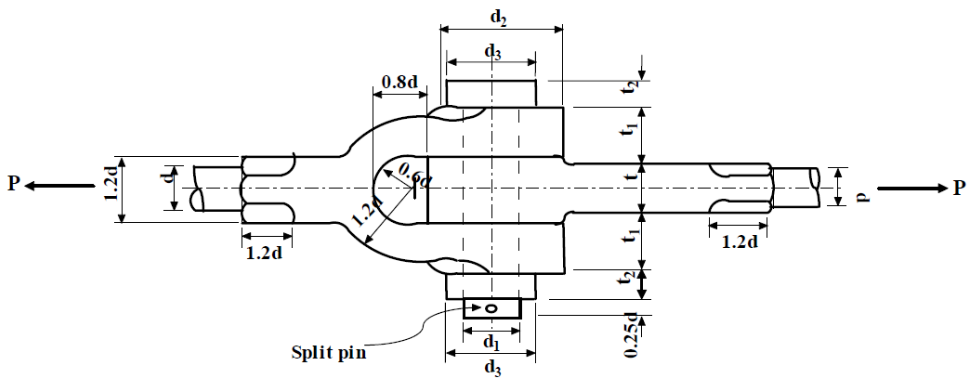


Fig.1. (A,b) Three components of knuckle joint *(1) Fork, (2) Eye (3) Pin*



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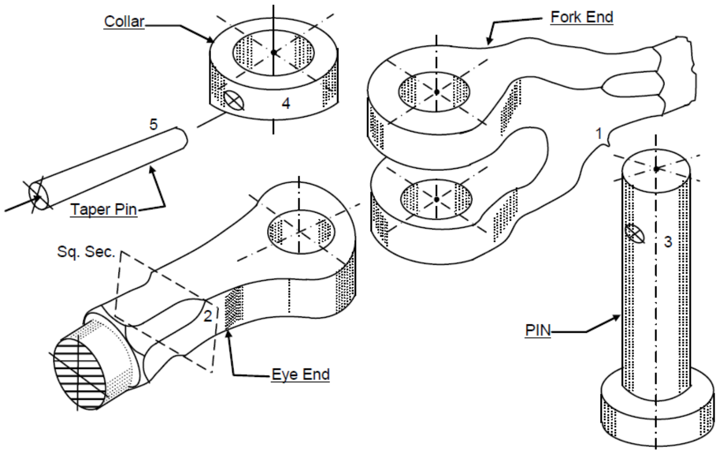

Fig. 2 . Key parts of knuckle joint

III. CALCULATION AND RESULTS

No.	Symple	Element	Result
1	P	Tensile load acting on the rod	100KN
2	D	Diameter of the rod	29
3	D_1	Diameter of the pin	29
4	T	Thickness of single eye	37
5	t_1	Thickness of fork	22
6	σ_t	Tensile stress	160Mpa
7	σ_c	Cushing stress	240Mpa
8	τ	Shear stress	107Mpa
9	$\tau < \tau_{all}$	Check the failure of knuckle pin in shear	76<107Mpa
10	$\sigma_t < \sigma_{tall}$	Check the failure of the single eye or rod in tension	94 < 160 MPa
11	$\tau < \tau_{all}$	Check the failure of the single eye or rod end in shearing	94 < 107 Mpa
12	$\sigma_c < \sigma_{call}$	Check the failure of the single eye or rod end in crushing	94 < 240 MPa
13	$\sigma_t < \sigma_{tall}$	Check the failure of the fork in tension	79 < 160 Mpa
14	$\tau < \tau_{all}$	Check the failure of the forked end in shear	76 < 107Mpa
15	$\sigma_c < \sigma_{call}$	Check the failure of the forked end in crushing	94 < 240Mpa

IV. DISCUSSION

All parts of Knuckle joint studied were made from steel grade 17HMBVA of high strength low alloy steel. Tensile properties often are measured during development of new materials to ensure quality specifications. The effect of tensile loads and induced stresses were found to be similar to those reported by Alejandro [7]. According to Tresca's [8,9] if maximum shear strength at any point exceeds the critical value, that is, yielding shear strength of a material, then the design fails [10]. Accordingly, maximum shear stress at any point on the body should be less than 0.58 times the yield stress . The tensile, crushing and shear stresses in the eye, in the fork end and all other parts of knuckle joint were found to be less than the allowable stress. This indicates that the designed knuckle joint can be safely operated. From the obtained results, the failure analysis for all parts of knuckle joint studied; tensile stress, shearing and crushing were accepted those below the allowable shear, tension and crushing stresses.

V. CONCLUSION

The effective design of Knuckle joint requires the predictive knowledge of its behaviour in working condition. The

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knuckle joint is the most commercially preferred design to connect mechanical parts when applying axial load and no eccentricity. The design of knuckle joint is simple to manufacture, assemble, and dismantle due to the presence of knuckle split-pin, which can help to disconnect components of joint. Tensile properties are frequently determined in the selection of new materials to ensure quality specifications and to compare different processes. More importantly, safe obtained from calculation of design stress or working stress applied of knuckle joint made from steel grade 17HMBVA high strength low alloy steel. The checking tensile, crushing and shear stresses in the eye, in the fork end and all other parts of knuckle joint were less than allowable stress which shows that the proposed design is safe to use.

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