



The Effect Of Drag Link Bending Radius On Fatigue Life And Static Forces Strength

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(First received November 1, 2022 and in final form December 23, 2022)

**2nd International Conference on Design, Research and Development
December 14 - 17, 2022**

Reference: Kılınc İ., Yıldız Y., Batı H. The Effect Of Drag Link Bending Radius On Fatigue Life And Static Forces Strength. Orclever Proceedings of Research and Development,1(1), 01-07.

Abstract

In heavy commercial vehicles, The parts that transfer the movement in the steering box to the wheels are called drag links. Drag links are bent in different geometries due to vehicle designs and other components in the steering system. Drag links are exposed to repeated tension and compression forces on the vehicle depending on the road conditions and the loads on the vehicle. In this study, static buckling forces and fatigue behavior of a drag link were determined according to different bending radii and the effect of bending radius on drag link life was investigated.

Keywords: Drag Link, Steering System, Bending Radius, Buckling, Fatigue

1. Introduction

Drag link is a part of the steering system that allows the wheels to turn left and right by transmitting the movement from the steering wheel to the wheels. It basically consists of two rod ends connected to each other by a connecting rod. The connecting rods used in drag links are generally produced from pipe material according to lightness and cost

criteria. Due to their distance from other components within the scope of legal regulation requirements, drag links have to be bended at different offset amounts. The bending process of the drag links is carried out with the help of apparatus and bending machines at certain bending radiuses. Figure 1 shows the drag link in a heavy commercial vehicle steering system.

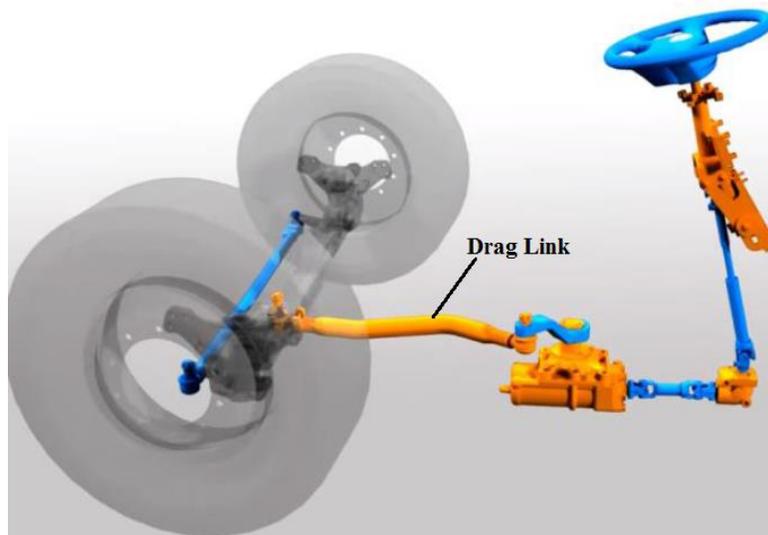


Figure 1 Heavy Commercial Vehicle Steering System (PM et al., 2015)

When drag links are subjected to tensile and compression loads, they are usually damaged in the bending regions after certain cycles. This situation requires detailed studies in the drag link bend region.

A drag link pipe undergoes plastic deformation from the bend region during the bending process. After bending process, thickening is observed on the inner wall of the bending region and thinning on the outer wall. Thickness reduction is greater when the pipe bend radius is small. As a result, bent pipe properties and reliability deteriorate (Lee et al., 2011). It is important to be aware of the bend radius size. If the bend radius is too short, the pipe may buckle (Rahman & Watkins, 2005). The radius of the pipe to be bent is taken as $1.5 D$ practically (Sandıkçı, 2012). Tensile and compressive stresses may occur on the drag link under different road conditions. The stresses cause fatigue, causing micro-cracks to form, and the drag link can be damaged by cracking in the future (Koca & Ekici, 2010). The bending of the pipes from the errors seen in the drag link is due to the buckling error of the pipe against the compression loads (Doke & Shaikh, 2016). The wall thickness and section deformation behavior of medium strength TA18 high-pressure pipes with a small bend radius and a normal bend radius are different from each other during NC bending (Zhiqiang et al., 2011).

Figure 2 shows the important parameters in a drag link bending process.

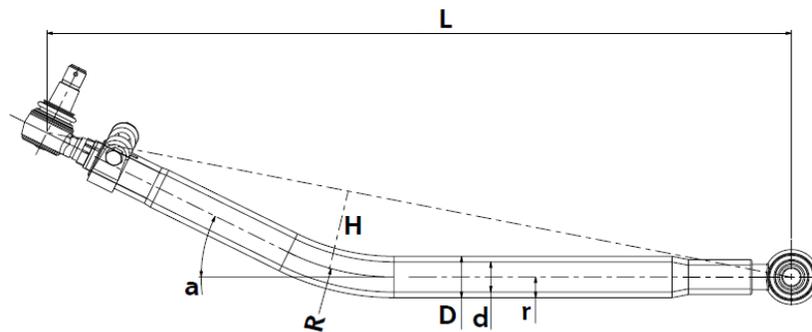


Figure 2 Drag Link Bending Parameters

R; bending radius, H; bending depth, a; bending angle, L; drag link axis distance after bending, D; pipe outer diameter, d; pipe inside diameter, r; represents the pipe radius.

Figure 3 shows the cross-sectional views of the drag link tube before and after bending.

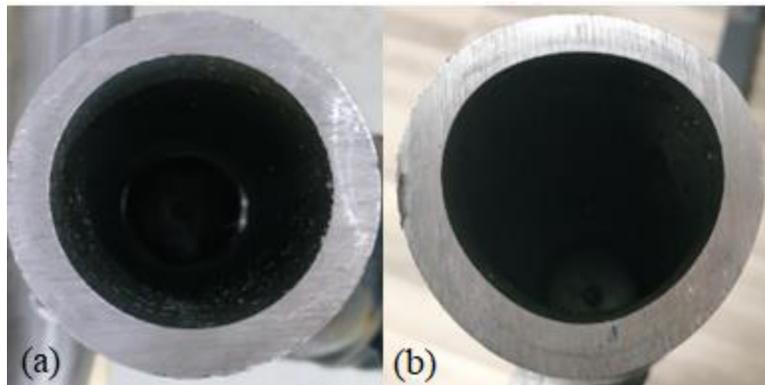


Figure 3 Cross Sectional Area of Pipe (a) Before Bending (b) After Bending

2. Materials and Methods

In this study, the drag links were produced in 3 different bending radiuses that R100, R150 and R175, using $\text{Ø}60 \times 6$ size DIN EN 10216-3 P460N material. Static buckling and dynamic fatigue tests of these drag links were carried out. The 3D data image of the drag link is shown in Figure 4.

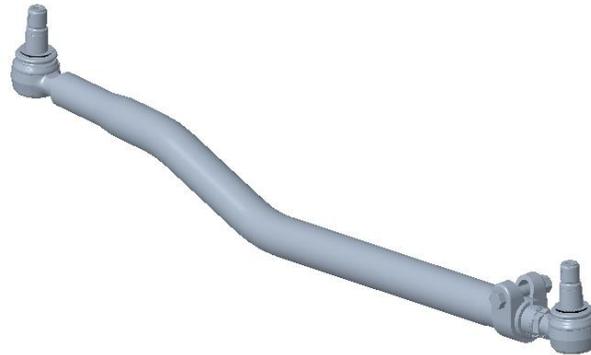


Figure 4 Drag Link 3D Cad View

2.1. Chemical Composition

The chemical compositions of the drag link pipe material P460N are shown in Table 1.

Table 1 P460N Material Chemical Compositions (weight %)

Content	C (max)	Si (max)	Mn (max)	P (max)	S (max)
%	0.20	0.60	1-1.7	0.025	0.020

2.2. Mechanical Properties

Mechanical properties of DIN EN 10216-3 P460N material are given in Table 2.

Table 2 P460N Material Mechanical Properties

Yield Stress (σ_{\min})	460 MPa
Tensile Stress	560-730 MPa
Elongation (min)	19%

2.3. Experimental Procedure

Static buckling and fatigue tests of 3 drag links that produced in different bending radii were performed and the effect of bending radius on buckling and fatigue behavior was investigated.

2.3.1 Buckling Tests

The drag links were fixed from the conical surface of the ball joint located at one rod end and the other joint was subjected to loading from its conical surface. The maximum force values at which the drag link undergoes plastic deformation were obtained. The buckling test setup is shown in Figure 5.

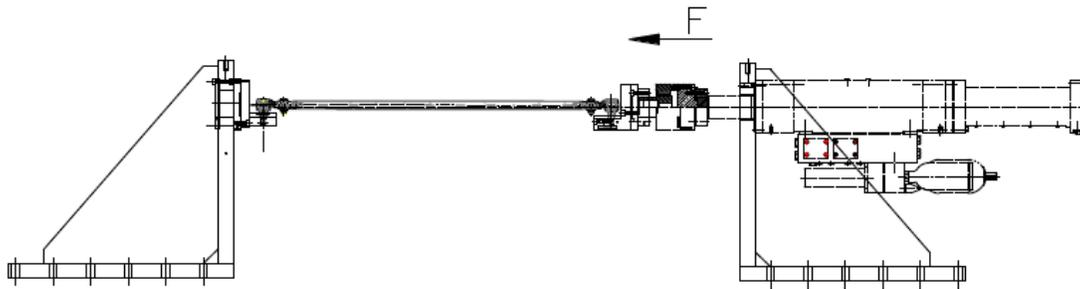


Figure 5 Buckling Test Setup

2.3.2 Fatigue Tests

In order to determine the fatigue behavior of the drag links, the drag links were connected to the test device as in the buckling test setup. For fatigue tests, the drag links were subjected to cyclic loading in 4 different block cycles at different tensile and compression forces.

3. Results

3.1. Buckling Tests

The minimum buckling load for the drag link is targeted as 57.5 kN. The experimental buckling load values obtained for drag links at different bend radii are shown in Table 3. It was observed that the buckling load values increased with the increase of the bending radius.



Table 3 Experimentals Buckling Load Values

Bending Radius (mm)	Part No	Buckling Load (kN)
100	1	52,6
	2	55,3
	3	51,9
150	1	57,4
	2	61,1
	3	59,8
175	1	71,1
	2	78,3
	3	73,2

3.2. Fatigue Tests

As a result of the fatigue tests of the drag links, the number of cycles of min 315000 cycles was targeted as a result of 4 block cycles. The experimental fatigue life cycle numbers obtained for drag links at different bend radii are shown in Table 4.

Table 4 Experimentals Cycle Number Acc. to Bending Radius

Bending Radius (mm)	Part No	Cycle Number	Result
100	1	65700	Broken from bending area
	2	91300	Broken from bending area
	3	77400	Broken from bending area
150	1	118000	Broken from bending area
	2	109200	Broken from bending area
	3	97800	Broken from bending area
175	1	594600	Broken from bending area
	2	582500	Broken from bending area
	3	601200	Broken from bending area

4. Conclusion

Within the scope of this study, static buckling and fatigue tests for a two-twist steering system part drag link according to different bending radii were performed and the effect of the bending radius was investigated.



- It has been observed that drag links bent with large bend radius show better static strength and fatigue resistance than drag links bent with small bend radius.
- As a result of fatigue tests, it was observed that all parts were damaged in the bending region.

5. Acknowledge

We would like to thank Ditaş Doğan Spare Parts Manufacturing and Technical Inc. for the opportunities it provides.

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