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EXAMINATION OF A FAILED FIFTH WHEEL COUPLING

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Abstract—Examination of a fifth wheel coupling which had failed in service showed that it had been modified and that the operating handle had been moved from its original design position. This modification completely eliminated the safety device designed to prevent inadvertent opening of the coupling locking mechanism. No alternative safety device was employed to ensure the safety of the modified design. Furthermore, the rubbing plate on the pup-trailer was significantly smaller than that on the fifth wheel, with the result that the load transfer conditions were not optimal. This may have resulted in excessive damage to the wearing components such as the locking jaw, the locking bar and the king pin. © 1998 Elsevier Science Ltd. All rights reserved.

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1. INTRODUCTION

In 1992/1993 the regulations in the Road Traffic Act in South Africa were changed to allow the maximum combined length of articulated vehicles to be extended from 17 to 22 m. This prompted a local transport company to extend the length of one of their horse and trailer combinations by the addition of a pup-trailer to the rear of the semi-trailer. This required a modification to the rear of the semi-trailer to accommodate the addition of a fifth wheel coupling to which the pup-trailer could be attached. The modified trailers had been in service for a relatively limited period of time when the pup-trailer separated from the semi-trailer whilst in motion. This resulted in irreparable damage to the pup-trailer and significant financial losses.

2. THE FIFTH WHEEL COUPLING MECHANISM

Fifth wheel couplings are used extensively and world-wide in heavy articulated vehicles. They are designed specifically for the coupling of a semi-trailer to a towing vehicle. In this context, a semi-trailer is a trailer which is supported at the rear end by wheels attached to the trailer itself, whilst the front end is supported on the towing vehicle. A typical fifth wheel is shown in Fig. 1. The weight of the front end of the semi-trailer is transferred to the towing vehicle through contact between the top surface of the fifth wheel and a corresponding flat surface on the underside of the front end of the trailer. These flat surfaces are referred to as “rubbing plates”. For optimum load transfer the area of the rubbing plate on the semi-trailer should not be significantly smaller than the area of the fifth wheel. Furthermore, in order to reduce friction and wear of the rubbing plates, and to allow free relative rotation between the plates, the plate surfaces are lubricated with grease.

The fifth wheel is mounted on two pedestals using a rubber bush and pin assembly. This arrangement allows the wheel as a whole to rock through a small angle and to thus accommodate any vertical movement resulting from uneven ground. The horizontal forces are transmitted from the towing vehicle to the semi-trailer through a king pin located at the centre of the rubbing plate of the semi-trailer. The king pin, in turn, fits into a lock jaw in the fifth wheel. To couple the system the towing vehicle is reversed such that the fifth wheel passes underneath the front of the semi-trailer. The king pin on the semi-trailer is guided into the fifth wheel by the tapered slots on the wheel, until it locks into the locking jaws. The locking mechanism is shown schematically in Fig. 2.

Upon coupling of the semi-trailer to the towing vehicle, the king pin on the semi-trailer causes

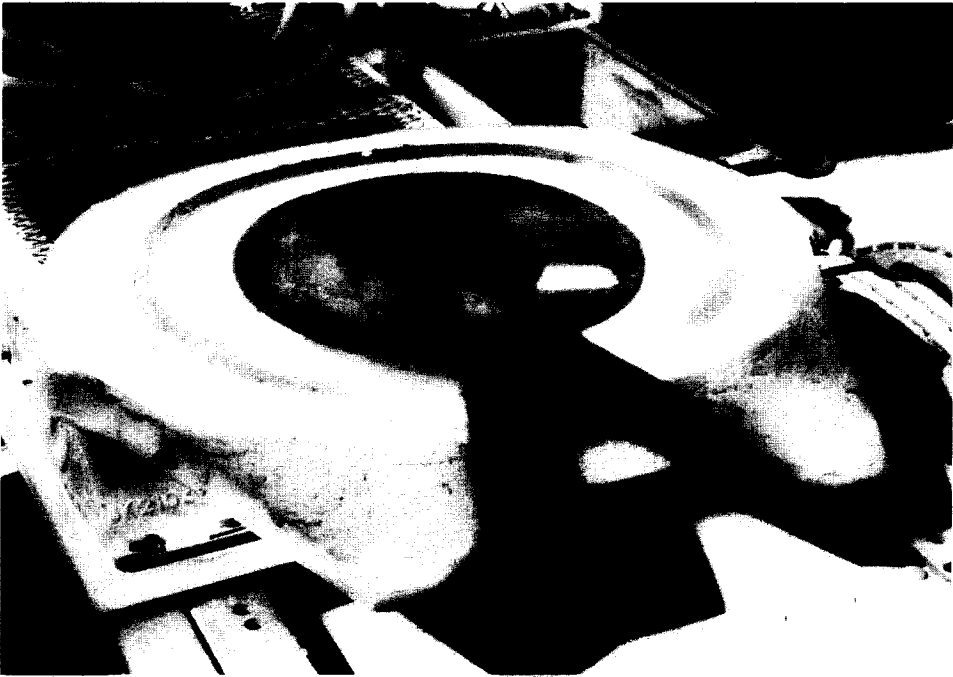


Fig. 1. A typical fifth-wheel coupling.

the lock jaw to rotate anti-clockwise to the position shown in Fig. 2(a). This in turn, allows the locking bar to move inwards (left as seen in Fig. 2) to secure the locking jaw and prevent it from rotating. In order to allow the movement of the locking bar, however, the operating handle must also be pushed in (left). In the closed position the lock jaw fits into a groove in the king pin which prevents upward movement of the pin. During operation of the coupled vehicles there is a tendency for the king pin to pull out of the locking mechanism. This can only occur if the lock bar is pushed out (right) and the lock jaw rotates clockwise to the open position. In order to prevent this from happening, the operating handle is fitted with several notches which allow it to be secured against the fifth wheel casing. Furthermore, a spring loaded hook is fitted to the slot through which the operating handle protrudes from the fifth wheel casing as an additional safety device to prevent the operating handle from opening. This feature is shown schematically in Fig. 3. The correct application of the safety hook is vital for the safety of the vehicle and recent fifth wheel designs have substituted the safety hook with an alternative spring loaded mechanism which locks automatically once the operating handle is moved into the coupled position. This new device avoids the possibility of human error in the fitting of the safety hook and is an indication of the importance of the locking device to the safety of the vehicle as a whole.

In order to uncouple the trailer the safety hook must be removed. The operating handle is then moved side-ways and out (right). This has the effect, through the action of the lever arm, of pulling out the locking bar which, in turn, allows the lock jaw to rotate clockwise to the open position. The operating handle can be held in the open position by securing it to the fifth wheel casing using a notch on the operating handle, Fig. 2(b).

Several of the components in the locking mechanism are subject to wear during operation. As a result, these components undergo dimensional changes which, if severe, may be deleterious to the safety of the coupling system. Three components which are particularly affected by wear damage are the lock jaw, the wearing ring and the king pin. The manufacturers of fifth wheel couplings stipulate limits on the maximum amount of wear that is permissible on most of these components to ensure continued safe operation.

3. EXAMINATION OF THE FAILED FIFTH WHEEL

The fifth wheel used in the modification of the failed semi-trailer was made from cast steel and was mounted with a rubber bush and pin assembly. The imposed load capacity was rated at 8000 kg

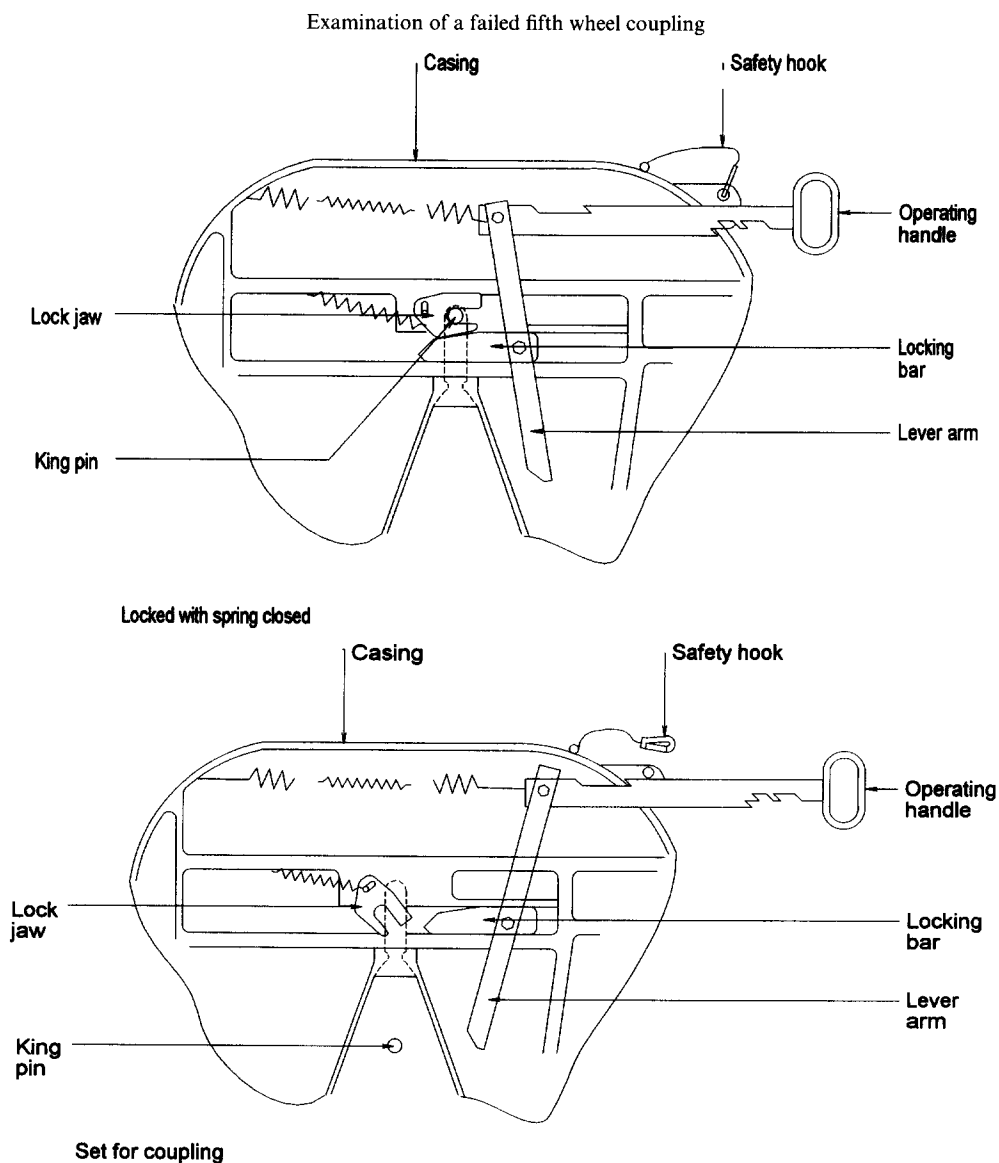


Fig. 2. A schematic diagram of the locking mechanism in a typical fifth wheel. (a) Locked with spring closed, and (b) set for coupling.

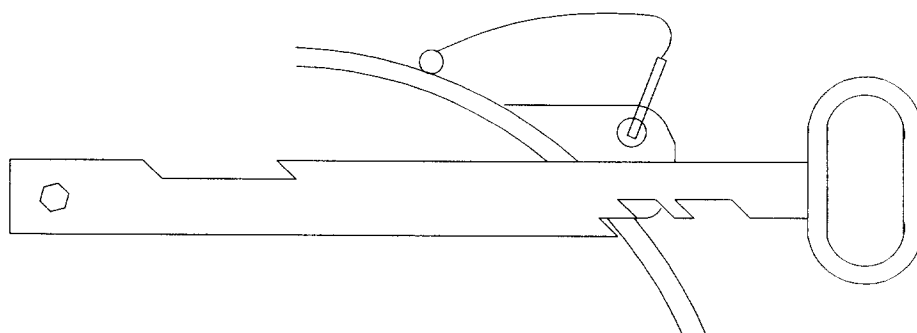


Fig. 3. A schematic diagram of the spring loaded hook arrangement which prevents the operating handle from opening.

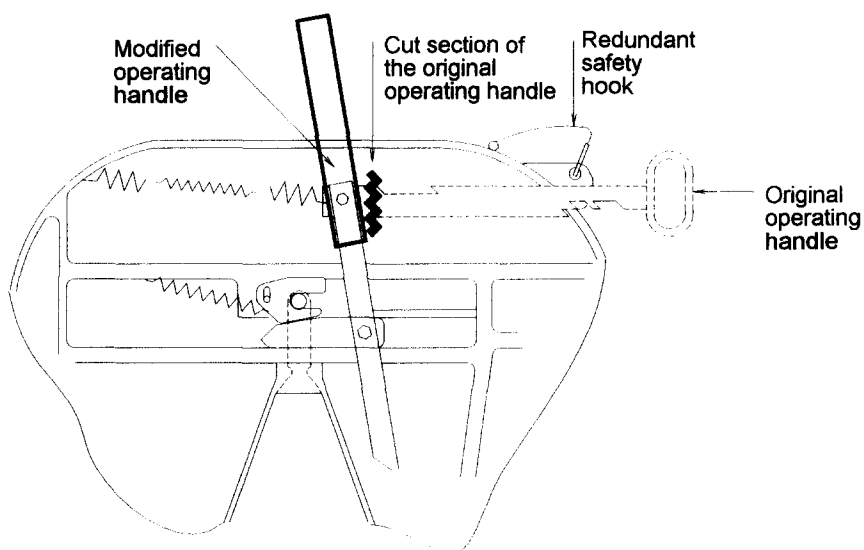
and the permissible weight of the articulated unit was 32,000 kg. The diameter of the wheel was approximately 600 mm. Examination of the modified fifth wheel showed that a modification had been made to the operating handle and lever arrangement which controls the locking mechanism. This is shown schematically in Fig. 4. The operating handle which should protrude through the slot in the casing of the fifth wheel (labelled in Fig. 4) had been cut and was instead welded onto and in line with the lever arm.

Furthermore, it is also evident that in the modified condition there was no locking mechanism to prevent the operating handle-lever arm combination from moving and possibly opening the lock jaw during operation. Thus, the spring loaded safety device which had been rendered useless by the modification had not been substituted by a device performing an equivalent function in the modified design. The importance of this safety device was discussed in detail in the previous section, and, as such, this modification can be expected to seriously reduce the safety and integrity of the coupling system.

The reasons for the observed modification were not clear but appeared to be due to restrictions in the space available on the modified towing semi-trailer. It was apparent from examination of the modified trailer that very little space was available for the operating handle to protrude out of the side of the fifth wheel, as required by the design. By removing the operating handle from its original position and welding it onto and in line with the lever arm, the operating handle protruded out of the front of the fifth wheel. In this position there was ample space to operate the handle during coupling and uncoupling of the vehicles.

A further feature of the modification which was of concern was the relative sizes of the rubbing plates on the pup-trailer and the fifth wheel. For optimum load transfer the area of these plates should be approximately equal. The diameter of the fifth wheel was approximately 600 mm, while the width of the rubbing plate on the pup-trailer was only 300 mm. There was therefore a large discrepancy in the relative areas. The fifth wheel was mounted onto the towing vehicle by means of two pedestals and the fifth wheel rocks about these pedestals when the draw bar is in tension (accelerating) or compression (decelerating). This tendency to rock is normally restrained by the rubbing plates. In the absence of sufficiently large rubbing plates, however, the rocking motion will cause abnormally high stresses on the locking mechanism and will lead to severe damage to the wearing parts.

Examination of the components susceptible to wear, i.e. the locking jaw, the wear ring and the king pin, show that excessive wear of several of these components had taken place. While the



Modified design

Fig. 4. A schematic illustration of the modified fifth wheel. The modified operating handle is shown in heavy lines, and the zig-zag line shows where the original operating handle was cut.

dimensional change to the wear ring was negligible, wear of the locking jaw had resulted in a significant dimensional change and this component should have been replaced. The kingpin was not available for examination and therefore the dimensions of the component could not be measured.

4. CONCLUSIONS

The modification made to the operating handle–lever arm arrangement eliminated the spring loaded safety device designed to prevent inadvertent opening of the coupling locking mechanism and no alternative safety device was employed to ensure the safety of the modified design. Furthermore, the area of the rubbing plate on the pup-trailer was significantly smaller than that on the fifth wheel, with the result that abnormally high stresses would be imposed on the locking mechanism. Finally, excessive damage of some wearing components had taken place, and this damage could be due to non-optimum design conditions. As such, the uncoupling of the fifth wheel during operation is believed to be a direct result of the modified configuration of the locking mechanism of the fifth wheel.

This failure illustrates the inherent danger in modifying established and proven designs of safety-critical components. Such modifications should be avoided as far as possible. However, where changes to existing designs are required, a thorough understanding of the component, its mechanics and especially its safety features is essential. Any modifications must be carefully analysed and the safety of the modified design verified.

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