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Independent Trailer Suspension Utilizing Unique ADI Bracket

Kristin R. Brandenberg
John R. Keough
Applied Process Inc. Technologies Div.- Livonia, Michigan, USA
Ian Lee
Steele and Lincoln Foundry
Doug Maxwell
ADI Engineering, Process and Heat Treatment, Pty. Ltd.
Phil Newman
Linehaul 21 Division of Airoad, Ltd.

ABSTRACT

In the increasingly competitive trucking industry, operators are continually seeking ways to haul higher volume and/or heavier loads to maintain profitability. Cross-continent shipments in Australia offer unique performance challenges to the box, frame, axles and suspension.

Independent suspensions on large over-the-road box trailers can allow flat floors and increased cargo space. This paper chronicles the development of a unique suspension system that utilizes a complex ADI casting to survive the rigors of the Australian Outback.

The suspension uses a short “stub” axle mounted and suspended at each wheel thus eliminating the need for a full axle running under the box and frame. This “axle-less” suspension allows the trailer box to have a flat floor and an additional 20 cubic meters of cargo space. The ADI suspension successfully replaced an earlier system constructed of steel weldments that failed in service. The low cost design, coupled with the increased cargo carrying capacity leads to a short payback on investment and improved profitability for the operator.

INTRODUCTION

Trucking in the Australian Outback is an interesting challenge. The terrain is rough and isolated, and the distances can be exceptionally long between service stops. When making the 3,500km trip from Sydney to Perth, the greatest challenge is to make the trip safely while effectively utilizing the space in the trailer.

The Australian truck designers utilize a different type of arrangement than those typically used in the United States. Their “road train” beds are longer in length and there is a need to use the space as efficiently as possible. **Figure 1** shows the trailer configuration with the new independent suspension system.

Figure 1: Linehaul truck trailer with new independent suspension system.

The idea was to redesign the suspension system on these truck trailers in an attempt to provide even more cargo space. Instead of filling the underbody of the truck with axles and suspension hardware, a totally independent suspension system was designed. This allowed the space below the truck bed to be used as cargo space. As a result, the suspension brackets needed to be tough enough to handle the rough terrain, dust and crowned roads found in Australia. The suspension system also needed to be stable enough to keep these large, double deck “road trains” on the road.

TRUCK TRAILERS

It is the constant drive of the trucking industry to design trailer configurations that will successfully haul the most cargo. The industry has attempted to utilize more space in its trailers by using the space between the wheels, etc. Limitations on trailer height (due to overpasses) have kept the trailers at standardized heights. This restricts new trailer designs to the utilization of the space below the typical truck bed. **Figure 2** shows a typical trailer configuration.

Figure 2: Wabash National Smooth Aluminum Dry Van

Some truck trailer manufacturers have started to utilize the space closer to the ground. However, their suspension systems still use full axles. **Figure 3** shows the “possum belly” configuration of some truck trailers. The added capacity is located only in front of the wheels, thus making the floor uneven and ultimately limiting the use of the trailer. Since it is not feasible to load this trailer using a forklift or dolly, it can only be loaded by dumping the load from overhead. As a result, this trailer is good for hauling chips or loose material but not boxed freight.

Figure 3: Titan Thinwall Possum Belly Trailer

Figure 4: Interior View of a Trailer Utilizing the Independent Suspension and a Double Deck Arrangement.

The success of using independent suspensions for truck trailers will result in increasing the capacity of these trailers. Furthermore, by using an axle-less suspension system, these trailers will have a flat bottom, and thus have the capability to be loaded by a forklift. **Figure 4** shows the Linehaul truck trailer outfitted with the independent suspension system. **Figure 5** shows the interior of the Linehaul truck trailer and it’s full walk-through capability for easy loading.

Figure 5: The Double Levels on the Interior of the Truck Allows Full Walk-Through Capability

THE SUSPENSION

The original independent suspension design was a fabrication made from low carbon steel. This first design iteration was a 50mm thick, v-shaped swing arm. It was to be tested on-road over the actual route the truck would take in service – a drive from Sydney to Perth and back. However, upon the first trial of these components, the wheels were splaying out under the truck even before the truck was fully loaded. The fully loaded trailer weighs 22.5 tonnes. The test was run as planned, but the welded components failed after approximately 1200 km of service. One of the suspension brackets began to crack at its weld points, and the design was re-evaluated. Concern was also raised because these brackets would flex so heavily that the negative camber induced uneven tire wear. A second set of welded steel brackets were tested, and these traveled approximately 4000 km before a failure occurred.

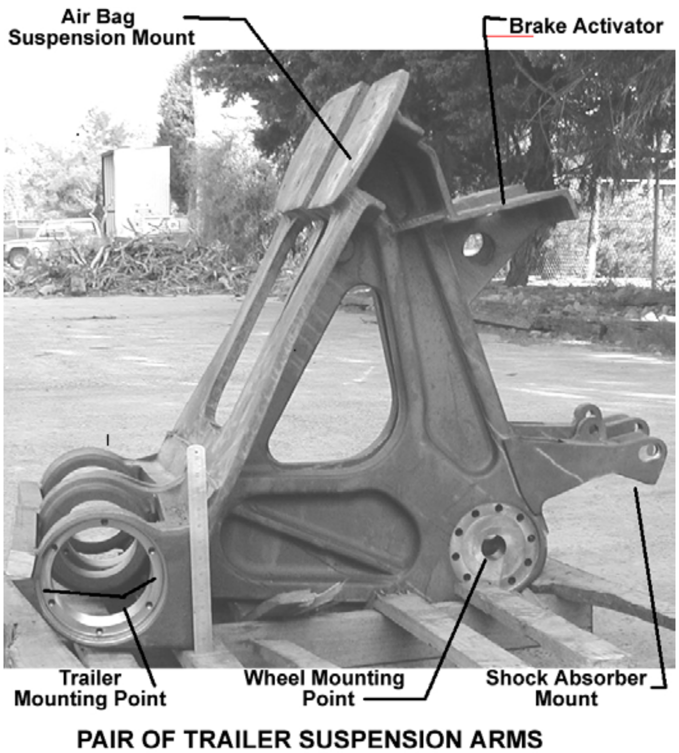

Figure 6: ADI Independent Truck Trailer Suspension Brackets.

The suspension was subsequently re-designed as a single-piece Ductile Iron casting that was then Austempered to Grade 2 Austempered Ductile Iron (ADI). The castings were produced at Steele and Lincoln Foundry of Dandenong, Australia. The heat-treating was performed at ADI Engineering, Process & Heat Treatment Pty. Ltd. also in Dandenong. The components were then finish machined and assembled at Pablo Castro Engineering in Sydney. Each independent suspension bracket is rated at 6 tonnes. The suspension system includes an air bag suspension system, and shock absorbers. **Figure 6** shows a photograph of a pair of brackets, labeled at their mounting points.

Figure 7: Independent Suspension Bracket as installed

AUSTEMPERED DUCTILE IRON

Subsequent to the failure of the steel fabrication, ADI was considered as the material of choice for this application due to its high strength. ADI is a proven material that can replace steel fabrications and forgings as a low-cost, low-weight alternative. The minimum ASTM standard properties of Grade 2 ADI are shown in **Table 1**. Typical properties that are seen in service are shown in **Table 2**. ADI starts as a Ductile Iron casting that is subsequently heat-treated using an isothermal heat-treating process that imparts improved properties to the component. By casting the part in Ductile Iron, the bracket could be made nearer to net-shape in comparison to previous fabrication, and welding was eliminated.

Table 1 –Minimum Properties of ASTM 897 150-100-07 (Grade 2) ADI.

Tensile Strength (MPa / Ksi)	Yield Strength (MPa / Ksi)	Elong (%)	Impact Energy (Joules / lb.-ft.)	Typical Hardness (BHN)
1050 / 150	700 / 100	7	80 / 60	302-363

Table 2 –Typical Commercial Properties of Grade 2 ADI

Tensile Strength (MPa / Ksi)	Yield Strength (MPa / Ksi)	Elong (%)	Impact Energy (Joules / lb.-ft.)	Typical Hardness (BHN)
1139 / 165	897 / 130	10	120 / 90	340

The ADI bracket is approximately 900 mm long and 1200mm high, with a weight of 105kg. The typical Brinell Hardness is 300, along with an un-notched Charpy impact strength in excess of 100 J.

Table 3 compares the properties of ADI to those of forged steel. ADI has an advantage over steel in yield strength, tensile strength and hardness. However, it has a lower stiffness than steel, which must be addressed in designing the component

It should be noted that the failures of the steel components occurred at the weld points. When a one-piece ADI bracket is produced, the weak, heat affected zones near the welds no longer exist.

Table 3 –Typical Properties of Steel vs. Grade 2 ADI[2]

	Forged Steel	ADI
Tensile Strength, MPa (KSI)	779.1 (113)	1034.2 (150)
Yield Strength, MPa (KSI)	510.2 (74)	792.8 (115)
Modulus, GPa (MSI)	205.4 (29.8)	166.8 (24.2)
Elongation, %	10	9
Hardness, BHN	262	280

The ADI bracket was put into service on the same Perth-Sydney trip as the previous fabricated steel bracket. These brackets have successfully traveled over 322,000 km with no problems. Along with the added 20 cubic meters of storage space inside the truck, it is expected that these new brackets will also increase tire life by over 80,000 km.

SUMMARY

This new, innovative bracket design will have a positive impact on the trucking industry in Australia. By using independent suspensions, truck trailers now have 20 cubic meters of additional storage space over the standard dry vans using full axle suspensions. The use of ADI in the critical bracketry has made this new design concept successful. With its high strength-to-weight ratio and affordable manufacturing cost, ADI was a logical, technical choice for this application. These independent suspensions systems are proving to be a true testament to the strength and durability of ADI as they traverse some of the most difficult terrain for heavy trucks.

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ADDITIONAL RESOURCES

+ Applied Process Inc. internal research
+ www.appliedprocess.com
+ www.ductile.org/didata Chapter IV