

Diesel and Electric Locomotive Chassis Design

Introduction

Diesel and electric locomotives come in a wide variety of layouts but can probably be narrowed down to two basic types: - the ridged chassis and the bogie locomotive. The ridged chassis type tends to be represented by the shunting locomotive such as the 08 shunting locomotive or some of the small industrial diesels. There are a few exceptions such as the solitary 2-D-2 "Fell" locomotive number 10100. For modelling purposes, these ridged chassis locomotives are very similar in design to the traditional steam locomotive chassis and are beyond the scope of this section. Reference should be made to Part 3 Section 6 for this type of locomotive. Here, we are more interested in the bogie locomotive.

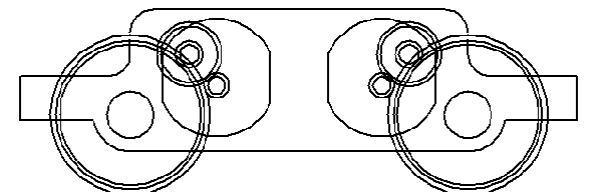
Diesel and Electric Locomotive Wheel arrangements

Diesel and electric locomotive wheel arrangements are described by counting axles, not wheels, and uses letters instead of numerals to denote driving axles with "A" being 1, "B" 2, "C" 3 etc. Non-powered axles are denoted by numerals. Groups of axles are separated by a hyphen if they are quite independent of each other, but by a "+" where powered bogies are linked by an articulated joint. If all axles on a bogie or frame are individually powered, a suffix letter "o" is added to the descriptive letter, thus the well-known Class 31 is described as an A1A-A1A, indicating that it is mounted on two independent six-wheel bogies, each of which has a non-powered axle in the middle with a motored axle at each end. The Class 47 has all six axles separately motored and is described as a Co-Co but a Class 52 Western, where the three axles on each bogie are linked with a drive shaft, is described as a C-C.

Types of Drive Systems

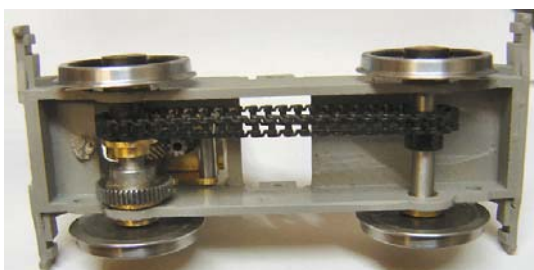
There are many ideas for drive systems for diesel locomotives. The three main systems used at the moment are:

Axle hung or Traction motors



These are separate motors for each powered axle. This type is common with most full size diesel electric locomotive and usually consists of a motor parallel to the axle with a spur gearbox linking it to the axle. This type is available commercially or some people have made them themselves. The advantage of this system is that the drive can be kept very low making it easy to disguise the drive in multiple units as none of the mechanism needs to enter through the floor. These units usually need to be mounted in the outside frame of the bogie which means a little more thought is needed in the bogie construction. A conventional steam type motor/gearbox can be used on each but this option can get a little expensive and care should be used to select a reasonable gear ratio to take into account the small wheels. Most respectable manufacturers should be able to offer good advice.

Chain Drive



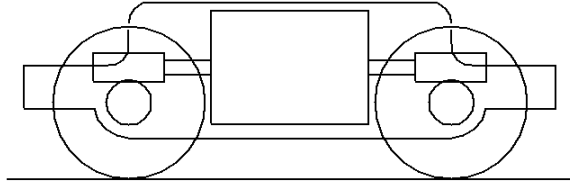
Chain drive is rarely used on modern prototypes but there are a number of commercially available systems available. A motor/gearbox unit is fitted on one axle with a delrin chain and sprocket used linking that axle with other axles on the bogie. The main advantage with this system is the cost and simplicity. Again, if a conventional steam motor/gearbox is used, care needs to be used to select a reasonable gear ratio.

Shaft Drive

Shaft drive can be divided into three sub groups, the double ended motor with a worm drive on each end, the motor driven lay shaft and the remotely driven lay shaft.

Double Ended Motor

This is probably the simplest system where a double ended motor is mounted between two axles with a worm and wheel gearbox mounted on each end. The advantage of this system is that it is fairly cost effective. It is also not very high. It probably can't easily be fitted below the floor of a multiple unit but a little bit of careful licence will disguise the works for all but the most concerning modeller. It can also be a self contained unit with dummy cosmetic outside frames added later. The disadvantage with this system is that it tends to be inefficient and not particularly easy to incorporate it into a long wheelbase bogie.



Motor Driven Lay Shaft



In this system, a lay shaft runs the full length of the bogie driving the outer axles of the bogie. This lay shaft is driven by a single ended motor, mounted above the lay shaft, by a set of spur gears. The advantage with this system is that there is no limit to the length of the lay so the system can be adapted to any length bogie. Because there are two gear stages, the inefficient high ratio worm and wheel can be avoided.

I mentioned that the lay shaft can drive the outer axles. There is no point in driving the centre axle of a three axle bogie because it is impossible to allow any compensation and so the bogie would rock on any humps in the track and could derail. As long as the centre axle supports no weight, there will be no loss of haulage ability.

Remotely Driven Lay Shaft



Instead of mounting the motor above the lay shaft, it could be mounted remotely through a flexible drive shaft. There are a

number of reasons for considering this system. The motor could be mounted below the floor of a multiple unit to keep the works out of site. One other reason could be to use a large diameter motor which could be unwieldy if mounted on the bogie. It would also be possible to mount just one motor in the middle of the locomotive and drive both bogies.

Gears

Many commercially available gear sets are primarily intended for steam locomotive. Diesel wheels tend to be much smaller in diameter. Care must be taken to ensure clearance between final drive gears and the rails and ramps found between the tracks. Another thing to remember is that smaller wheels need to turn faster for the locomotive to match the speed of a larger wheeled locomotive so the gear ratio needs to be adjusted. Many good express diesel locomotives have been ruined because they would not go faster than 40 mph.

Number of Powered Axles

For locomotives, the aim should be to power two outer axles on the powered bogies. If the bogies have three axles, the middle axle could be left unpowered and as long as it carries minimal weight, it won't detract from the locomotives ability to haul. Powering the middle axle may be prototypical but will also add complications to the model.

Powering both bogies will produce a better balanced locomotive and is vital if heavy trains are to be handled but may be an unnecessary complication and expense if it is intended to pull lighter loads. One power bogie will give more than adequate traction for hauling light loads of 5 or 6 coaches or a dozen wagons. With multiple units intended to pull just it self or perhaps one trailer, it is possible to power just the one axle as long as the non powered axles are free running but it may be better to power two axles if the unit needs to work on gradients or if the bearings are not as free running as perhaps they could be. If there is any doubt, it is better to be safe and allow for more, rather than fewer, powered axles. To spend hours completing a model only to find it does not run satisfactorily can be soul destroying.

Weight

There is no point in making a locomotive any heavier than is necessary to do the job. Any excessive weight just puts extra strain on the drive system and bearings and works against us when climbing hills. It should also be remembered that if axle bearings wear, it may change gear centres and cause premature gear failure.

Weight Distribution

It is important, not only to make the locomotive heavy enough, but to distribute the weight correctly. Obviously, a locomotive must have sufficient weight on the driven wheels to pull the train before the wheels slip but there must also be enough weight on the non driven axles to prevent them de-railing and to enable the locomotive to run smoothly. If the locomotive only has one power bogie, it can be arranged for the non powered bogie to support less weight but if the difference is too big, the locomotive will be out of balance and will behave badly through the curves and on poor track. Leading and trailing wheels need some weight to guide the locomotive through the curves. Middle axles that are not powered need very little weight on them.

If only one axle on the bogie is powered, weight can be distributed onto the powered axle either by moving the bogie pivot away from the centre towards the powered axle or by supporting the weight of the body on a pad positioned between the bogie pivot and the powered axle.

One other point to bear in mind is the bogie pivot height. Ideally the pivot should be on the centre line of the axles. It isn't critical that it is exactly on the centre line but the farther from the centre, the more the tendency for the bogie to tip when the power is put on. A longer bogie will tend to be more stable than a shorter one so could be a very important point with a short bogie.

Bogie Design

Bogies, either ready to run or in kit form, are available from commercial sources for most diesel and electric prototypes, and, where they are available, many modellers will prefer to use them. This section is aimed at those unusual prototypes for which commercial bogies are not available, or where the builder prefers to make their own.

Design Criteria

Any bogie design for model purposes must take as a starting point the configuration of the chosen prototype. Within these parameters, however, there are several choices that are at the discretion of the builder.

On the prototype, the axles will usually run in axle boxes fixed to a side frame located on the outer face of the wheel. While this can certainly be followed in the model it may be found easier if an inside frame arrangement is used with dummy castings added to represent the prototype side frames, axle boxes, dampers and the like.

Side play on the outer axles should be kept to a minimum or problems with buffer locking can occur. Centre axles can have a little side play for clearance on curves but even on the longest bogies on the sharpest of curves, this does not have to be much, 0.5 – 1 mm being more than adequate for most models. If it is excessive, the wheels will strike the dummy axle boxes and shorting will occur.

Suspension

Much has been written about the pros and cons of whether or not some form of suspension should be incorporated into models and if so, what form this should take. One additional consideration is the number of powered axles. Most diesel bogies driving on the outer axles can be considered as 4 wheel bogies with centre axles floating in a slot and just coming along for the ride. Most bogies would benefit from one of the outer axles being allowed to rock giving a three point suspension. This idea becomes more desirable for longer bogies. Consideration must be given to the amount of complexity to the chosen drive train when deciding how much benefit compensation can offer.

Bogie Mounting

There are two methods of mounting a bogie into a body. One is to fix it to a stretcher that in turn is permanently fixed transversely to the body. The other is to fix it to a floor which itself forms part of the chassis and to which the body is fixed. If your chosen pick-up system leaves the bogie electrically live, remember that the bogie to chassis/body pivot needs to be insulated. The bogie pivot should allow the bogie to rock for and aft to allow the locomotive to travel over any undulations in the track. There must also be some mechanism to prevent the body rocking from side to side. This can be done by sitting the body on rubbing plates set as wide as possible or using a large diameter pad. If these rubbing plates are only used on one bogie, that bogie will keep the body level allowing the other bogie to rock from side to side to cater for any twist in the track.

An example of scratch built unit.

A three-axle bogie with individual nose-hung motors and working sprung suspension by Tony Clapperton

