

Diesel Dawn

The construction of a 5" Gauge petrol hydraulic locomotive.

Part 3:- Fitting the engine and hydraulic pump to the mainframes and hydraulic motors to the bogies.

I had now ordered all the hydraulic components required to build the loco. At around the same time delivery was taken of the main frames, bogies and wheel sets to build a class 37. When bought the main frames simply consisted of the side frames, buffer beams and stretchers to take the bogie pivots. I had not ordered the flexible hoses to connect all the items up because I did not know the required lengths until the motors and pump had been mounted.

The first job was to fit the engine, a Briggs and Stratton "Classic" 3.5hp, into the main frames. The engine is a vertical crankshaft type so the idea was to fit this and the hydraulic pump above what would be the fuel tank of the full size 37. The poly-v pulley drive between the two would then run in the dummy fuel tank allowing the engine to sit low enough in the frames to clear the bodywork. The pulley fitted to the engine was the same as used on the previous test chassis "Bitsa". This was the same diameter

The base of the engine has a cast round web which was slightly wider than the main frames. The whole engine is made from aluminium so the hacksaw made light work of this web. Not providing any strength to the engine, it could be removed without causing any problem. With all the side frame surfaces being vertical some 40x40x4mm angle BMS was welded on to mount the engine and pump. Not only did this make the frames much more rigid but also created a "sub-frame" for the engine and pump to sit on preventing any distortion under the action of the belt. With the mounting holes drilled the engine was mounted onto the angle at the no. 1 cab end of the chassis. The hydraulic pump was then mounted to a piece of 6mm BMS which spans the angle sub-frame at the no. 2 cab end. I chose to place these in this manner because, on the prototype, no.1 end houses the engine radiator cooling group. So the engine at this end it could draw cooling air from outside the bodywork through the cooler group grilles. The poly-v belt is tensioned, quite simply, by milling elongated holes in the mounting holes in the base plate for the hydraulic pump. This allows it to slide and is drawn into position with a detachable M6 lead screw. When the tension of the belt is correct (I find the correct tension is when the belt moves a quarter twist, with only thumb and finger, at the midpoint between the pulley centres) the M8 mounting bolts are tightened locking the pump in position. The shaft bearings on the hydraulic pump used in this project were not designed to take the side forces exerted by the belt. So a special double raced ball bearing unit, designed to fit the pump body, was fitted to prevent damage. I'm glad I checked this with the supplier as its an expensive item!

Final drive design

To make life easy the hydraulic motors were selected so that their optimum operating speed was the same as the speed required of the loco axles. This meant no gearing up or down was required, just a direct drive. Also, as space is at a premium, a compact final drive linking all three axles to the motor on each bogie was required. I had now discovered that each student was allowed a budget to put towards their major project. In addition to this Sussex Uni has an engineering stores counter where components can easily be ordered and charged to the individual student account. So I started thumbing through the RS catalogue for final drive transmission methods. At first a synchronous toothed belt similar to an automotive camshaft drive belt was considered. The problem with this drive system is that there is little or no allowance for movement between the pulley centres. An example could be, at worst case scenario, when the loco encounters a bump and the suspension is at full travel on one axle box and its neighbour is at bottom travel (never down at "The Park"!), whilst the vertical difference in axle travel is 12.7mm the difference in centre distance is around 0.5-0.7mm. This may not seem like much but it's enough to cause the belt to start jumping teeth, if its slack enough to allow this axle box travel, when the axles are level, quickly knacker it! However, RS sell several different pitches of roller chain and a range of sprockets. Here there is much more latitude for movement due to the sprocket teeth being deeper. This isn't old pressed bike chain as on Bitsa, but proper engineering roller chain. 3 main pitches of chain were considered – 05B-1: 8mm pitch, 06B-1: 9.53mm pitch and 08B-1: 12.7mm pitch. Some calculations were done and drawings made from these to insure the chain was not too slack or too tight whilst, taking into account the extra slack needed to allow for axle box travel. The slack condition is taken when the loco is driving i.e. ALL slack is on one side of the sprockets. I ensured that the traction motors drive from the rear axle of each bogie so that when the loco is travelling forward, like it will most of time, that the slack is on the top side of the sprockets and not dangling in the track. 06B-1 best suited the task. As a back up plan I bought some 16mm diameter Delrin rod from RS that could be machined to make rollers and control the slack. Steel ones could be used as the chain is hardened but I thought this would be too noisy. Later, when the loco was finally running, I found that tensioners were not required. The idea was to have the hydraulic motors axle hung so the drive is taken from the hydraulic motor output shaft to one end of the rear driving axle. Drive is then taken from the other end of the axle to the middle driven axle, then from this to the end driven axle. The reason for driving the rear axle on each bogie is to keep the chain out of the track in the forward direction.

Several people questioned the axle hung motor design on a single axle out of three on a bogie. This of course gives an imbalance of unsprung mass on the bogie potentially causing rough running at speed. Due to the size of the hydraulic motor there is no other way of mounting it satisfactorily. I was confident that any problems could be cured with adjustments to springing and/or damping, that is, if any problems did occur at the average line speed of 6mph!

Hydraulic Motor Mounting

Measurements were taken from the club loco "TRIUMPH", of similar bogie wheelbase, and it was found that the bogies swing through 15° inclusive on the tightest left and right hand curves. The motors must be held high enough to clear both the bogie and main frames to prevent fouling, as the bogie swings on curves. The motor is 60mm diameter and the height from the axle centre to the top of the main frames is 100mm with the axle boxes on the bottom keeps. So the mounts will be constructed with 160mm between centres (axle and motor shaft), giving 30mm clearance between the motor and mainframes.

The motor plus its mounting plate are reasonably heavy at 2.6kg and will require positive location on the axle. Ball raced bearings best suit this job in terms of strength and durability with both sides of the race protected preventing debris ingress. Two bearings per motor mount will be required to provide strength and prevent side moments on the bearings. The system is very similar to a car wheel bearing.

The motor mounting plate is constructed from 6mm BMS. Two mounts are built, so to speed up the job, both are clamped together and retained with tight fitting 3mm silver steel dowels. First the mounting centres are marked out and drilled for these. The outline of the mounts is then marked out, roughed to shape with a hack saw the bastard cut file and all burrs removed (Fig. 1). Then it is clamped to the faceplate, making sure the mounting hole is concentric using a wobble centre and dial test indicator. The mounting hole is drilled and bored to size (32mm) for the motor and then the whole process repeated for the bearing barrel end (38mm). There are 8 holes on the mounting plate, with only 3 on the motor. This is to allow the motor to be mounted at several different angles if required when routing the hydraulic hoses. The outline of the mounting plates was then milled to final dimensions, the dowels punched out and they are separated.

Next the bearing barrel was drilled and rough bored from a piece of 1.5" BMS round stock. It was only rough bored because it then has to be silver soldered, flush to one end of the 6mm mounting plate. Obviously the silver soldering involves heating the job to red heat: 650°C or so. This causes the surface of the steel to oxidise commonly called scale. If the bearing barrel was bored to final dimensions, with a smooth finish, the scale would then ruin this. So the final cuts, to make the bearings a press fit, were done after soldering. The whole assembly was then cleaned up ready for the bearings and axles to be pressed in.

Due to the motors being axle mounted they are fully floating. A method of preventing the motors from turning about the axle is required. The solution is a radius arm connecting the motor mount to the bogie frame using two ball-in-socket swivel joints: - one on each end of the arm. This system prevents the motor moving fore and aft, under the reaction force of driving, but still allows the motor to move up, down and side to side with the action of the suspension. A simple bracket using 40x40x4mm angle anchors the radius arm to the bogie chassis cross member.

Axles

Six axles were turned from 20mm BMS which is a bit of an overkill but it was free from Uni! Four of which mount only sprockets and wheels (driven), two (driving) have motor mounting bearings and a sprocket receiving drive from the motor as well. They were turned up between centres to ensure accuracy and repeatability as I have experienced problems with plain chuck turned ones from suppliers. The journals which run in the axle boxes are turned 12.65mm (for ½" axle boxes) as well as accepting the wheels. Inside the journal is a land of 14.95mm dia leading up to 15mm register which, is the inside diameter of the ball bearings in the motor mounts. The axle boxes themselves are made from Delrin as on "TRIUMPH". This in itself was an experiment: as the loco under construction will be much heavier than a battery electric. I wanted to use sealed ball bearings as used in the motor mounts but there wasn't time to make the axle boxes to hold them, Delrin being plastic is much easier and quicker to machine!

The drive from the motor to the axles is direct 1:1 so all sprockets will be the same size – 15 tooth 45.5mm PCD. Two sprockets mounted on each hydraulic motor shaft were bored to 16mm and then broached for a 6mm keyway. A simple washer and M6 countersunk cap-head screw retain these. The driven axles are 20mm BMS so four sprockets were bored to this.



Final Bogie Design

Both sprockets on each driving axle are bored to 14.95mm, to be located on the lead ins. All sprockets are roll pinned to the axles using 3mm roll pins.

That's all for now, in the next issue I shall discuss the design for the hydraulic plumbing arrangements and finally her first test run!

James M