Motors for Railway models: A helicopter view

Missenden Railway Modellers

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What type of motor should I use?

- Open frame Tri-ang X04 & Pittman types
- Pancake motors
- Coreless motors
- 3 pole / 5 pole skew wound or not?
- Portescap
- Can type motors such as the Mashima
- Replacements for Mashimas

Number of poles?

- 3 poles is minimum to guarantee self-starting
  - Most, but not all, motors have odd numbers of poles
  - More poles than magnets
- More poles means rotation is smoother
  - There are more pull/push points per revolution
  - Compare 4 vs 6 cylinder car engines
  - Or 2 vs 3 Cylinder (but not 4!) cylinder steam
  - Turn a motor by hand and feel the “cogging” effect
- Skewing the poles reduces cogging
  - Magnetic force applied gradually to coils as they approach the magnet
  - Smoother rotation, less torsional vibration

Torsional vibration

- **Wikipedia: Torsional vibration** is angular vibration of an object—commonly a shaft along its axis of rotation. Torsional vibration is often a concern in power transmission systems using rotating shafts or couplings where it can cause failures if not controlled.
- Think of it as jerky rotation; motor speeding up and slowing down in steps per revolution
- In models, it usually appears as excess gearbox noise
- Made worse by:
  - High motor and gear speed
  - Use of straight cut gears
  - Number of gears in the gearbox

Speed?

- More motor speed = more noise
- Higher reduction ratio = more gear noise
- Spur gears – even more noise
  - Particularly if rotating at motor speed
- Max speed of a steam locomotive is normally 5-7 rps
  - A4 with 80” wheels does 252 revs/mile, 7rps @ 100mph
  - 9F with 63” wheels is doing 8 rps at 90mph
- 20:1 gearing, 7rps is 140rps at the motor; 8400rpm.
- Best to use slow-revving motors, under 10000rpm no-load

Flywheels?

- Add inertia to motor
  - Can smooth locos with poor pickup
  - May reduce torsional vibration on poor motors
- Require space to fit
  - Not much point in using one that is too small or too light
- Small locos that most need them don’t have the space for them
- Exacerbate out of true noise & vibration
- DCC decoders offer inbuilt acceleration/deceleration settings
  - Which don’t have to be the same, or indeed linear
- Are they really necessary with DCC and today’s motors?

How are you going to control it?

- An H&M duette?
- DC “Feedback” controller?
- DCC decoder?
  - Sound?
- What’s the best choice for my motors?

DCC Sound?

- Loco needs to be mechanically silent
  - You really don’t want motor noise overweening the sound decoder
  - Especially if the loco is coasting
- Noise starts with the motor
- Torsional vibration: generates gearbox noise
- Rotational vibration causes resonance noise
- High motor speed requires high reduction ratios, which exacerbates gearbox noise

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Let’s look at the Pros & Cons of different types

X04/Pittman Style motors

- Cons
  - Magnet remote from windings: poor magnetic circuit
    - Older magnet materials suffer immensely if the magnetic circuit is ever broken
  - X04 only 3 pole
    - 5 pole versions were available
  - Open commutator – easy to clean but easy to oil as well
    - Makes inside of loco dirty
  - Large current draw, gets worse as the magnets weaken
    - Also reduces brushgear life
  - Very prone to excessive torsional vibration
  - Very high speed: ~ 20000rpm
    - After all, it was made for toy trains, not scale models!
    - Obscures all the other issues
  - Poor low speed and starting characteristics
  - Physically very large and hard to mount: frame cutouts required
- Pros
  - None

Pancake motors

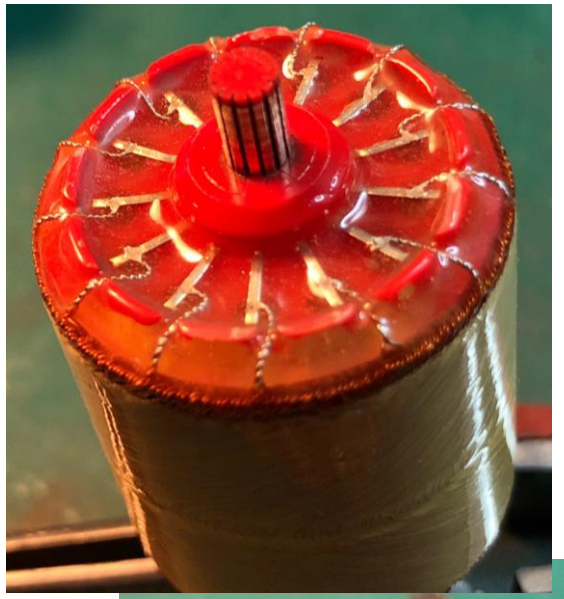
- These ones you find in Hornby tender drives
- Cons
  - 3-pole
  - Poor to useless slow speed characteristics
    - So they run fast to compensate
    - Which requires higher gear ratios
  - Tend to be matched with spur gears
    - Noisy…
  - Torsional vibration
  - Note too that most of them have traction tyres!
    - Which says a lot….
  - High current draw – especially if the magnet is getting weak
  - Impossible remounting
- Pros
  - None

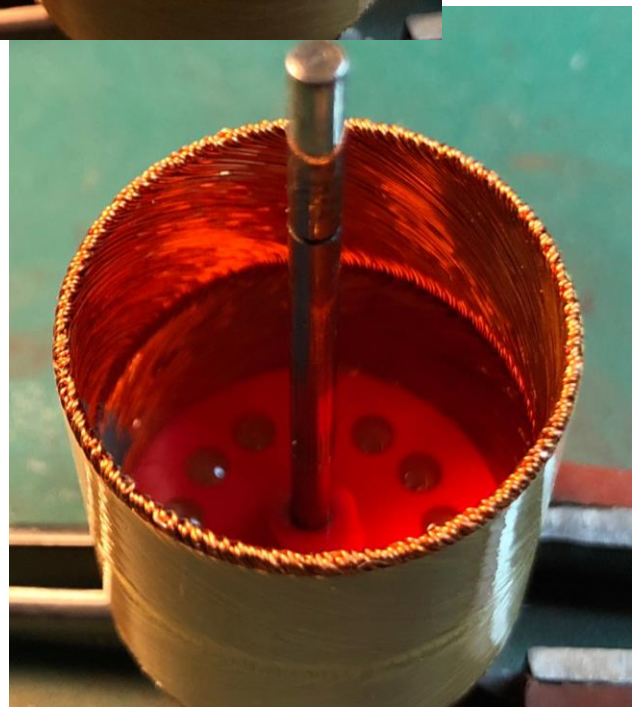
Coreless motors

- Cons
  - Designed to accelerate and decelerate very quickly: no flywheel effect
  - Some are intended to run at very high speeds
    - May require high gear ratio – which is a recipe for added noise
  - Noisier than you might think
    - High frequency hissing noise from the brushgear
  - Very easy to damage
    - No iron core to absorb heat generated if stalled mechanically
    - Brushgear cannot take excess currents – see right
    - Low-frequency pulse spikes will cause brushgear damage
      - unsmoothed DC, low frequency BEMF or old, low frequency DCC decoders
  - Many cannot take end-thrust from a worm drive
    - Primary drive must be spur/belt or via a separate gearbox with thrust bearings and a coupling
  - Shaft length often quite short – under 10mm
  - Good ones tend to be expensive; £50 to £150 each and more….

Coreless motors

- Pros
  - Smooth rotational characteristics:
    - often have 9/11/13 poles or even more:
    - **no** torsional vibration
  - Low current draw
  - Designed for control via high-frequency PWM
    - They’re not actually designed for pure DC
  - Usually have mounting holes in the driven end
  - Some models available double-ended
    - Diesels, flywheels…
  - Newer motors run more slowly
    - Reduces the issues of gearbox noise





Portescap

- Brand of Coreless motor
- 1970s go-to motor choice
  - Because the alternatives (X04…) were much worse
  - 1219 in particular runs very fast
- Sold for model railway use with integrated gearbox
  - Deals with the high speed – and the lack of torque
  - All spur gears including bevel primary reduction
  - Gearboxes often very noisy

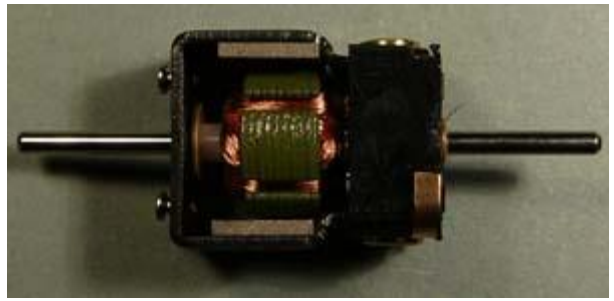
Mythbusting: Coreless motors and “Feedback”

- Coreless motors are damaged by low frequency pulses
  - Heats up the brushgear, which has no thermal capacity
- Early DC “feedback” controllers work at around 10hz
  - DC “halfwave” or “pulse power” was either 25hz or 50hz
- DCC Decoders use Pulse Width Modulation (PWM) to drive the motor
  - The supply is on or off, with nothing in between
  - “Duty Cycle” controls the speed – ratio of on to off
  - When on, the power is always 12v or so
- What matters is the PWM speed
  - Modern decoders use 19Khz and above
  - Some reach as high as 50Khz
  - Which is all fine with coreless motors
- Coreless motors **are safe to use** with modern DCC Decoders

Small Open Frame

- Cons
  - Less than optimal magnetic circuit
    - Flat magnets not curved round the armature
  - Run rather fast
    - May be noisy
- Pros
  - Often good torque for the size
  - Easy to mount – screw mounts in the ends
  - Good Solder tags
  - Double-ended

Mashima M16K



Sagami cans

- Cons
  - Awful cogging
  - Useless low speed characteristics
  - Noisy
  - Hard to mount: no screw holes in the end
- Pros
  - None

Mashima cans

- The go-to motor of the 90s/00s/10s
- But now out of production:
  - magnet supply issues
  - retirement of Mashima-San
- Cons
  - None, really
- Pros
  - Price, performance, reliability, quietness
  - Choice of sizes
  - Good low speed performance and torque
  - Easy mounting via holes on drive end
    - Which allow for integrated/addon gearboxes of the High Level variety
  - Double shafts

What do we really need?

- Silent operation: compatible with DCC Sound
  - No vibration of any kind
- Insulated brushgear
- Good low speed torque
- Realistic top speed: 6000 – 10000rpm area
- Good mounting options
  - 15mm or so drive shaft length
- Generous sized oil-retaining bearings
- Able to take axial thrust from worm drives.

Don’t fall into the trap…

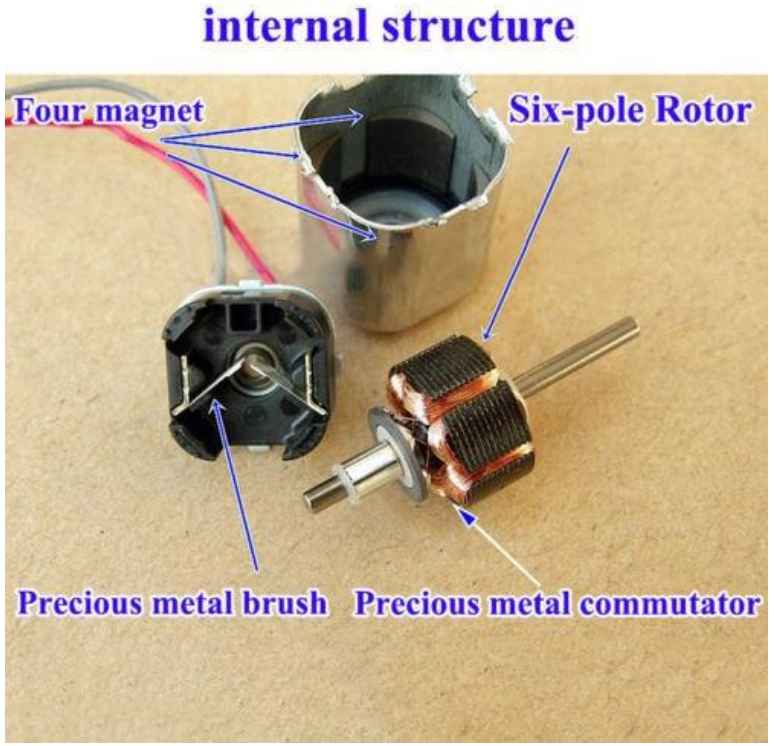
- Use a 3v or 6v motor with DCC by tweaking CV5 or the speed table?
  - It won’t work
  - PWM always supplies track voltage to the motor
    - Just not all of the time…
- The motor won’t last long
  - Seconds if it is a coreless motor
    - Such as a phone vibrator motor or drone motor.
- Always use a 12v motor
  - Or resistors – which you must then expect to get HOT

What now and next

- Mashimas are hard to get
  - Roxey Mouldings, Scale Link, Branchlines (no web site)
- Chinese-made 3 and 5-pole motors
  - Good value for money in most cases
  - Often used in Korean and Chinese made brass models
  - Mitsumi brand
  - Canon also make small motors – again, 3 pole
  - Comet Models, Taff Vale and many other suppliers often keep these
- Maxon, Portescap, Faulhaber modern coreless
  - Expensive: think £50 upwards in most cases
  - Digikey sell Portescap motors singly
  - Maxon UK also sell singly
- TramFabriek have a large range of small, relatively slow speed, coreless motors at decent prices

Minebea

- Minebea motors – via eBay
  - Designed by Mitsumi
- 15mm square 6-pole/4 magnet motor
  - Massive torque
  - Slow speed – 6500 rpm max
  - As near silent as you will get
  - 2mm shaft
  - I can recommend these wholeheartedly
    - Easily outperform $150 Maxons
  - £3 for two….
  - Google “SE15HOSLTP”
- Other sizes also available
  - 10mm is however a 6v motor….



Other Suppliers…

- NorthWest Short Line: US railway modeling supplier
  - Range of Chinese motors
- RS Components!
  - Have a Mashima 1833 clone made by Canon
  - And other good, larger motors

Avoid…

- Motors not made for model railway use
  - May be noisy, very noisy
    - I've seen motors intended for cordless screwdrivers and vending machine drives in some Chinese-made O-Scale models
  - Boat motors:
    - Noisy – there's no reason for them to be quiet
  - Slot car motors
    - designed to run in one direction only and for short periods only
    - And require vast currents and run very hot
    - Noise is important to their users!
  - Radio control plane motors
    - Often 3v
  - Drone motors
    - 3v, and very short shafts
  - Pager motors
    - 3v, 6v.
- Anything that looks too cheap to be true
  - It probably is (except the Minebea motors!)
- Anything with a stall current draw over 2 amps
  - 1 amp for 4mm scale and below

Questions, Comments

- ~~Find me in the DCC Sound workshop~~
  - ~~Dahl syndicate room~~
  - ~~by the door to the old building/bar/dining room~~
- ~~Catch me in the bar!~~
- mick@mickmoignard.com