Rebuilding an Engine

This is a passage on the work required to overhaul an A+series transverse engine and box as it seems a hot topic at the moment. What follows is a breakdown of parts and what work is required to re-condition. The engine would be of a standard spec it assumes that you have a worn smoking engine and that no extra parts are to be changed i.e. you rebuild the parts that were originally fitted to the engine. It also assumes that it was a worn but running engine with no major flaws like cracked water ways. All gaskets and seals are replaced.

Part 1 the cylinder head.

Strip head, remove valves, keep valves in order and keepers with associated retainers. Visually inspect retainers and keepers for scuffing cracks and general wear. Replace any that are suspect. Remove the valve stem oil seals and bin them.

Check springs for free length and full poundage any that are short then replace.

De-coke head and clean gasket surfaces (use rotary wire brushes for this). Inspect head for cracks especially around the valve seats especially across the narrowest point. Check threads for damage replace any that are pulled or stripped.

Inspect valve guides for wear across the biggest wear point. Consider 0.0015" oversize to be the max permissible wear. Change the worn guides or even better change the lot. Ream the new guides to 9/32" diameter.

Inspect the valves for stem wear. Any scoring or scuffing than replace. Consider 0.0005" stem wear to be the point where new valves should be fitted.

The valves should be mounted in a seat grinding machine and be refaced in such a manner that the seat face is clean and its width is the same as a standard valve its angle should be set at 45 degrees. The valve stem tip should also be refaced at the same time.

The valve seats in the head should now be re-cut to bring them back to as-new condition to achieve the correct 45 degree seat angle and so that the width matches that of the valves to be used. The outside diameter of the seat should be cut 0.002-0.005" smaller than that of the valve head diameter. The valves should then be reseated into their seats by lapping them with fine paste.

The head casting must be skimmed to produce a flat surface for the head gasket to seal properly. Have the head skimmed only by the minimum amount to achieve a flat surface.

Clean casting by having it dipped in a hot caustic tank or similar and then blow out all internal passage ways with an airline. Oil the casting now as it will rust very quickly.

Rebuild the head using 8 new valve stem seals and oil all parts as they are assembled.

Check pushrods for straightness by rolling them on a flat surface (top of the block) if they are bent then replace. Remove the wear pip at the bottom of the pushrod using a bench grinder.
Rockers, replace the rocker shaft. If the rockers are badly worn at the tips or the in the rocker shaft bore replace the whole set for new.

Part 2 Engine block

Remove timing gear and crank pulley, while doing so inspect all items and engine block for wear scuffing cracks pulled threads etc. Remove all other ancillaries. Turn block upside down, remove camshaft and then followers. Bin followers. Check camshaft for wear. If pitted or scored replace with a new or reground item. A second hand cam in good condition can also be fitted of the same spec. Check condition of cam bearings if ripped or scored they will need to be replaced. Remove oil pump and bin. Remove pistons and rods. I do not like re-ringing the A-series as this will involve honing the bores which will already be worn. This will generate even larger clearances thus building in unreliability from the start. Remove the crankshaft and measure the bearing journals for size, ovality and taper. I like my cranks to be perfect so I

would not install a worn journal onto new bearings.

Inspect the crank for crack/general condition. If the tapered area where the flywheel sits is damaged change the crank. If you are unsure of the cranks condition have it crack tested by your local machine shop.
Have the crank reground to standard tolerances and supplied with new bearings and thrust washers to suit. Do not use heavy duty bearings on standard un-hardened crank journals. Turbo engines have a hardened crank. If they need grinding they will also have to be re-hardened. These engines require the use of a heavy duty type bearing. Check the freshly ground journals and faces before fitting. Also have the crank tail polished or reground and polished if required.

Deplug the block. Clean it and check/replace any damaged threads. Check for loose main cap dowels/replace if required. Have it bored to the next oversize and install the pistons for which the compression you want to achieve . Do NOT USE pistons that are cheap in a high compression engine only use the proper high CR piston in the high CR engine.
Have the block bored 0.0025-0.003" bigger than the skirt diameter of the pistons chosen.

You may wish to have the con-rods resized and the main bearing tunnels in the block done also.

Have the block decked to ensure its flatness and only have the minimum taken off to achieve this. Ensure that there is a good 0.5-1mm chamfer around the bores to aid piston installation.

Have the block dipped in the same way as the head to remove all swarf.

Before rebuilding the block make sure that it is spotlessly clean, wash out oil ways with paraffin blow through with an airline until dry.

Clean crank in a similar fashion. Place new bearings into block and lubricate with engine oil or build lube. Place crank into block and rotate in direction of rotation. Crank should be perfectly free to rotate. Install centre main bearing cap and thrusts and torque to spec. Check rotation it should be free to rotate. Check end float to standard specs. Install other caps and check for freeness after each is torqued. If it is tight you must stop and rectify the problem. See machine shop if problem persists.
Check ring gaps aim for 0.003 - 0.004" per inch of bore.

Install piston and rod assembly one at a time. Ensure that bores are well oiled. Rotate engine after each piston/road assembly has been installed to check for free rotation. Due to ring friction the crank will be progressively stiffer to turn after each piston/rod has been installed.

Install new cam followers, and install cam and check for freeness. Use a good quality cam lube on followers and cam.

Fit new oil pump after first checking the end float on the pump. Aim for 0.0015 - 0.002" Replace the oil pressure relief valve with a 9/16" ball bearing and cut 1.25 coils off of the spring.

Install the timing gear assembly fit a new chain and tensioner if fitted. Line up the dots on the timing wheels is all that is required for a standard engine. Replace fuel pump (use OE type only) and fit a new water pump, HC type.

As for the distributor strip, clean and check the conditions of the bearings. Any play replace the unit. Never assume that the curve is correct for your rebuilt engine as this will depend on the exact spec of the engine. To get the best from the unit and to avoid nasty engine problems have it checked by someone who will be able to assess the suitability of the unit and advance characteristics and carryout any mods that may need to be done. Consider the fitting of electronic ignition as mandatory.

Part 3 Transmission

Drop case bearings should be replaced regardless of condition at overhaul stage. This goes for the primary gear bushes. Have the bushes replaced and bored to give 0.0035" clearance over the crank tail. Also replace the C-washer and retaining ring. Set end float to 0.002-0.006".

Set the idler gear end float to 0.004".

Drop case should be cleaned thoroughly and if you can have it dipped as per head and block. The case should be modified if the latest type of idler gear bearing is used by machining a slot so as to allow oil to enter the bearing housing from behind. The Original drilling gets blocked off as the new type bearing has no chamfer on its edge thus effectively closes off the hole.

The gearbox, before stripping the main gear set, take a few minutes to examine the unit. Check gear dog teeth for wear. Measure the lay gear end float and note this down. Check the play on the diff output shafts.

Start off by removing the diff unit and strip this complete to inspect the internals. You will most probably need a new diff pin, in which case all of the contents need to be replaced. These being the pin, the planet gears the shims and fibre washers. The other part which seems always to be overlooked is the replacement of the differential cage and crown wheel bushes. These should be replaced and bored out to give a clearance of between 0.0005 and 0.00075" on the appropriate output shafts. To complete the overhaul new diff roller bearings should be used. The diff endplates should be checked for wear. A freshly bored bearing will have a clearance of 0.001" over the pot joint. Excess clearance here will lead to drive shaft oil leaks in service.

Strip the remainder of the gearbox and systematically check the different areas. Clean the case, if possible use your local engineering shop hot wash tank as earlier. Examine the case for stripped/pulled threads, and cracks especially around the centre bearing web. Replace if cracked. Check the lay shaft bore is not excessively worn, replace if movement is obtainable.

Lay shaft assembly, check for signs of wear/pitting/grooving replace if worn. Check lay gear for chipped teeth, distressed teeth, and worn bearing bores. Replace if required. Contrary to popular opinion it is ok to mix and match gears, as long as sufficient backlash remains. (I have never had a problem). Fit new bearings. If the end float was too great as measured in the earlier check, then obtain a thicker shim of the required size to bring the end float into tolerance.

The main shaft assembly should be stripped. The synchro hubs if serviceable need the synchronizer hub springs changing. New springs should have a coil bound pressure of 4.5kg. Old items need to be changed if the pressure is less than 3.5kg. If the hubs are worn, i.e. the internal teeth are rounded they will need to be replaced. Again the replacement items should have the springs checked/replaced as required.

Check all if the baulk surfaces on the gear idlers for chipped/missing coating. Replace any gears that are damaged. Also check the gear dog teeth for rounding, replace any that are worn, the gears usually affected are 1st and most commonly 2nd.

Baulk rings need only be re-newed if you require maximum service life or they are completely worn out. To check, place baulk ring onto gear idler cone and measure the gap produced if any between the ring and the dog teeth. New rings produce a gap of between 0.035 - 0.040" If the gap is 0.015" or less change the ring. Good serviceable second hand ones can be used.

Check the main shaft (3rd motion shaft) nose bearing journal for wear/pitting/scoring. Likewise check the internal journal in the 1st motion shaft.

Change all of the gearbox bearings for new.

The bronze selector forks should have between 0.005 - 0.010" clearance when new on there respective hubs, when this exceeds 0.030" replace the items.

The input selector shaft that runs from the outside of the case to the inside needs to be assessed for wear. The fit of the inner shaft to it outer needs to be as tight as possible, as does the outer to the case bore. Excessive clearance here will greatly exaggerate oil leaks from an already problematic area. Also check the tightness of the selector shaft pin which engages with the bell crank lever stack. Hold the pin in a vice and pull the shaft gently. If it moves then you need to straighten it again and run a bead of mig weld around the back of the pin to lock it in place. The excess weld then needs to be cleaned off with a fine file to give a smooth untouched finish.

The next item that needs attention is the reverse idler gear. If the gear contains the split type 2 piece bearing it needs to be replaced with the single one piece type. This is to stop the problem of the bearings moving and jamming up the gear change mechanism. Replace the bearing and size it so that it has 0.015mm clearance over the shaft.

Before building up you gear box there are a few more things to check. The first and major one is 'Do I need diff housing gaskets?' Well the check this take the diff housing and gear case and bolt the 2 together. Torque up the housing, and then measure the diameter of the bores where the main diff roller bearings reside. Check them across the mating surfaces and at 90 degrees. It should measure 3" - 0.002". If it is under at 90 degrees the you need to lap the case until with the addition of gaskets the torqued up diameter is as above" all round. If the dimension is over 3" then again you will need to lap the housing. The gasket will increase the diameter at 90 degree reading by a nominal 0.008" (depending on gasket).

While you have the diff housing to hand, check the condition of the rod change bush which is that little rubber bush which is mounted on the highest part of the housing. Be careful when removing this as it is all to easy to break the casting by drifting it too hard. It is easiest to drift out the rubber centre then using a chisel, turn the outside tube, in, on itself. This will reduce the effective diameter and allow the bush to be drifted out.

Next check the condition of the Speedo gears/shafts, the shafts can be changed from the gears by drifting out the shaft and simply drifting in a new item. Use araldite on the nylon pinion and if you feel so inclined some loctite on the steel worm gear.

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