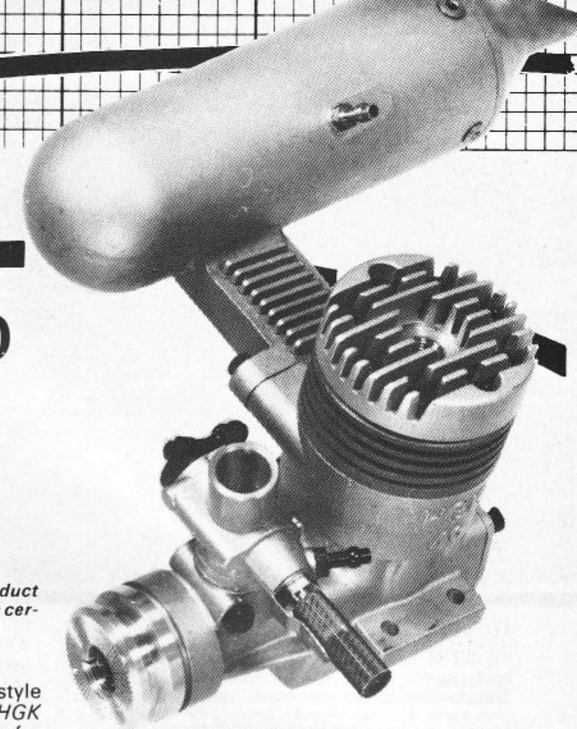
ENGINE TEST

No. 3 HGK 40 SPORTS

by Mike Billinton



Above: HGK's 40 is an interesting new product with a respectable performance - the price is certainly attractive too.

WHILST MUCH ATTENTION is naturally drawn towards Japan's overall performance as a dominant exporter in many of the world's markets, it is easy to overlook the severe internal competitive pressures facing the smaller, relatively new manufacturer of model engines, within that country itself.

It is no surprise then, that so far the *HGK* range of engines have been a little overshadowed by the other long-standing mass-production giants in Japan. To succeed in this situation demands products of high standard as well as considerable financial backing — even to get a foot in the door.

On the basis of this particular off-the-shelf test engine — the quality is certainly there, so the technical team responsible for the engines themselves seem quite capable of coping with these particular pressures — whether though the associated business arrangements are as confident is maybe less certain.

Allied to the technical merit of the *HGK* range, there is the added interest of an intriguing 'new' approach to model engine construction which should appeal to the many individualists in our hobby.

After making an initial appearance during 1978, the range of engines produced to date have been:

0.15cu. in. R/C sports and speed C/L.
0.21cu. in. R/C sports and car.
0.40cu. in. R/C sports and car.
0.45cu. in. R/C sports helicopter and marine.

The .45 is also available in rear disc format. It is understood that a .61 has been under development, whilst a fixed compression diesel variation of the .40 has undergone some preliminary tests. This is somewhat less inflexible than the usual fixed comp style of engine solely because the particular *HGK* method of engine construction allows for varying shims under cylinder base enabling the 'fixed' ratio to be changed to suit different fuels. The 0.40cu. in. is a robust engine which makes a diesel conversion a more than normally practical exercise.

Mechanicals

1. Cylinder. The 'new' approach referred to is the quite logical idea of replacing the now quite common brass liner with an aluminium one. This is a feature of all *HGK* engines to date. In fact this 'AAC' construction is a long-standing feature of many small industrial engines, but has not made much headway in the model engine field.

Some consequences flow from this material change: the lighter aluminium enables a thicker, more rigid cylinder to be used without weight penalty. So thick in fact, that at .28in thickness (in this .40 engine) it provides sufficient material for the transfer passages themselves. This then means that the whole upper cylinder can now be of mono-block construction, with the cooling fins being turned on the outside surface. The total cylinder is matt anodised mid-grey — less immediately eye-catching but theoretically superior in heat transference between metal and air. The whole of the cylinder's upper facing can now form the gasketted sealing surface between cylinder and head, which also results in very swift heat conduction when compared with the normal fairly narrow liner top sealing flange. The four built-in ports are of normal Schnuerle pattern. Exhaust timing at 154° is moderately high for what is nominally an R/C sports motor, and has a 13° lead over the transfers, which themselves have a 6° lead over the boost port timing. This latter port is appreciably curved on its upper surface however, so that boost change initially enters in two separate streams which gradually widen and join as the whole width of the port opens up. Internal running surface is a very fine ground finish to .0007in taper (tight at TDC), with subsequent thin hard chrome plating. Such is the confidence in accurate grinding processes these days, that the previous honing methods are often omitted.

2. Crankshaft. In chrome-molybdenum, case-hardened. It is an easy sliding fit in the twin ball races. Mainshaft is pitched at the largest diameter normal in this engine size — 15mm, and has a large 10.7mm induction hole. Like the exhaust timing, the induction timing at 196° total, seems more suited to somewhat higher rpm than is usual for an average R/C sports motor.

3. Crankcase. In aluminium alloy, this now becomes a compact rigid bottom end diecasting, whose major purpose is to accommodate the large upper cylinder block and the twin ball race crank.

Although not finished to the highest standards of sophistication currently being attained elsewhere, the case nevertheless is very accurately machined and clearly is strong enough for much higher duty than is envisaged for normal sports operations. Only small sections of transfer passages remain in the bottom of the cylinder section of the case — and this is likely to have provided some savings in original die costs. A groove connects base of induction throat to front ball race — effectively sucking surplus oil from front bearing back into the induction air flow. The front race is shielded in any case, so the front end of crank remained quite dry during the tests.

4. Connecting-rod. In press forged aluminium alloy, this is a substantial part with X-section of 4 × 10mm i.e. slightly beefier than some Racing 61 rods! Again pointing to the possibility (or intention) of higher-duty or higher rpm operations. Unbushed at little end, but very closely and finely fitted, there are two lubrication holes — one above and one below gudgeon pin bore. Big-end has a thinwall bronze bushing with two lubrication holes on underside of rod.

Left: complete spread of parts for the HGK - notice the removeable stud for propeller retention.

HGK — 40SF — R/C

Dimensions and weights

Capacity — .398cu. in. (6.52cc)
Bore — .8335in (21.2mm)
Stroke — .730in (18.5mm)
S/B ratio — .876/1
Timing periods — Exhaust 154°
Transfer 128°
Boost 115°
Induction 196°
(opens — 43° ABDC
(closes — 59° ATDC)

Combustion Vol. — .56cc
Compression ratios — Theoretical 12.6/1
Effective 8.98/1
Exhaust port height — .230in
Cyl. head squish — .009in
Squish band width — .17in
Squish angle — 5°
Overall height — 3.3in
Length — 3.3in
Width — 2.06in
Mounting hole spacing — .687in × 1.65in
Frontal area — 4.8sq. ins.
Carb. bore 8mm
Carb. effective X-sectional area 22sq. mm
Crankpin dia. — .216in (5.5mm)
Mainshaft dia. — .590in (15mm)
Induction bore — .420in (10.7mm)
Induction port opening — .5in × .42in wide
Rod X-section 4 × 10mm
Rod centres — 34mm
Gudgeon pin dia. — .197mm (5mm)
Weight (without silencer) — 13.4oz (.38 kilos)
Weight (with silencer) — 16.6oz (.47 kilos)

Performance

Max. BHP:
.94 at 20,900 rpm (Open exhaust/5 per cent nitro/8mm carb)
.80 at 17,300rpm (Standard silencer — 7.5mm outlet)
Fuel and carb as above.

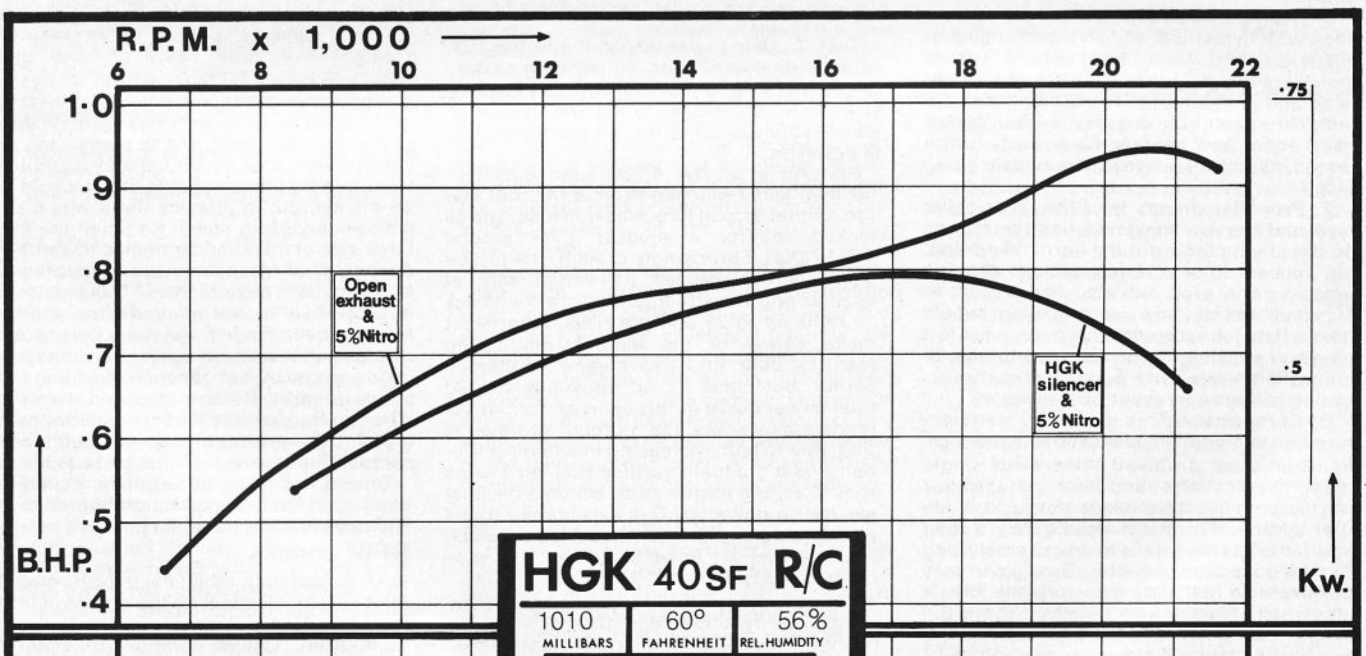
Max torque:
69oz ins at 8,200rpm (Open exhaust/5 per cent nitro)
64oz in at 8,300rpm (silencer — as above)

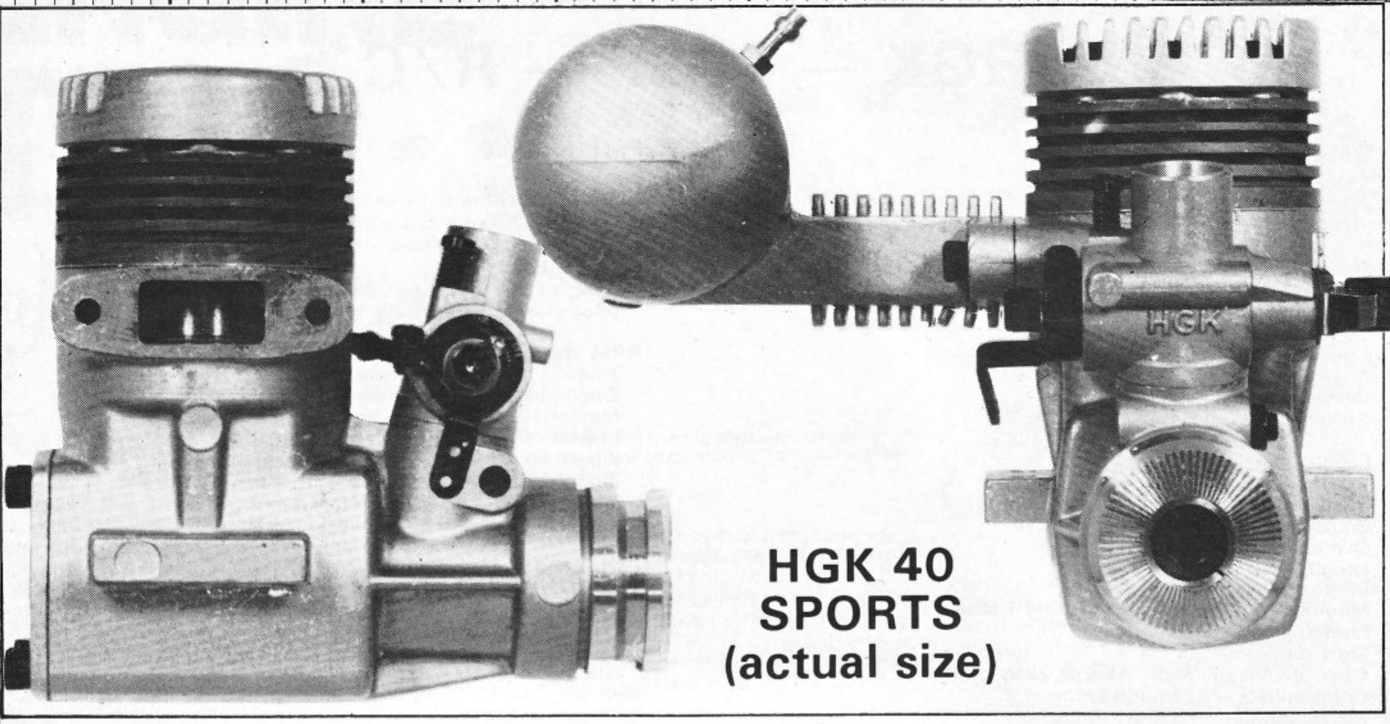
RPM standard propellers:
Zinger 11 × 8 — 9,130rpm (open ex)
Zinger 11 × 8 — 9,090rpm (silencer)
Master 10 × 6 — 12,760rpm (open ex)
Master 10 × 6 — 12,500rpm (silencer)
Zinger 10 × 4 — 14,270 (open ex)
Zinger 10 × 4 — 13,890rpm (silencer)
Zinger 9 × 4 — 16,460rpm (open ex)
Zinger 9 × 4 — 16,360rpm (silencer)

Performance equivalents:
BHP/cu. in. — 2.36
BHP/cc — .14
Oz in/cu. in. — 173
Oz in/cc — 10.6
Gm metre/cc — 7.6
BHP/lb — 1.12
BHP/kilo — 2.47
BHP/sq. in. frontal area — .196

Manufacturer:
HGK Products Co. Ltd., Tokyo, Japan.

UK Distributor:
Ripmax Ltd., Green Street, Enfield, Middx.





HGK 40 SPORTS (actual size)

5. Piston. Of high-silicon, this has two cutaways for good gas access to bottom of transfer passages. Two very firm wire circlips retain gudgeon pin as normal. Both crown and piston wall are in excess of 2mm thickness which all assists the heat dissipation problems if even higher duty was undertaken.

6. Cylinder-head is the usual aluminium alloy with symetrical squish band (angled at 5°). It is held down by eight bolts — four of which are the main through bolts which hold head and cylinder block to the crankcase. All bolts throughout the engine are Allen socket head style, and another nice touch is the thread insert in brass, to accommodate glow-plug.

7. Propeller driver. Is of the taper-collet type, and has very sharply-defined serrations on the driving face; not the normal knurling, but appears to be a rather detailed shaping process. The prop-nut also has a built-in serrated washer face, so propellers would have a hard job escaping. This nut runs onto a length of studding which screws into nose of crankshaft — always a good practical crank-saving measure in event of crashes.

8. Carburettor. This is of HGK manufacture and is a well made and effective device. In usual steel air-bleed style, with single main needle valve and rotating spraybar having an adjustable width slot for the idle fuel setting. The main needle has a long knurled brass boss fixed to an extremely long threaded section needle. This gave very positive rigid fuel settings, whilst the idle jet screw was equally very positive, giving full range (lean to rich) over only 40° movement, but it could be held steady in any one of 12 positions.

9. Silencer. Provided as standard, this is a quite large expansion style with outlet dia. 7.5mm. Weight 3¼oz.

Power tests

As new, this AAC engine (when dry) had a very slight 'dragging' piston/liner fit over the top 1mm of piston travel. This was barely perceptible when oil was present. Certainly a very free fit at every other point, yet compression was absolutely secure. This particular aspect was so good that only rarely was mechanical starting necessary. The normal operational use of this style of motor is not the subject of much variation, consequently only two power curves were aimed for; i.e. open exhaust and standard silencer.

As is frequently the case with modern engines fitted with high expansion cylinders, the manufacturer places very little emphasis on running-in; though they are slightly more guarded where the use of high-nitro fuel is envisaged. In practice this test engine was perfectly happy to run flat out at any rpm after an initial 15 minutes assessment, starting evaluations, and general running, had been completed.

Test 1. Using open exhaust and five per cent nitromethane with 20 per cent castor. No glow-plug was provided with the engine, so a Fox R/C shielded 1½ volt was used, and which survived all of the 50 separate runs undertaken.

Starting at a low 6,700 rpm, each individual load reduction (from 8,000 on) saw the normal drop in torque as rpm rose, and all looked set for a modest ¾HP around 16/17,000. Surprisingly though, the torque from thereon ceased its earlier rate of decline, and staged something of a comeback — right up to 21,000rpm. This did at least make sense of the various high-speed features built into this engine mentioned earlier, but made for an unusually shaped final power curve in this open ex. format. As readers may know, the 'normal' situation is that, due to both increasing mechanical friction and a gradually rarified fuel/air mix as rpm rises, the torque (once set on a decline) carries on downhill. This excepts the tuned pipe or similar exhaust wave devices which improve fuel/air flows significantly at pre-determined rpm points.

The only answer to this finding (other than inaccurate dyno readings, that is), must be that with some combinations of port timings, either some recovery of torque outside of a mean expected line is possible at certain rpm because of an abnormally improving air flow situation, or equally likely — other parts of the torque curve actually represent 'depressed' areas having less good air flows, and where slightly less torque than expected is being generated.

The writer's subjective assessment of the event (always a useful supplement to the actual recorded figures) was that the *HGK*40 again became quite lively past 18,000rpm in the open exhaust set-up, with a final result that a second semi-peak occurred at 21,000 giving .94bhp. Though not superior to competitors in this engine bracket, the rpm where the peak was found was at a higher point than is usual. In assessing this, or any other power figures arrived at, it is well worth keeping in mind the particular induction area being used.

The *HGK* carb at 8mm diameter and 3½mm thick spraybar results in a quite small resultant cross-sectional area of 22sq. mm, so there is clear scope for some increase of power by the use of larger bore carburettors.

Test 2. Using the standard *HGK* silencer and five per cent nitro fuel again, a more normally shaped power curve resulted. Though even here operation was quite sprightly up to 20,000. Actual values for power were not that much lower than those of the open exhaust test, with the main effect of the silencer being just to restrict top end performance past 17,000. It may be thought from this that the silencing effect would not be marked but in practice there was a sensible reduction in noise. No doubt the fairly large size of this silencer helped towards the dual goals of reasonable sound suppression and minimum power losses. This was solely a subjective assessment, as no attempts have yet been made to measure noise output because all tests have so far been conducted inside a somewhat resonant building. The build-up and reflection of sound therein at differing frequencies would not allow meaningful DB measurements, although *comparative* findings would just be possible.

During the tests, atmospheric conditions were such that no correction figures to the bhp results were necessary.

RPM checks

As indicated in table, these confirmed the relatively small effect on the engine of fitting the standard silencer, at least up to 16,500rpm. Whilst certainly of value for comparative tests in known weather conditions, rpm figures can benefit from a little 'interpretation' on occasion.

To mention just the following points where anomalies can occur, will indicate to readers some of the problems:

Dense, oxygen rich air will both increase power and increase air resistance on propellers — with a possible resultant higher power but no rpm increases. Sometimes even a small *reduction* in rpm may be revealed, and this is further confused by the fact that some props will be completely stalled due to high (static) pitch, and this can lead to yet further differing results.

Alternatively, the atmosphere may be dense because it contains a lot of water vapour — the specific reduction in oxygen content then giving a reduction of power whilst the prop itself is still having to contend with a 'thick' medium. In this case rpm reduction could be considerable. That's all when static; if one then adds to these points the effect of air density changes on the aircraft itself (it could get away with a smaller area prop when density is high, and vice versa), plus another known fact that, all things being equal, increase of rpm allows smaller area props to be used, then it can be seen that the potential problems are large. The actual problems are usually much smaller, and only of interest where high performance is sought. It should be clear though, that severe atmospheric changes can lead to suspect rpm results.

Carburettor settings and idle speed

A particularly attractive feature of the HGK40 was the very precise fuel setting and response possible, whether on full throttle or idle. A safe minimum idle speed was 2,670rpm when using a Zinger 10 × 4, silencer and five per cent nitro. Once the idle setting had been adjusted for warm motor running (about two notches leaner than best cold idle setting), the pick-up from idle to max. speed on the 10 × 4 was impressively swift and certain, even when very quick repetitions of full-range movement were attempted. The writer's experience of the whole range of model engine carbs is necessarily limited as yet, but of those handled so far, the *HGK* was definitely one of the most easy and pleasant to handle. It seems fairly durable as well.

General comments

Resulting from the tests, the style of performance, and the mechanical points referred to earlier, the strong impression was that the *HGK*40 would respond very well to high-nitromethane fuels, and would equally well cope with the extra power if fitted with a tuned pipe. The necessary overlap between Ex. and Tr. timing is not that large, though the boost port is more suitably timed (and possibly positioned) for best tuned pipe effects.

That the engine was not tested with high nitro and/or a tuned pipe was almost entirely because it is felt preferable, as a general principle, to test engines in the form, and with the equipment, which relates to the normally expected use. This does however result in occasional natural queries such as the ones in this case ... "Is it a more powerful motor in disguise?"

The other semi-related point of general interest was the evidence of a very round cylinder at all times. There was very little sign of the usual slightly asymetric piston-expansions (wear patterns mainly on the exhaust port side) which occur even with some ABC motors.

Whether this attributable to the enhanced rigidity of the very thick cylinder or to its naturally superior heat transference (compared with the less effective separate liner inside crankcase — possibly touching, possibly not) or a combination of both, is hard to say. It is certainly always worth reminding oneself that metal is far from being a rigid material — it's relatively quite elastic in fact. So any attempt to increase rigidity by thicker (though hopefully not heavier) sections of material, usually brings benefits in a variety of areas; and one of them will be a capacity to more easily resist thermal distortion. The consequent improved 'circularity' will increase rate and evenness of heat dissipation quite apart from reducing any loss of compression — above or below piston. The end result is an increased capacity to withstand much hotter fuels, or to cope with lean settings ... that dreaded situation for the modeller, which is almost entirely due to the adjustable fuel settings we allow. No self-respecting full-size car allows its driver such a 'luxury' — were it in fact to be the norm, the roads would present an interesting sight! There are reasons for this self-indulgence of course — differing fuel mixes, variable operations and cooling methods, etc. — but we certainly pay for this with the adjustable needle valve's 'life-or-death' power. Fortunately the ABC system (and now the AAC), provides much greater freedom from the adverse effects of over-lean settings. This is a direct consequence of the vastly superior heat control and dissipation given by these new systems. It is logical to assume therefore, that the one piece cylinder/case can give yet more advantage in this respect.

Having said this though, provides little justification for now allowing lean runs to more easily occur, because with our fuel/oil lubrication system, a lean setting *also* means less oil per stroke getting through, and that can of itself be a bad point, quite separate from the question of whether the extra heat generated by a lean setting can be dissipated by a superior piston/liner material combination.

Summary

It would be invidious to mention names, but maybe readers will recognise the feeling: some engines promise much — but on occasion gradually get on the wrong side of the operator ... others grow on one from quiet beginnings. The *HGK*40 was of the latter type; so, return of this test unit may be a little drawn out ...

It appears to be well suited to its main role as an R/C sports motor; very rugged and accurately produced.

On a more general point, it would certainly be unfortunate if commercial and competitive pressures within Japan were to cause undue problems for this range of engines, which offer some interest and variety because of their slightly unusual mechanical make-up.