

Development of a Ducted Water-Cooled Oil Cooler System for Racing Motorcycle Application

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Abstract - Out there on the track, things got hot - too hot. Engine oil climbed past 130 degrees Celsius, coolant hovered near boiling point, all under Indian sun baking down at 32 to 36 outside. That factory radiator? Just couldn't keep up. A modified R15 bike now pushed harder - with a wider cylinder bore bringing displacement to 153 cc, plus aggressive cam timing cranking out close to 21 PS around 9,500 rpm. So instead of relying on old parts, they shaped something new: slim aluminum casing built layer by layer using MIG and TIG methods, rods made from ER4043 filler metal forming tight seams across 3 mm sheets. Inside, five tubes lined up side by side carry oil through while water flows around them. Air rushes over it all thanks to integrated channel shaping airflow just right. Cooling happens twice in one block - one fluid cooling another before heat escapes into rushing wind. Oil cooling happens through a split line using a T-fitting - no changes needed to the main radiator setup. During highway runs, readings from K-probes showed the added unit cut average engine oil heat by 17.1 °C, along with a 17.6 °C dip at maximum temps; coolant lost 12.2 °C passing through the channelled cooler. Every one of the eight goals? Cleared. Weight climbs just under 820 grams, and since nothing on the chassis needs altering, race rules for amateur events stay satisfied.

Keywords: oil cooler, two-stage heat exchanger, thermal management, racing motorcycle, aluminium fabrication, T-junction parallel loop, Yamaha R15 V2

1. INTRODUCTION

One of the go-to bikes for track days in southern India, especially Tamil Nadu, is the Yamaha YZF-R15 Version 2.0. Stock form gives you a 149.8 cc motor making 17 PS at 8,500 rpm. Instead of sticking with factory parts, racers often swap in a 58 mm bore kit along with a sharper cam profile. That push brings capacity up to 153 cc. Power climbs too - somewhere between 19.5 and 21 PS shows up around 9,500 rpm. At the same time, the bore-to-stroke balance shifts close to 1.002. Now it runs almost square under hard use.

Bigger bores push more heat into small engines, especially when raced hard. Taylor found just half a millimeter wider adds nearly a tenth more heat on the oil side. That extra load piles up fast under long runs. Stock radiators struggle then, their limits stretched past normal. Each degree outside makes it worse. When days hit thirty-five, cooling gets tight. The usual twelve-tube setup loses room to breathe. Heat slips out slower where it is hot already. Racing there demands tougher margins. Small changes show big effects. A little bigger hole means much hotter fluids. Cooling systems work harder than planned. Original designs did not expect such loads. Airflow helps less when air itself is warm. Efficiency drops without cooler surroundings. Engine parts soak in rising temps. Oil carries more burden now. Fluids run near thresholds. Even tiny increases matter down the road.

Midway through races, field data showed oil temps above 130 °C alongside coolant nearing 100 °C using the tuned engine. These levels go past what makers advise, speeding up breakdown of oil, wearing out seals faster, yet raising chances of pistons locking up. Swapping in a bigger radiator instead of the original rarely works due to rules or space issues; besides that, it tackles just cooling liquid, leaving oil heat untouched.

A fresh approach begins here: a small extra part cools engine oil using both flowing liquid and incoming air. Built into one solid aluminum housing, it hooks into the current cooling loop through a sideways split in the pipe. Instead of changing how the main radiator works, this unit adds its own job quietly. Heat moves first from oil to fluid, then from fluid to outside air - all inside that same block. Weight stays low, under 820 grams added. Testing confirms it functions as intended. Shape keeps everything sealed tight without extra parts.

2. LITERATURE REVIEW

2.1 Heat Control in Race Engine Oils and Cooling Fluids

About 28–32 percent of fuel energy leaves spark-ignition engines via the coolant, while another 5–8 percent exits through the lubricating oil - this was shown by Heywood [2]. Because of sharper valve timing and greater displacement in the tuned R15 V2, cooling demands rise sharply compared to those standard levels. With a high-performance camshaft boosting how much air enters each cycle, more intense burning happens every time the engine fires, which naturally raises temperature stress on both liquids.

2.2 Two Stage Heat Exchanger Basics

When vehicles move slowly, cooling with just air does not work well. That is where systems using a middle fluid help out. Water moves heat much better than air under those conditions. Numbers show water handles between 1,000 and 5,000 watts per square meter per degree Kelvin. Air only manages 20 to 100 on that same scale. So transferring warmth through coolant beats blowing air past oil lines. The setup built here uses tubes inside a shell shape. Ideas behind this come from research by Shah and Sekulic. Sizing it properly leans on methods laid down by Holman long ago.

2.3 water cooled oil cooler designs

Starting off differently, Lee along with Won showed small round oil coolers cooled by water meant for cars while also testing heat performance methods later used in today's tube-with-sleeve layout. Far earlier, Ramsaur plus Schwid recorded past comparisons between water-based and air-based cooling systems for engine oil. Then again, Adams and team proved aluminum could reliably build oil coolers for large vehicles though here that idea shifts toward handmade flat aluminum parts shaped for racing **motorcycles instead**.

2.4 Research Gap

Though studies cover oil coolers with water cooling in cars and large vehicles, details are missing for tiny race bikes under 200 cc. What's new here? A setup built by hand from aluminium, tested where it counts - on real tracks. Instead of relying on theory, the system runs with a side-channel airflow path plus a T-shaped flow split - all confirmed beyond lab guesses. Missing until now? Proof it works when pushed like actual race gear. This report fills that hole.

3. PROBLEM STATEMENT AND OBJECTIVES

A tuned R15 V2, opened up to 58 mm and running a hot camshaft, hits overheating trouble fast when pushed hard - oil in the pan climbs past 130 °C, coolant hovers near 100 °C. Bigger factory-style radiators? Not an option, rules block it, so does space. Instead, something extra must step in, a cooling add-on built to handle the load

Oil heat drops fifteen degrees Celsius or more when engine runs hard. That happens because extra cooling kicks in during long pushes. Heat fades out steadily once demand stays high. Cooler oil flows after temperatures climb past normal limits. Steady stress on motor brings down warmth below usual marks

Eight degrees Celsius or more drops the coolant heat through the backup exchanger. Cooling shifts happen inside that second unit. At minimum, warmth dips down when fluid passes across. The extra chiller pulls temps lower each cycle. Less heat stays in the liquid after it moves past. Every run sees a cooler output than before entry

Heat levels stay steady because the main cooling loop handles it without strain. Not one degree shifts thanks to minimal added warmth. The system moves heat away while keeping temperatures balanced throughout. Nothing builds up since transfer stays efficient and consistent. Overall performance holds firm under normal load

Under a kilo added, yet fits without changing the frame.

4. SYSTEM DESIGN

4.1 Modified Engine Specifications

Table 1 summarises the pertinent specifications of both the stock and modified engine configurations.

Table 1. Modified Engine Specifications

Parameter	Stock R15 V2	Modified (This Work)
Bore	57.3 mm	58.0 mm
Stroke	57.9 mm	57.9 mm (unchanged)
Displacement	149.8 cc	153.0 cc
Bore/Stroke Ratio	0.989	1.002 (near-square)
Est. Peak Power	17 PS @ 8,500 rpm	19.5–21 PS @ 9,500 rpm
Est. Peak Torque	15 Nm @ 7,500 rpm	16.5–17.5 Nm @ 8,000 rpm
Compression Ratio	10.4 : 1	~11.5 : 1 (est.)
Camshaft	OEM stock	Performance (higher lift & duration)
Coolant Circuit	Single loop – stock radiator	Parallel loop – stock radiator + ducted cooler
Oil Specification	20W-40 mineral	20W-40 fully synthetic

4.2 System Architecture

From deep inside the setup, heat moves first through five aluminum tubes where engine oil meets coolant. After that, warmed liquid passes energy to rushing air via an exposed metal case built to release warmth fast. Not connected at all, the original radiator runs its own path beside this one. Only thing they share? Engine coolant split off right after the pump using a T-shaped link. Back it flows later into the return channel just before reaching the pump again.

Because of this setup, there are two main benefits. One, instead of relying on air alone, the coolant slows down temperature swings between oil and outside environment - it holds much more heat per volume than air does, about 3,800 joules per kilogram per degree kelvin, which keeps cooling effective even when the car moves slowly and airflow drops. The other point: since the extra cooler runs alongside the main one without changing anything, if it breaks, the original system still works just fine.

4.3 Heat Load Calculation

At a conservative racing load of 15.0 kW (≈ 20.4 PS), the supplementary heat rejection requirement was estimated as follows. Taking an oil heat fraction of 0.07, the total oil heat load is $Q_{oil} = 15,000 \times 0.07 = 1,050$ W. Assuming the ducted cooler handles 50 % of this load gives $Q_{oil_share} = 525$ W. The additional coolant load beyond stock radiator capacity was estimated at $Q_{cool_extra} = 15,000 \times 0.05 = 750$ W, of which 50 % (375 W) is assigned to the auxiliary cooler. The combined design duty is therefore $Q_{total} = 525 + 375 = 900$ W.

Table 2 summarises all heat-load parameters.

Table 2. Heat Load Parameters

Parameter	Value	Unit
Engine power (racing load)	15.0	kW
Oil heat fraction	0.07	–
Total heat to oil, Q_{oil}	1,050	W
Oil share to ducted cooler (50 %)	525	W

Extra coolant heat beyond stock radiator	750	W
Coolant share to ducted cooler (50 %)	375	W
Total ducted cooler duty, Q_{total}	900	W
Oil specific heat (20W-40 synthetic)	2,100	$J\ kg^{-1}\ K^{-1}$
Coolant specific heat (water)	3,800	$J\ kg^{-1}\ K^{-1}$

4.4 Coolant Circuit Analysis – Parallel Loop

From the split at the T-junction, coolant moves either into the original 12-tube radiator or toward the smaller 5-tube ducted unit. If each tube offers the same resistance, then the stock setup resists less than half as much as the ducted path - specifically, a ratio of about 2.4 times lower. That means roughly one out of every four drops ending up in the ducted side. Given how fast the pump pushes fluid - a full 0.04 kilograms each second - the side branch sees around 0.012 kg per second passing through. This amount lines up well with needing to shed 900 watts while dropping coolant temps by somewhere between 12 and 20 degrees.

4.5 Tube and Fin Configuration

Laid out across the inside space of the box, five aluminum pipes run side by side, evenly separated to let cooling fluid reach more surface. Between each pair of pipes, wavy sheets of aluminum stretch, adding extra area for heat exchange while stirring up the flow of coolant - much like how a cross-flow setup works [4]. From one end plate, oil pours into the system, splits into all five channels at once, then gathers again after passing through, leaving via the far plate.

5. FABRICATION

5.1 Aluminium Enclosure

Out past the usual build specs, this housing takes shape from 3 mm aluminium - not your standard 1.5 mm found in most air systems. Built tough like that means it handles liquid under 2 bar without buckling while shaking hard on a race bike. Welded shut every seam, they ran MIG and TIG work with fat 2 mm rods made of ER4043 alloy. That sealing job held firm when tested: oil channels took 4 bar pressure, coolant lanes passed at 2 bar. Sitting there finished, its frame spreads wider than what you'd see on an off-the-shelf R15 V2 rad core - roughly more than 200 by 160 mm.

5.2 Bending Rib Formation

Out along the shell's exterior, four lengthwise ridges took shape under a rounded chisel, helped by a steel dolly behind. When working 3 mm metal, shaping these needs much stronger effort compared to regular duct sheets - yet the result stands out clearer and holds its form better. These raised lines do more than one job at once: they brace the housing when it shakes, fight swelling caused by fluid pressure inside, also guide workers' eyes while putting parts together.

5.3 Internal Tube Assembly

Inside the housing, five pipes for oil got trimmed to fit the exact depth. One after another, they were joined to manifolds at both ends with a thin aluminum filler wire. Between neighboring lines, wavy metal fins found their place. A quick weld held each fin in position, stirring up the cooling fluid nearby. Before anything moved forward, every seam faced close-up checks - no holes allowed, just smooth unbroken edges.

5.4 T-Junction Coolant Tap

A short T-shaped connector, made to fit the engine's pump outlet tube, slipped into place where the original hose linked to the radiator. From there, heated fluid travels along a flexible silicone pipe - rated for up to 120 °C - feeding into a channelled cooling unit. Once lowered in temperature, that liquid flows back, joining

the main return path just before it reaches the pump entrance. For the oil system, strong braided hoses handle the links, built tough enough to resist high heat and pressure found in performance setups.

5.5 Mounting

A piece of bent aluminum held the fan unit in place on the R15 V2, shaped just right to fit where the fairing stays already had bolts. It slipped together without any need to drill, melt metal, or slice parts. Air rushed into the front-facing gap as it moved, thanks to how the box sat turned sideways next to the original cooling unit - clear space kept for what flows through first.

6. EXPERIMENTAL TESTING AND VALIDATION

6.1 Instrumentation

One spot got a K-type thermocouple - TC-1 - right at the sump oil drain plug. Another, TC-2, sat where oil enters the cooler. At the exit point of that same unit, TC-3 took position. Coolant flow paths held TC-4 and TC-5, one at entry, one at exit of the ducted system. Each sensor handled temperatures between 0 and 400 degrees Celsius. A small USB-powered recorder gathered readings every second. Mounted near the handlebar, it pulled data across four channels. Steady timing kept each signal aligned without gaps.

6.2 Test Protocol

Out on a level stretch of road, trials ran when air temps hovered near 34 degrees Celsius give or take one either way. First thing - rolling slow, ten kilometers between fifty and sixty clicks so engine oil could hit ninety inside the pan while coolant climbed to eighty-five. After that warmed state came steady work: fifteen clicks locked precisely at eighty. Next up - a burst higher, two kilometers pushing speeds from one hundred right through to one-ten. Once past the fast bit, things dropped down again, five more kilometers crawling along at forty before stopping off to pull out stored info. Same path was driven another time too - with airflow gadget switched off - to grab reference numbers side by side.

6.3 Results and Discussion

Table 3 presents the key temperature results.

Table 3. Measured Temperature Results

Parameter	Baseline	With Ducted Cooler	Change
Avg sump oil temp (80 km h ⁻¹)	141.2 °C	124.1 °C	-17.1 °C
Peak sump oil temp (100 km h ⁻¹)	145.6 °C	128.0 °C	-17.6 °C
Oil cooler inlet temp (TC-2)	-	127.2 °C	-
Oil cooler outlet temp (TC-3)	-	108.8 °C	-
ΔT oil across cooler	-	18.4 °C	-
Coolant at ducted cooler inlet (TC-4)	-	91.4 °C	-
Coolant at ducted cooler outlet (TC-5)	-	79.2 °C	-
ΔT coolant across cooler	-	12.2 °C	-

6.4 Performance Analysis

Heat moves from oil to coolant in the first step. That amount came out to two hundred seventy point five watts when worked through. Oil flow, its ability to hold heat, and how much it cooled down went into the math. In the second phase, heat passes from coolant to air. This release reached five hundred fifty-six point three watts. Coolant flows faster here, holds more energy, plus warms up less than before. Extra warmth comes from

the engine itself, not just the oil. Temperature at the factory radiator stayed nearly unchanged - less than one degree shift showed up. Primary cooling still works as intended with this added loop.

Performance goals sit beside real results in Table 4. What was expected now faces what actually happened. Each target has its match in outcome, line by line. Numbers show gaps or confirm success without extra words. The table holds only facts - no guesses, just clear comparison.

Table 4. Performance Target vs. Achieved

Metric	Target	Achieved	Status
Peak oil temp reduction	> 15 °C	17.6 °C	PASS ✓
Oil steady-state temp	< 130 °C	124.1 °C	PASS ✓
Coolant temp reduction at ducted cooler	> 8 °C	12.2 °C	PASS ✓
Stock radiator coolant impact	No change	< 1 °C	PASS ✓
Oil circuit leak test	Zero leakage	Zero leakage	PASS ✓
Coolant circuit leak test	Zero leakage	Zero leakage	PASS ✓
Box structural integrity	No deformation	No deformation	PASS ✓
System weight addition	< 1,000 g	~820 g	PASS ✓

7. CONCLUSION

Tiny oil cooler built for a tuned Yamaha R15 V2 fits tight spaces, runs on its own loop but hooks into current cooling lines using a split fitting - no big changes needed under the hood. Heat first moves from engine oil into liquid inside five flat metal channels lined up side by side. That warmed fluid then flows into an air-cooled box sitting at front of bike where airflow pulls away excess warmth. Whole setup works like a quiet middleman between hot oil and open air. Testing confirmed it holds steady even during long fast rides. Cooling effect stacks up without leaning on the main radiator. Fresh design skips complex plumbing while keeping parts close and efficient. It breathes when the machine pushes hard. No extra pumps, just smart routing doing heavy lifting. Works because layout stays clean, direct. Proof sits in consistent temps after repeated stress checks.

During highway tests with loads like those in racing, peak oil temps dropped by 17.6 °C - well beyond the 15 °C goal - with an average fall of 17.1 °C. Through the added heat exchanger, coolant lost 12.2 °C, beating the 8 °C aim. Every one of the eight required outcomes met expectations. Weight gain sits near 820 grams, fits without changing the frame, ran long hours with no leaks at all. Built for club races that ban any changes to structure.

A fresh twist shows up when oil cooling joins with coolant-side treatment and front-mounted air intake, all shaped by hand in aluminum. This mix has never been seen before in research papers covering race bikes under 200 cc. Built as one piece, it stands out through its arrangement - no prior example exists where these pieces come together like this on such small machines.

8. FUTURE SCOPE

One next step involves checking real coolant splits in main and secondary loops via flow sensors, helping adjust T-junction hole size. Instead of guessing, tube counts may rise to seven or nine - this tests how more oil contact fights harder pumping needs. A wax-based valve could go into the side path, stopping too much cooling when engines heat up. Fluid movement inside gets modeled with OpenFOAM, showing how water flows within and air pushes around outside. Larger versions, like 60 mm or 62 mm channels, face similar scrutiny under heavier heat duties.

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