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Calculation-Based Comparative Evaluation of Oil Pressure and Hydraulic Losses for Baseline Ms-20 and Aeroshell Oil W100 Plus in the M-14p Aircraft Piston Engine Lubrication System

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Abstract- This study presents a calculation-based comparison of baseline MS-20 oil and AeroShell Oil W100 Plus in the M-14P aircraft piston engine lubrication system. Temperature-dependent viscosity is determined using the ASTM D341/Walther model and incorporated into hydraulic calculations of flow characteristics, pressure losses, and main oil-gallery pressure under representative operating regimes. The results quantify differences in viscosity–temperature behavior and hydraulic performance between the two oils, providing a basis for assessing AeroShell Oil W100 Plus as a potential replacement for MS-20. Final lubricant selection requires additional evaluation of tribological, chemical, and operational criteria.

Keywords— M-14P; MS-20; W100 Plus; hydraulic losses; viscosity–temperature relationship; ASTM D341.

I. INTRODUCTION

This study evaluates the effect of oil temperature on the hydraulic characteristics of the M-14P engine lubrication system when AeroShell Oil W100 Plus is used, with MS-20 serving as the baseline oil for comparison. All results are obtained using the same model and identical calculation conditions to ensure consistency and comparability. [1], [2]

The investigated range covers oil temperatures from 20 to 100°C at an engine speed of n = 2050 rpm. The principal parameters are kinematic viscosity ν, total circuit pressure loss ΔpΣ, and main oil-gallery pressure p_main.

II. SIMULATION BASIS

The calculation model couples the oil temperature-viscosity relationship with the hydraulic balance of the lubrication system. Temperature-dependent viscosity is determined using the Walther/ASTM D341 relationship; pipeline losses are calculated from the Reynolds number and Churchill friction factor; and pressure losses through the filter and oil cooler are evaluated using the corresponding hydraulic relationships.

The main-gallery pressure is obtained from the balance between actual pump delivery, flow through the journal bearings, and discharge flow through the pressure-regulating valve. [1], [5]

For AeroShell Oil W100 Plus, the calculation uses ν40 = 195.0 cSt and ν100 = 19.96 cSt. MS-20 is retained as the reference baseline throughout the evaluation. [3], [4], [5].

The nonlinear hydraulic-balance problem is solved iteratively for each oil temperature.

The procedure first evaluates the temperature-dependent oil properties, then calculates bearing-flow demand and circuit pressure losses, and finally solves the flow-balance residual for the main-gallery pressure using Brent's method. The calculation sequence is summarized in Figure 1 [1], [5].

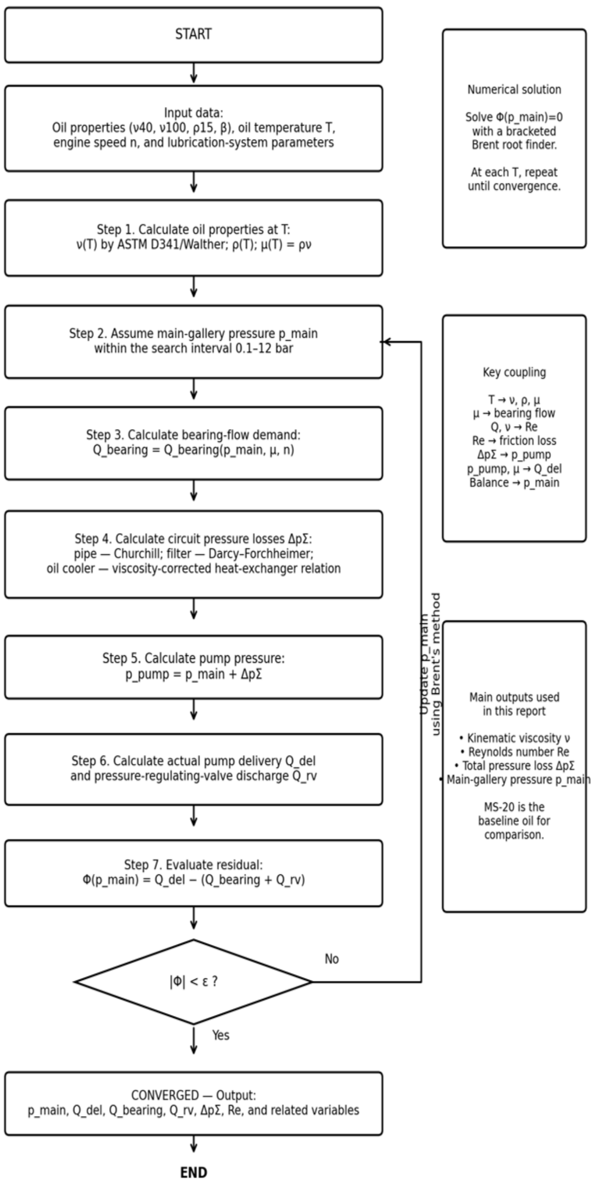

Figure 1. Calculation algorithm for the nonlinear hydraulic-balance model.

III. SUMMARY OF SIMULATION RESULTS

The results show that both oils exhibit the same overall temperature-dependent trend: as temperature increases, viscosity and hydraulic losses decrease; at high temperatures, the main-gallery pressure also decreases because of increased internal leakage and flow through journal-bearing clearances. [5]

Table 1: Summary of calculation results

T (°C)	ν MS-20 (cSt)	ν W100 Plus (cSt)	ΔpΣ MS-20 (bar)	ΔpΣ W100 Plus (bar)	p_main MS-20 (bar)	p_main W100 Plus (bar)	Δp_main (bar)
20	1102.0	666.8	1.360	0.830	6.76	7.21	+0.45
30	513.1	345.8	0.630	0.430	7.34	7.41	+0.07
40	265.0	195.0	0.330	0.250	7.39	7.29	-0.10
50	149.2	118.0	0.190	0.150	7.15	6.98	-0.17
60	90.3	75.8	0.120	0.100	6.73	6.53	-0.20
70	58.1	51.2	0.080	0.070	6.17	5.98	-0.19
75	47.6	42.8	0.070	0.061	5.86	5.69	-0.17
80	39.4	36.1	0.060	0.052	5.54	5.39	-0.15
85	33.0	30.8	0.050	0.045	5.21	5.08	-0.13
90	27.9	26.4	0.040	0.040	4.89	4.78	-0.11
95	23.8	22.9	0.040	0.034	4.32	4.15	-0.17
100	20.5	20.0	0.030	0.030	3.70	3.61	-0.09

IV. COMPARISON OF HYDRAULIC-LOSS VARIATION

In the low-temperature region, W100 Plus produces markedly lower hydraulic losses than MS-20. At 20°C, ΔpΣ decreases from 1.36 bar for MS-20 to 0.83 bar for W100 Plus, corresponding to a reduction of approximately 39%. At 40°C, the respective pressure losses decrease to 0.33 and 0.25 bar.

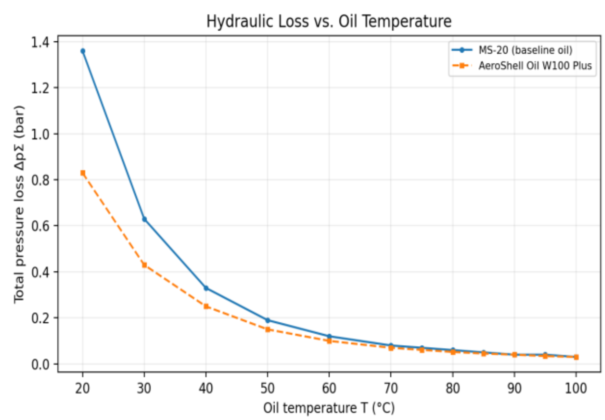

Figure 2. Comparison of total pressure loss for MS-20 and AeroShell Oil W100 Plus.

Above 70°C, the difference in pressure loss between the two oils narrows rapidly. At 75°C, ΔpΣ is approximately 0.070 bar for MS-20 and 0.061 bar for W100 Plus; by 100°C, both values are approximately 0.03 bar. Therefore, the lower flow resistance of W100 Plus is most pronounced during engine start and warm-up.

V. COMPARISON OF MAIN-GALLERY PRESSURE VARIATION

In the 20–30°C range, W100 Plus gives a slightly higher p_main than MS-20. At 20°C, the corresponding values are 7.21 and 6.76 bar; at 30°C, they are 7.41 and 7.34 bar. From approximately 40°C upward, p_main for W100 Plus is lower than that for MS-20, although the difference remains small overall.

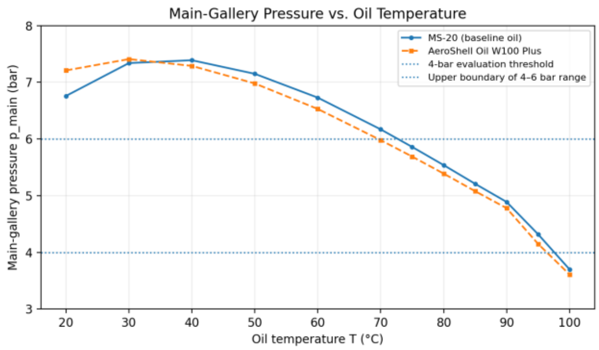

Figure 3. Comparison of main oil-gallery pressure as a function of temperature.

In the 70–85°C operating range, the similarity is pronounced. At 75°C, p_main is 5.86 bar for MS-20 and 5.69 bar for W100 Plus, a difference of 0.17 bar. At 85°C, the respective values are 5.21 and 5.08 bar, a difference of 0.13 bar. This is the range in which W100 Plus most closely matches the pressure characteristics of the baseline oil.

As oil temperature increases to 90–100°C, the pressure of both oils continues to decrease. At 95°C, MS-20 gives 4.32 bar and W100 Plus 4.15 bar. At 100°C, the respective values are 3.70 and 3.61 bar, both below the 4-bar threshold used in the model to identify the low-pressure region.

VI. EVALUATION BY OPERATING REGIME

Start-Up and Warm-Up Regime (20–40°C)
W100 Plus has a lower viscosity than MS-20 and therefore substantially reduces resistance in the oil circuit. This is a hydraulic advantage during the establishment of oil circulation after start-up. Main-gallery pressure remains comparable to, or slightly higher than, that obtained with the baseline oil. [2], [3]

Transitional Regime (40–70°C)
As temperature increases, the differences in viscosity and hydraulic loss between the two oils gradually decrease. The main-gallery pressure of W100 Plus is approximately 0.10–0.20 bar lower than that of MS-20. This small deviation indicates that the hydraulic responses of the two oils begin to converge. [5]

Steady Operating Regime (70–85°C)
This range shows the closest agreement. W100 Plus maintains p_main at approximately 5.98–5.08 bar, whereas MS-20 provides approximately 6.17–5.21 bar. The difference is small, while the hydraulic loss of W100 Plus is equal to or lower than that of MS-20.

High-Temperature Regime (90–100°C)
Although pressure losses in the oil circuit are very small in this region, p_main for both oils decreases significantly because lower viscosity increases internal pump leakage and flow through journal-bearing clearances. At 100°C, both simulated pressures fall below 4 bar; therefore, this should not be regarded as a favorable sustained operating region according to the model pressure criterion.

VII. ASSESSMENT OF HYDRODYNAMIC COMPATIBILITY

Considering both pressure and hydraulic-loss criteria, AeroShell Oil W100 Plus demonstrates substantial compatibility with MS-20 within the principal operating-temperature range. W100 Plus clearly reduces flow resistance at low temperatures, while at 70–85°C its main-gallery pressure is only approximately 0.13–0.19 bar lower than that of the baseline oil. [1]

The absolute difference at high temperature is also small; however, both oils show reduced pressure margin as the temperature approaches 100°C. Maintaining oil temperature within an appropriate range is therefore important for the stability of the lubrication system.

VIII. CONCLUSIONS

The pressure and hydraulic-loss trends of AeroShell Oil W100 Plus are similar to those of MS-20 throughout the investigated temperature range.

In the 20–40°C range, W100 Plus provides lower hydraulic losses; at 20°C, the total pressure loss is approximately 39% lower than that of MS-20.

In the 70–85°C range, W100 Plus maintains main-gallery pressure close to that of the baseline oil; the difference is only about 0.17 bar at 75°C and 0.13 bar at 85°C.

Above 90°C, the main-gallery pressure of both oils decreases rapidly; at 100°C, both simulated values are below 4 bar.

Considering pressure and hydraulic loss alone, W100 Plus exhibits good hydrodynamic compatibility with MS-20 in the principal operating range of the M-14P engine.

Airworthiness & Qualification Considerations: Final qualification for operational substitution requires verification against secondary airworthiness criteria, including oil-film shear strength, anti-wear additive packages, oxidation stability, deposit control, and specific operational limit compliance.

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