

HNAT 737 技术问题说明

提示单编号	撰写	校对	批准/日期
TIP737-2021-52-002	王康业	朱小明	曾晶/2021.10.26

标题 燃油泵低压轴剪切导致的双发推力不一致

一、适用性

737

二、背景描述

2021年6月，机队出现一起由于燃油泵低压轴剪切导致的双发推力不一致故障，走了较多的弯路。特做记录。

三、解释说明

一)，事件经过

11日：

14：10 机组反映左右发推力不一致，自检 EEC 无故障信息

14：50 完成译码，确认右发 N1 无法加速到目标 N1，双发推力最大相差 6%，决策停场排故。

12日：

目视检查 T12 传感器无异常，完成 T12 到 EEC 之间线路检查未见异常；检查右发油门杆解算器角度正常，连杆未见松动；更换 HMU、EEC 和 T12 传感器，试车测试故障依旧。

13日：

经过专题会议讨论，确定油路和气路的检查方案。检查翼梁活门马达作动器和活门作动正常；检查 PS 管路未见漏气，用氮气完成 PS3 管路吹除。人工转动 N2 时发现 MFP 的低压叶轮泵不随动，从观察口检查可视的叶轮叶片，发现下部不平滑，疑似损伤。

14日：

剪开主燃油滤发现由少量银白色金属屑，金属屑安排送检，确认为铝材料（燃油泵壳体）；更换燃油泵。

15日：

完成 VBV、VSV、TBV 系统检查；完成右发伺服燃油热交换器、主滑油/燃油热交换器、燃油喷嘴油滤更换。

16日：

试车测试正常，飞机放行。

二)，系统原理及失效原因分析

1，系统原理简述

如下图所示，燃油泵（MFP）有两级增压：第一级为低压的叶轮泵，第二级为高压的齿轮泵。燃油进入燃油泵后首先经过 MFP 的低压泵增压，分离燃油中的气体，避免在高压级增压损坏齿轮。经过初级增压的燃油再到 IDG 的滑油冷却器和主滑油/燃油热交换器进行热交换，完成加温的燃油经主燃油滤再进入 MFP 的高压齿轮泵，再次增压的燃油分两路进入 HMU，一路用于伺服燃油作动各个发动机部件，另一路经 FMV 的计量再供往燃烧室用于提供推力。

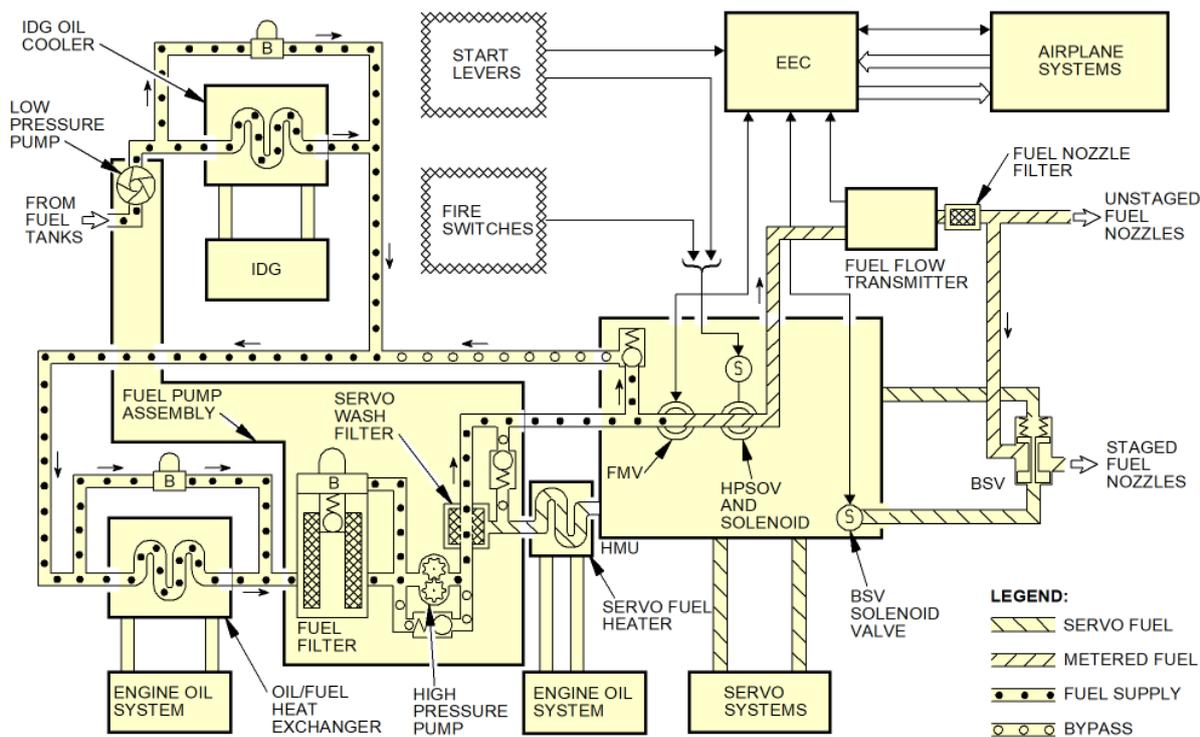


图 1

2, 故障分析

EEC 是通过油门杆的输入信号来改变发动机推力的。EEC 再根据马赫数、外界环境和下游的引气负载情况以及 ID PLUG 提供的额定推力, 计算 N1 指令值, 通过控制 HMU 内 FMV 的开度, 来实现发动机推力的控制。由于机组描述的故障现象为双发推力不一致, 因此排故思路一般可分为:

- a) 控制发动机推力的输入信号出现故障 (TRA resolver/P0/PT/T12/TAT/PS3);
- b) 控制推力的系统出现故障 (EEC);
- c) 执行部件出现故障 (MFP、HMU);
- d) 排气系统故障导致功率丢失 (VBV/VSV/HPTACCV/LPTACCV/TBV);
- e) 下游引气负载影响 (CTAI/WTAI/PAK)。

EEC 在地面的时候使用 T12 提供的总温信号, 起飞 5 分钟后转为使用 ADIRU 的 TAT 探头总温信号, 由于目标 N1 双发是一致的, 且故障在 TO/GO 后到离地后 10 分钟, 因而大气数据信号可能性较低。其次, EEC 可从四个地方得到 P0 压力, 分别是 ADIRU1/2 和双发 EEC 的 P0 传感器。正常情况下, 若四个信号都良好, EEC 使用 ADIRU1 的 P0 来控制两台发动机。由于本机该故障只影响一台发动机, 故也可以排除 P0。通过译码, 发现油门杆解算器角度在双发油门杆位置一致的情况下基本一致, 地面读取油门杆各位置角度数据也符合要求, 因此 TRA 也可以排除。

下游引气负载的影响往往会导致双发 N1 目标值不一致, 而本机译码核实确认双发 N1 目标值是一致的。起飞滑跑阶段, 机组接通 TOGA 后, 可以明显的看到右发 N1 无法加速到目标值, 虽然 FMV 有较大的开度, 但 FF 明显偏小于左发。此时左发 regulator 参数为 3, 右发为 9。至此, 可能的故障源可缩小在上述 b、c、d 所列部件范围内。

11/06/2021 Time	APR_GROUND	TOGA	AIR-ROTTL	ENG1FCO	ENG2FCO	ENGLTA (%)	ENGLTA (%)	ENGLN1 (%)	ENGLN2 (%)	ENGLN1TGT (rpm)	ENGLN2TGT (rpm)	ENGLN2 (%)	ENGLN2 (%)	ENGLFF (%)	ENGLFF (%)	FMV_POS_S1	FMV_POS_S2	PS3_SEL (ps)	PS3_SEL_2 (ps)	ENTRL_REG_1	ENTRL_REG_2
05:13:32	GROUND	GROUND	GROUND	GROUND	GROUND	46.23	45.88	28.88	28.63			72.63	72.75	1520	1488			62	56	15.00	9.00
05:13:33	GROUND	GROUND	GROUND	GROUND	GROUND	46.23	45.88	32.13	31.25			76.63	76.13	1792	1712			70	62	15.00	9.00
05:13:34	GROUND	GROUND	GROUND	GROUND	GROUND	46.23	45.88	36.00	33.88	91.50	91.50	81.25	79.75	2080	1888			88	66	9.00	9.00
05:13:35	GROUND	GROUND	GROUND	GROUND	GROUND	46.23	45.88	45.88	38.38			86.00	83.63	2544	2096	25.88	33.50	114	90	9.00	9.00
05:13:36	GROUND	GROUND	GROUND	GROUND	GROUND	46.23	45.88	48.63	47.00			84.50	85.25	2016	2272			94	106	6.00	6.00
05:13:37	GROUND	GROUND	GROUND	GROUND	GROUND	46.23	45.88	45.75	44.88			84.50	85.75	1888	1648			100	98	3.00	3.00
05:13:38	GROUND	GROUND	GROUND	GROUND	GROUND	51.50	55.55	47.13	50.13	91.50	91.50	85.63	87.25	2000	2560	69.00	61.25	132	114	3.00	9.00
05:13:39	GROUND	GROUND	GROUND	GROUND	GROUND	62.40	65.39	63.00	68.38			90.88	91.88	3520	4176			228	186	9.00	9.00
05:13:40	GROUND	GROUND	GROUND	GROUND	GROUND	66.62	66.45	83.00	82.38			94.88	94.63	4384	4352			236	262	15.00	9.00
05:13:41	GROUND	GROUND	GROUND	GROUND	GROUND	69.08	66.62	87.75	84.25			94.13	95.25	7200	6572			312	270	9.00	9.00
05:13:42	GROUND	GROUND	GROUND	GROUND	GROUND	70.31	66.62	90.75	84.88	91.50	91.50	97.63	95.75	7984	6688			322	276	3.00	9.00
05:13:43	GROUND	GROUND	GROUND	GROUND	GROUND	70.66	66.62	91.63	85.38			98.13	96.13	8192	6720	74.00	78.50	330	276	3.00	9.00
05:13:44	GROUND	GROUND	GROUND	GROUND	GROUND	70.66	66.62	91.63	85.00			97.88	96.25	8064	6736			326	280	3.00	9.00
05:13:45	GROUND	GROUND	GROUND	GROUND	GROUND	70.66	66.62	91.75	85.75			98.00	96.38	7968	6752			328	282	3.00	9.00
05:13:46	GROUND	GROUND	GROUND	GROUND	GROUND	70.66	68.91	91.63	85.88	91.50	91.50	98.25	96.38	7936	6752			328	280	3.00	9.00
05:13:47	GROUND	GROUND	GROUND	GROUND	GROUND	70.66	70.14	91.75	86.00			98.13	96.50	7894	6752	72.63	79.00	326	282	3.00	9.00
05:13:48	GROUND	GROUND	GROUND	GROUND	GROUND	70.66	70.84	91.50	86.13			98.13	96.50	7824	6752			328	284	3.00	9.00
05:13:49	GROUND	GROUND	GROUND	GROUND	GROUND	70.49	72.42	91.63	86.13			98.13	96.50	7840	6768			326	284	3.00	9.00
05:13:50	GROUND	GROUND	GROUND	GROUND	GROUND	70.49	71.54	91.75	86.13	91.50	91.50	98.13	96.50	7856	6784			328	286	3.00	9.00
05:13:51	GROUND	GROUND	GROUND	GROUND	GROUND	70.49	72.25	91.50	86.38			98.13	96.50	7840	6800	72.75	79.88	328	286	3.00	9.00
05:13:52	GROUND	GROUND	GROUND	GROUND	GROUND	70.49	71.89	91.75	86.38			98.00	96.50	7856	6800			328	286	3.00	9.00
05:13:53	GROUND	GROUND	GROUND	GROUND	GROUND	70.49	72.07	91.63	86.38			98.00	96.63	7840	6800			326	286	3.00	9.00
05:13:54	GROUND	GROUND	GROUND	GROUND	GROUND	70.49	74.63	91.75	86.38	91.50	91.50	98.25	96.50	7888	6816			326	286	3.00	9.00
05:13:55	GROUND	GROUND	GROUND	GROUND	GROUND	70.49	75.76	91.75	86.50			98.13	96.50	7824	6816	72.25	80.00	324	286	3.00	9.00
05:13:56	GROUND	GROUND	GROUND	GROUND	GROUND	70.49	77.87	91.50	86.50			98.25	96.50	7792	6832			326	288	3.00	9.00
05:13:57	GROUND	GROUND	GROUND	GROUND	GROUND	70.66	78.93	91.63	86.50			98.13	96.50	7792	6816			328	286	3.00	9.00
05:13:58	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	78.93	92.13	86.50	91.50	91.50	98.38	96.38	7920	6816			334	286	3.00	9.00
05:13:59	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	78.93	92.38	86.50			98.38	96.38	8032	6832	73.75	79.63	332	286	3.00	9.00
05:14:00	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	78.93	92.38	86.50			98.25	96.38	8016	6848			332	286	3.00	9.00
05:14:01	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	78.93	92.50	86.50			98.25	96.38	8064	6832			334	286	3.00	9.00
05:14:02	GROUND	GROUND	GROUND	GROUND	GROUND	71.37	78.93	92.50	86.38	91.50	91.50	98.25	96.25	8080	6832			334	284	3.00	9.00
05:14:03	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	78.93	92.63	86.38			98.25	96.38	8016	6848	74.25	79.50	334	284	3.00	9.00
05:14:04	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	78.93	92.63	86.38			98.25	96.38	8112	6848			334	284	3.00	9.00
05:14:05	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	78.93	92.63	86.38			98.25	96.38	8144	6832			334	284	3.00	9.00
05:14:06	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	75.94	92.50	86.38	91.50	91.50	98.25	96.38	8128	6832			336	286	3.00	9.00
05:14:07	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	75.94	92.50	86.50			98.25	96.38	8144	6864	74.38	80.13	334	286	3.00	9.00
05:14:08	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	75.94	92.63	86.50			98.25	96.38	8160	6880			334	286	3.00	9.00
05:14:09	GROUND	GROUND	GROUND	GROUND	GROUND	71.37	75.94	92.63	86.38			98.13	96.25	8160	6864			334	286	3.00	9.00
05:14:10	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	75.94	92.63	86.38	91.50	91.50	98.25	96.38	8208	6864			334	284	3.00	9.00
05:14:11	GROUND	GROUND	GROUND	GROUND	GROUND	71.37	75.94	92.63	86.38			98.13	96.25	8208	6864	74.50	79.50	334	284	3.00	9.00
05:14:12	GROUND	GROUND	GROUND	GROUND	GROUND	71.37	75.06	92.63	86.25			98.25	96.38	8192	6864			334	286	3.00	9.00
05:14:13	GROUND	GROUND	GROUND	GROUND	GROUND	71.37	75.06	92.75	86.25			98.25	96.38	8208	6880			338	284	3.00	9.00
05:14:14	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	75.06	92.63	86.38	91.50	91.50	98.25	96.38	8208	6896			336	284	3.00	9.00
05:14:15	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	75.06	92.75	86.38			98.25	96.38	8256	6880	74.75	79.88	338	286	3.00	9.00
05:14:16	GROUND	GROUND	GROUND	GROUND	GROUND	71.19	75.06	92.75	86.25			98.25	96.38	8240	6880			336	284	3.00	9.00
05:14:17	GROUND	GROUND	GROUND	GROUND	GROUND	71.37	75.06	92.63	86.25			98.25	96.38	8208	6896			338	286	3.00	9.00
05:14:18	AIR	AIR	AIR	AIR	AIR	71.19	75.06	92.63	86.13	91.50	91.50	98.25	96.38	8256	6880			338	286	3.00	9.00
05:14:19	AIR	AIR	AIR	AIR	AIR	71.19	75.06	92.63	86.13			98.25	96.38	8272	6896	74.88	79.88	338	286	3.00	9.00
05:14:20	AIR	AIR	AIR	AIR	AIR	71.19	75.06	92.63	86.25			98.38	96.38	8288	6912			338	286	3.00	9.00
05:14:21	AIR	AIR	AIR	AIR	AIR	71.19	75.06	92.63	86.25			98.25	96.38	8304	6928			336	286	3.00	9.00

图2 地面起飞加速阶段

这里的 regulator 是用来表征发动机推力管理的参数，各数字代表的含义如下图所示。在接通自动油门的情况下，由 FMC 计算每个飞行阶段的 N1 目标值，并通过 DEU 传送给 EEC。在起飞爬升阶段，A/T 同时使用 EEC TRA 目标和 FMC N1 目标来设定推力，即通过控制 FMV 的开度来实现推力的设定。此时由于右发 N1 无法加速达到目标值，EEC 只能将 FMV 的开度开得更大（9 对应着加速的上限）。因此，可推断 EEC 的控制，以及 HMU 内 FMV 的作动都不存在问题。

Reg.	Fuel Control Mode
0	Undefined
1	N1 Climb Limit
2	Min. PS3 Limit
3	N1/N2 Speed Control
4	Max. N2 Speed Limit
5	Max. PS3 Limit
6	Wf Decel Rate Limit
7	Wf Accel Rate Limit
8	WF/PS3 Min Decel Limit
9	WF/PS3 Topping Accel Limit
10	Min. WF limit 300 lbs/hr
11	Max. WF limit
12	N1/N2 Over speed limit
13	dFMV/dt Min. Limit
14	dFMV/dt Max. Limit
15	N2 Rate Accel Limit Fast as allowable
16	N2 Rate Decel Limit Fast as allowable

图3 FMV controlling regulator definition

接近巡航高度，机组收油门后，双发的 N1/N2/FF 恢复一致，右发的 regulator 也回到了 3。但能明显看到，此时右发 TRA 和 FMV 的角度是均偏大于左发的。

11/06/2021	AIR_GROUND			ENG1TLA	ENG2TLA	ENG1N1	ENG2N1	ENG1N1GT	ENG2N1GT	ENG2N2	ENG1N2	ENG1FF	ENG2FF	FMW_POS_SL_1	FMW_POS_SL_2	PS3_SEL_1	PS3_SEL_2	CNTRL_REG_1	CNTRL_REG_2
Time				(deg)	(deg)	(%)	(%)	(rpm)	(rpm)	(%)	(%)	(R/R)	(R/R)			(g/s)	(g/s)		
05:22:48	AIR	AIR	AIR	71.89	72.95	97.13	94.50			97.25	98.13	6144	5792			252	230	3.00	9.00
05:22:49	AIR	AIR	AIR	71.89	72.95	97.13	94.50			97.38	98.13	6144	5776			250	230	3.00	9.00
05:22:50	AIR	AIR	AIR	71.89	72.95	97.13	94.63	97.13	97.13	97.38	98.13	6144	5792			250	230	3.00	9.00
05:22:51	AIR	AIR	AIR	71.89	69.43	97.13	94.63			97.38	98.13	6128	5792	62.13	70.38	250	230	3.00	9.00
05:22:52	AIR	AIR	AIR	71.89	67.32	97.13	94.13			98.00	98.13	6128	5760			250	228	3.00	9.00
05:22:53	AIR	AIR	AIR	71.89	65.21	97.13	94.13			99.25	98.13	6128	5760			250	228	3.00	6.00
05:22:54	AIR	AIR	AIR	71.89	65.21	97.13	91.63	97.13	97.13	97.88	98.25	6128	5232			250	210	3.00	3.00
05:22:55	AIR	AIR	AIR	71.89	65.21	97.13	90.63			97.38	98.25	6128	4880	62.00	54.25	250	206	3.00	3.00
05:22:56	AIR	AIR	AIR	71.89	65.21	97.13	90.13			97.25	98.25	6128	4832			248	204	3.00	3.00
05:22:57	AIR	AIR	AIR	71.89	65.21	97.13	89.88			97.13	98.13	6112	4800			250	204	3.00	3.00
05:22:58	AIR	AIR	AIR	71.89	65.21	97.25	89.88	97.25	97.25	97.13	98.25	6112	4784			250	202	3.00	3.00
05:22:59	AIR	AIR	AIR	71.89	65.21	97.25	89.75			97.00	98.25	6096	4784	62.00	53.75	248	202	3.00	3.00
05:23:00	AIR	AIR	AIR	71.89	65.21	97.13	89.75			97.00	98.25	6096	4784			248	202	3.00	3.00
05:23:01	AIR	AIR	AIR	67.15	65.21	96.63	89.75			97.00	97.63	6032	4784			248	202	3.00	3.00
05:23:02	AIR	AIR	AIR	64.51	65.21	90.50	89.75	97.25	97.25	97.00	96.38	4832	4784			218	202	6.00	3.00
05:23:03	AIR	AIR	AIR	64.51	65.21	89.50	89.75			97.00	97.38	4640	4768	50.75	53.63	202	202	3.00	3.00
05:23:04	AIR	AIR	AIR	64.69	65.21	89.25	89.75			97.00	97.38	4560	4768			202	202	3.00	3.00
05:23:05	AIR	AIR	AIR	64.69	65.21	89.00	89.75			97.00	97.25	4512	4784			202	202	3.00	3.00
05:23:06	AIR	AIR	AIR	64.69	65.21	89.00	89.88	97.25	97.25	97.13	97.13	4512	4784			200	202	3.00	3.00
05:23:07	AIR	AIR	AIR	64.69	65.21	88.88	89.75			97.13	97.00	4512	4800	50.63	53.75	202	202	3.00	3.00
05:23:08	AIR	AIR	AIR	64.69	64.63	88.88	89.75			97.00	97.00	4512	4784			202	202	3.00	3.00
05:23:09	AIR	AIR	AIR	61.52	61.52	88.88	87.13			95.50	96.88	4528	4400			202	184	3.00	16.00
05:23:10	AIR	AIR	AIR	61.52	61.52	85.13	84.75	97.38	97.38	94.88	94.88	3840	3856			186	176	16.00	3.00
05:23:11	AIR	AIR	AIR	61.52	61.52	84.50	84.63			95.00	94.75	3808	3936	44.88	46.88	178	176	3.00	3.00
05:23:12	AIR	AIR	AIR	61.35	61.52	84.25	84.63			95.00	94.75	3792	3920			178	176	3.00	3.00
05:23:13	AIR	AIR	AIR	61.17	61.52	84.00	84.63			95.00	94.50	3760	3904			176	174	3.00	3.00
05:23:14	AIR	AIR	AIR	61.17	61.52	83.88	84.50	97.38	97.38	95.00	94.50	3744	3904			176	174	3.00	3.00
05:23:15	AIR	AIR	AIR	61.17	61.52	83.88	84.50			95.00	94.50	3744	3904	44.38	46.75	176	174	3.00	3.00
05:23:16	AIR	AIR	AIR	61.17	61.52	83.88	84.50			95.00	94.50	3760	3904			176	174	3.00	3.00
05:23:17	AIR	AIR	AIR	61.17	61.70	83.88	84.50			95.00	94.50	3760	3920			174	174	3.00	3.00
05:23:18	AIR	AIR	AIR	61.17	61.70	83.88	84.50	97.38	97.38	95.00	94.50	3776	3920			176	174	3.00	3.00
05:23:19	AIR	AIR	AIR	61.17	61.70	84.00	84.50			95.00	94.50	3776	3920	44.63	46.75	174	174	3.00	3.00
05:23:20	AIR	AIR	AIR	61.17	62.05	84.00	84.75			95.13	94.63	3776	3936			176	176	3.00	3.00
05:23:21	AIR	AIR	AIR	61.70	62.58	84.00	85.38			95.50	94.63	3776	4064			176	180	3.00	3.00
05:23:22	AIR	AIR	AIR	62.23	62.75	84.88	86.00	97.38	97.38	95.88	95.13	3936	4176			178	182	3.00	3.00
05:23:23	AIR	AIR	AIR	62.58	63.11	85.63	86.50			96.00	95.50	4048	4224	47.50	49.63	182	184	3.00	3.00

图4 空中巡航阶段

结合故障现象及上述译码数据，分析故障原因是在高功率时由于右发供油不足导致右发N1无法达到目标转速，造成双发推力不一致，而在较低的功率时，由于不需要太多的燃油供给，双发推力可保持一致。在检查中人工转动N2时发现MFP 低压叶轮泵不随动，初步怀疑低压轴出现了剪切。由于低压轴位于MFP 主驱动轴的后部，所以它的剪切并不影响高压齿轮泵的工作。但低压轴剪切后，影响了泵的整体供油效能，将会导致高功率时推力无法到达N1 目标值。



图5 MFP 低压叶轮疑似损伤

查阅CFM的WTT材料，世界机队上也曾出现过此类事件，其典型的故障特征就是在起飞爬升阶段N1无法到达目标值。CFM厂家认为是燃油泵缺少润滑导致的，往往会在更换HMU或MFP后出现，主要原因可能是更换部件后空气进入燃油系统，在随后的试车时未先提杆给MFP润滑，在腔内燃油不足的情况下直接运转发动机会导致MFP干磨、过热，进而造成驱动轴剪切。此外，还有5起案例是在翼梁活门失效在关位后导致的。

Engine Motoring without Boost Pump Pressure



10 TOA & 4 Interruptions/Delays in 2018

- Typically results in failure to achieve commanded power (TO, climb)
- Fuel Pump impeller shaft found broken/sheared
 - Engine unable to achieve N1 Target during TO
 - Throttle split

Pump rotation without fuel as lubricant

- During fuel system maintenance fuel in pump replaced by air
 - HMU or Fuel Pump replacement
 - Engine installation on wing or in test cell
 - Aircraft maintenance (Spar Valve)
- Failed start with spar valve closed
 - New observation in 2018
 - 5 events reported



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Engine Motoring without Boost Pump Pressure



What happens within Fuel Pump when it runs dry?

Impeller: rotor stator contact



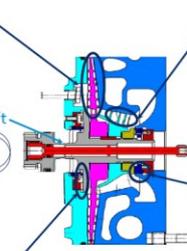
Rubbing marks

Inducer: rotor stator contact



Rubbing marks

Impeller shaft shear neck



Thrust bearing: overheating

Thrust bearing: contact with impeller shaft



Dry film worn



O'ring melted

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图 7 WTT 材料

手册也体现了相关的要求，燃油泵和 HMU 的 AMM 拆装手册中加入了 CAUTION 提醒。

I. Fuel Pump Package Installation Test SUBTASK 73-11-11-720-001-F00

CAUTION: DO NOT MOTOR THE ENGINE BEFORE VERIFYING THAT THE FUEL SPAR VALVE IS IN THE OPEN POSITION AND FUEL BOOST PUMP PRESSURE IS APPLIED TO THE FUEL PUMP INLET. THE FUEL PUMP AND THE HYDRO MECHANICAL UNIT ARE FUEL LUBRICATED, ZERO FUEL PRESSURE CAN CAUSE DAMAGE TO THE FUEL PUMP AND THE HYDRO MECHANICAL UNIT.

三) 工程政策

- 1, 73N-73-010-01/02 每 FH 2500 更换发动机的燃油滤。
- 2, 针对燃油泵旁通活门保持卡环的主动升级改装 SB73-0221/SB73-0225, 航控机队已全部完成。

四、小结

该机双发推力不一致故障，是由于右发 MFP 故障导致供油效能下降，无法达到目标供油。在排故上受制于经验，走了不少弯路。核心围绕高功率推力无法达到，从气路和油路两方面进行检查，最终找到的根源所在。