

Supplementary

Table S1. Complete configuration parameters for all 38 manufacturing processes.

Process Name	Type	Quality Parameters (Base Yield/Std Dev/Rework Rate)	Cost Parameters (Equipment/Labor/Energy) [CNY/h]	Maintenance (Interval/Duration)	Buffer Capacity	Logistics Distance
Electrode Preparation Stage						
Gravure Stirring	ELECTRODE_P REP	0.992/0.006/0	3200/32/620	24h/30min	2524	18m
Gravure Coating	ELECTRODE_P REP	0.993/0.008/0	4200/32/680	24h/30min	2964	25m
Ceramic Stirring	ELECTRODE_P REP	0.991/0.007/0	3100/32/580	24h/30min	2282	15m
Cathode Stirring	ELECTRODE_P REP	0.990/0.008/0	3800/32/650	24h/30min	2132	22m
Cathode Coating	ELECTRODE_P REP	0.993/0.007/0	4200/32/680	24h/30min	2982	28m
Cathode Rolling & Pre-slit	ELECTRODE_P REP	0.991/0.006/0.82	2800/32/420	24h/30min	3304	12m
Cathode Die Cutting & Slitting	ELECTRODE_P REP	0.989/0.007/0.85	2600/32/380	16h/25min	2416	15m
Anode Stirring	ELECTRODE_P REP	0.991/0.007/0	3800/32/650	24h/30min	2086	20m
Anode Coating	ELECTRODE_P REP	0.995/0.006/0	4200/32/680	24h/30min	3784	25m
Anode Rolling & Pre-slit	ELECTRODE_P REP	0.992/0.006/0.83	2800/32/420	24h/30min	3012	12m
Anode Die Cutting & Slitting	ELECTRODE_P REP	0.990/0.007/0.86	2600/32/380	16h/25min	2310	15m
Cell Assembly Stage						
Winding	CELL_ASSEMBLY	0.950/0.012/0.94	3800/45/480	8h/20min	2346	32m

Process Name	Type	Quality Parameters (Base Yield/Std Dev/Rework Rate)	Cost Parameters (Equipment/Labor/Energy) [CNY/h]	Maintenance (Interval/Duration)	Buffer Capacity	Logistics Distance
Preheating	CELL_ASSEMBLY	0.986/0.008/0.92	2200/32/580	12h/20min	2362	8m
Hot Pressing	CELL_ASSEMBLY	0.988/0.007/0.90	2400/32/620	8h/20min	2292	10m
X-ray	CELL_ASSEMBLY	0.992/0.005/0	3200/45/280	12h/30min	2300	15m
Matching	CELL_ASSEMBLY	0.995/0.003/0	1800/32/180	24h/20min	2192	8m
Ultrasonic Welding	CELL_ASSEMBLY	0.985/0.008/0.75	2600/45/380	8h/25min	2174	12m
Tab Welding	CELL_ASSEMBLY	0.985/0.008/0.72	2600/45/380	8h/25min	2174	12m
Mylar Wrapping	CELL_ASSEMBLY	0.988/0.006/0.95	1800/32/220	16h/20min	2218	10m
Case Pre-welding	CELL_ASSEMBLY	0.987/0.007/0.78	2400/45/360	8h/25min	2174	15m
Top Cap Laser Welding	CELL_ASSEMBLY	0.985/0.008/0.76	3200/45/420	8h/25min	2174	18m
Formation & Aging Stage						
1st Helium Test	FORMATION	0.992/0.004/0	2800/45/280	12h/30min	2366	12m
Vacuum Baking	FORMATION	0.995/0.003/0	3400/32/2200	24h/40min	2468	45m
1st Electrolyte Injection	FORMATION	0.988/0.006/0	2600/45/380	8h/25min	2178	15m
High Temp Soaking	FORMATION	0.994/0.004/0	3600/32/2400	24h/40min	2064	42m
Formation	FORMATION	0.996/0.003/1.00	5600/52/2400	24h/40min	2248	38m
High Temp Aging	FORMATION	0.998/0.002/0	4200/32/2200	24h/40min	2044	40m

Process Name	Type	Quality Parameters (Base Yield/Std Dev/Rework Rate)	Cost Parameters (Equipment/Labor/Energy) [CNY/h]	Maintenance (Interval/Duration)	Buffer Capacity	Logistics Distance
2nd Electrolyte Injection	FORMATION	0.990/0.005/0	2600/45/380	8h/25min	2270	15m
Sealing Tab Laser Welding	FORMATION	0.988/0.006/0.82	3200/45/420	8h/25min	2344	18m
Packaging & Inspection Stage						
2nd Helium Test	PACKAGING	0.992/0.004/0	2800/45/280	12h/30min	2276	12m
Capacity Testing	PACKAGING	0.997/0.002/0	4800/45/580	24h/40min	2088	35m
DCR Testing	PACKAGING	0.995/0.003/0	3200/45/420	16h/30min	2254	22m
OCV1/IMP1	PACKAGING	0.996/0.002/0	2800/45/380	16h/30min	2178	20m
OCV2/IMP2	PACKAGING	0.996/0.002/0	2800/45/380	16h/30min	2178	20m
Wrapping	PACKAGING	0.965/0.012/0.971	1800/32/220	12h/20min	2072	15m
Sorting	PACKAGING	0.999/0.001/0	1600/45/180			

Notes:

- Cost parameter units: Equipment Cost (CNY/hour), Labor Cost (CNY/hour), Energy Cost (CNY/hour)
- Buffer capacity is calculated based on two hours of process throughput
- Maintenance parameters refer to the interval and duration of regular equipment maintenance
- Logistics distance refers to the actual distance to the next process; Sorting is the final step, so no distance is given
- Standard deviation in quality parameters reflects the natural fluctuation of process parameters
- A rework rate of 0 indicates that the process does not support rework