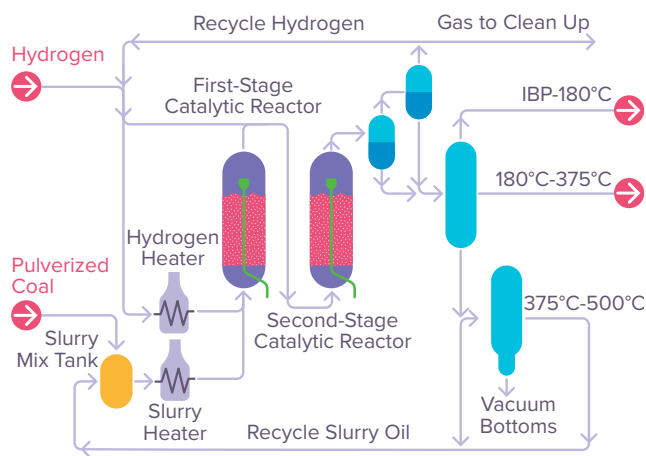


The H-Coal[®] Process was originally developed in the 1970s and has been demonstrated on more than 30 types of coal in bench-scale pilot plants and in continuous Process Development Units (PDUs) where up to 15 barrels of clean fuels were produced daily. In the 1980s, the process was scaled up to 200 TPD at the Catlettsburg, Kentucky H-Coal[®] demonstration plant.

H-Coal[®]_{TS}: the next step

The need for improved yield and selectivity have led to the catalytic, two-stage coal liquefaction process (H-Coal[®]_{TS}), which yields up to five barrels of oil per ton of coal on a moisture-free basis. The two-stage process enables optimizing the operating conditions in each reactor, promoting hydrogenation reactions in the first stage at lower temperature, and hydrocracking reaction in the second stage at higher temperature.

Pulverized coal and recycle oil are mixed to provide the coal slurry feed to the process.



↑ Figure 4: H-Coal[®]_{TS} flow scheme

The coal slurry is pumped to reaction pressure, preheated, mixed with hydrogen, then fed to the first-stage ebullated-bed reactor where the coal is partially converted and the recycle oil is hydrogenated. The higher temperature second stage allows the hydrogen transfer to complete the conversion of the coal to distillates products, which are recovered by flash separation and distillation. The ash and any unconverted coal are removed at the bottom of the vacuum tower.

YIELDS, WT% MOISTURE & ASH FREE (MAF)	H-COAL [®]	H-Coal [®] _{TS}
C ₁ -C ₃	11.3	8.6
C ₄ -525°C	51.0	77.9
Process Performance, wt% MAF		
Coal Conversion	93.7	96.8
Hydrogen Consumption	6.1	7.3
C ₄ -525°C (Barrels per Ton)	3.3	5.0

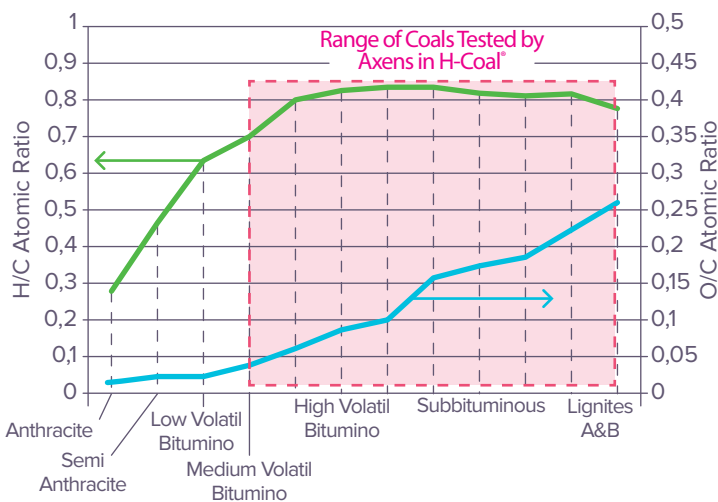
↑ Table 1: H-Coal[®] and H-Coal[®]_{TS} process performances

The H-Coal[®]_{TS} reactor system is superior to other thermal or slurry based catalyst systems currently under evaluation. The ebullated-bed reactor provides:

- Increased catalyst activity due to the greater concentration of catalytic reaction sites
 - Proven technology for catalyst addition and withdrawal, allowing used catalyst to be easily separated from the liquefaction reactor products
 - Proven technology for catalyst reuse through reclamation, regeneration or rejuvenation
 - Stable, high quality liquid products which can be upgraded to finished gasoline and diesel fuel
 - Simple flow scheme leading to high unit on-stream time
- With Axens extensive experience in refining, Axens can optimize the liquefied product upgrading scheme to improve products quality and adapt product yields for maximizing gasoline, diesel or aromatics. Moreover, the environmental footprint of the liquefaction unit can be reduced using carbon capture and sequestration. Up to 80% of the CO₂ can be captured.

Feedstock flexibility

A wide range of coal feeds from high-rank bituminous through lignite have been tested in the pilot units and can be processed in the H-Coal[®] Process.



↑ Figure 5: Coals tested in H-Coal[®]