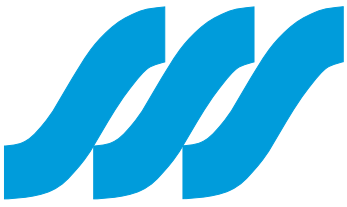
SSS CLUTCH
Key to combined cycle flexibility



Tapada do Outeiro, Portugal

SSS Clutch: key to combined cycle flexibility

Thirty years of experience in Europe has shown the combined cycle to be a highly efficient and reliable generating system with the flexibility of operation to work at all levels of utility operations from base load to mid load, to peaking duty.

Over thirty years ago SSS also installed their first clutches in utility gas turbine packages to enable them to provide synchronous compensation at off peak times in long, lightly loaded transmission networks.

Development since then has taken the combined cycle up to almost 60% efficiency with a single-shaft arrangement of gas turbine, generator and steam turbine to form a block of typically 350 MW capacity. With this has come a new market for the SSS clutch in power generation.

In a single-shaft combined cycle block the gas turbine, generator and steam turbine are all on one shaft, but they are not always required to operate at the same time. Unless the steam turbine can be separated from the gas-turbine and generator it is always rotating with it, regardless of whether or not there is steam available.

There are two single-shaft design concepts. Either the generator is mounted on the end of the line, or in the middle, in which case a clutch must be placed between the steam turbine and the generator. SSS has supplied clutches for all of the single-shaft combined cycle blocks built by Siemens and ABB whose design concepts both use a centrally-mounted generator. There are several advantages in this arrangement.

First. Since the steam turbine is not coupled to the gas turbine the GT output torque is not transmitted through the steam turbine shaft to the generator. Therefore, some of the bearings are smaller because they do not carry the combined load of both the gas turbine and steam turbine as is the case with an end-mounted generator.

Second. As the gas turbine runs up, the steam turbine is held on turning gear and only starts to accelerate when steam is available from the HRSG. Only when the steam turbine has reached synchronous speed does the clutch engage whereupon loading commences. There is no need for an auxiliary package boiler to provide steam for gland sealing and condenser evacuation.

Third. When the plant is shut down the steam turbine takes longer to cool down by several days than the gas turbine. By separating the steam turbine the gas turbine can be stopped earlier, so saving considerable time at maintenance outages since the gas turbine can be opened up and work started while the steam turbine is still cooling down and turning on barring gear.

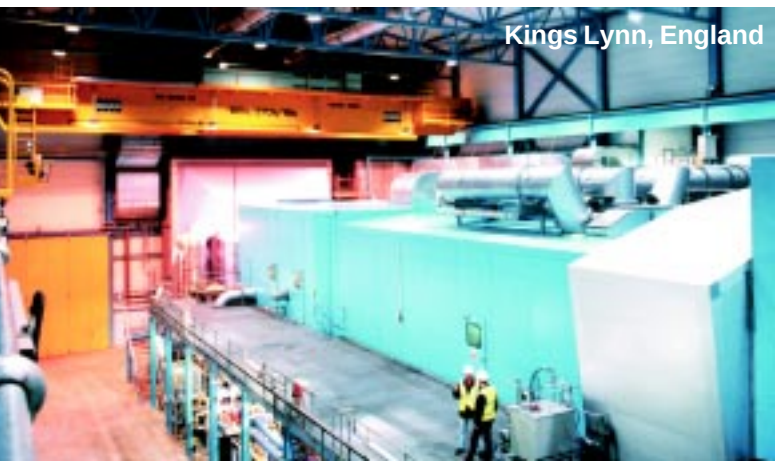
Fourth. At commissioning the steam turbine does not have to be ready in order for the gas turbine and HRSG to be commissioned. As in a multi-shaft arrangement, the erection of the steam turbine can be completed in isolation, protected by the open clutch. Steam raised during commissioning of the gas turbine and HRSG can be dumped straight into the condenser.

Generally a single-shaft combined cycle has a common lube-oil system for the full power train, including the SSS clutch, which is mounted between the steam turbine and generator bearing pedestals. Oil leaves adjacent bearings axially along the shaft and enters the clutch from either end. It then flows centrifugally out and is discharged back into the main lube-oil reservoir.

The basic SSS clutch is an automatic freewheel, but unlike a normal freewheel transmits the load through teeth acting like splines with very high normal and overload torque capacity. Furthermore, it can overrun with the output at full speed and the input at rest for the life of the plant if necessary.

When the steam turbine accelerates to the same speed as the generator, the external clutch teeth are precisely aligned with the internal tooth spaces by means of a pawl and ratchet mechanism and are automatically engaged by shifting along helical splines. The pawls only transmit a small force to initiate tooth engagement, but turbine torque is only transmitted through the fully engaged teeth when the pawls are unloaded. As soon as the turbine speed slows relative to the generator the clutch teeth automatically start to disengage. The clutch includes a powerful double-acting oil dashpot to slow engagement and disengagement.

For larger powers the pawls first move a small relay clutch into tooth engagement which in turn moves a larger clutch into engagement. All SSS clutches for the larger combined cycles are of this type.



Kings Lynn, England

SSS Gears made their first clutch before 1950 and up to the end of 1999 will have supplied over 11000 units. One of the largest applications has been in the drive trains of gas turbine powered warships of 29 Navies.
After first a British grid blackout, and then the 1964 North-east America power blackout, which extended over two countries and covered an area from Toronto to New York City, there emerged a market for aero-derivative gas turbine packages to serve as peaking units. Boston Edison in the United States, and utilities in Canada and Europe saw that by incorporating a clutch to separate it from the gas turbine, the generator could be used as a synchronous condenser for reactive compensation outside of peak hours. Many of these units rated in the range of 20 to 70 MW are still in service.
But other applications produced the requirement for much larger clutches. The Huntorf air-storage scheme in northern Germany, boasts the largest clutch so far made. The plant, based on the ABB Type 13D can be likened to a giant sequential combustion gas turbine with a generator positioned between the turbine and compressor stages. It was designed to store compressed air at off-peak times in an underground cavern to be discharged back through the turbine section to generate power at peak times. There are therefore two clutches: a 300 MW unit between the turbine and generator, and an 80 MW unit between generator and compressor. During compression, the turbine side clutch is open and the generator, acting as a motor, drives the compressor to charge the cavern. During generation the turbine clutch is closed to drive the generator, and the clutch on the compressor side is open. The plant went into operation in 1979 and has experienced thousands of clutch engagements without any problems.

Power Plants in service with SSS Clutches
All SSS clutches in combined cycle plants with gas turbines over 200 MW are in ABB and Siemens power trains because they have centrally mounted generators.

Kings Lynn, England
Owned by Anglian Power Generators, the plant is situated about 200 km north of London near the town of Kings Lynn and consists of a single-shaft block of Siemens Model V94.3 and a 120 MW steam turbine Total block rating at 15°C is 335 MW on gas. The plant has been in full commercial operation since December 1997.

Tapada do Outeiro, Portugal
Situated in northern Portugal, on the Douro River, east of Oporto this is the first combined cycle plant in Portugal and comprises three single-shaft blocks of the 255 MW Siemens Model V94.3A. It is the definitive single shaft block arrangement for this gas turbine. The clutch is placed between the steam turbine, which is rated 85 MW, and the generator. It was used during commissioning so that the gas turbine and HRSG could be tested while work continued to complete the steam turbine. The first block went into operation in June 1998 and the second in September of that year with the third unit scheduled for completion in May 1999.

Taranaki, New Zealand
Reorganization of the electricity supply system in New Zealand led to Stratford Power being formed to build a combined cycle near New Plymouth, on the North Island. The contract was awarded to ABB in 1995 as the first


Taranaki, New Zealand

example of a single-shaft combined cycle block with their GT26 gas turbine at its initial rating of 251 MW. Total block capacity is 356 MW. The plant went into operation at the end of 1997 with the steam turbine, generator and clutch sized for the final gas turbine rating of 265 MW which will be achieved at the scheduled maintenance outage in the second quarter of 2000.

Otahuhu, New Zealand
The second combined cycle to be ordered in New Zealand is owned by Contact Energy and is located in the southern suburbs of Auckland alongside an old simple cycle gas turbine station. It consists of a single shaft block of Siemens Model V94.3A rated 357 MW and it went into operation in early 1999.
At the original Otahuhu power station, completed in 1969, the four gas turbines were fitted with clutches at the outset because it was designed as a peaking plant at the end of a long transmission network bringing base load hydro power from the South Island. Today the plant operates mainly as a synchronous condenser

Agawam, Massachusets, USA
Currently under construction with commercial operation planned for the end of 1999, the plant is owned by Berkshire Power, a New England IPP group who plan to run it as a merchant plant in the deregulated electricity supply system of the Northeastern USA. It is the first SSS Clutch applied to an ABB single-shaft block using the 184 MW GT24 gas turbine in the 60 Hz market.

Santa Rita, Philippines
This oil-fired combined cycle plant will be the largest in the Phillipines when it is completed in 2000. It consists of four single-shaft blocks of Siemens Model V84.3A, each rated 220 MW, with the first block due in service at the end of 1999. This is the first application outside North America of the SSS Clutch in association with Siemens largest 60 Hz gas turbine.


Agawam, Massachusets, USA

Combined cycle reference list

Clutch ratings of 100 MW and above*

Customer	*Site*	*Country*	*GT Type*		*Clutch Rating*		*Plant*
					MW	*rev/min*	*MW*
Anglian Power Generators	Kings Lynn	England	Siemens	V94.3	150	3000	1 x 338
Turbogaz SA	Tapada do Outeiro	Portugal	Siemens	V94.3A	150	3000	3 x 330
Stratford Power	Taranaki	New Zealand	ABB	GT26	152	3000	1 x 325
Contact Energy	Otahuhu	New Zealand	Siemens	V94.3A	150	3000	1 x 330
National Power Corporation	Santa Rita	Philippines	Siemens	V84.3A	100	3600	4 x 220
Associated Electric Cooperative	St Francis	USA	Siemens	V84.3A	100	3600	2 x 220
Power Gen	Cottam	England	Siemens	V94.3A	194	3000	1 x 330
CFE	Monterrey	Mexico	ABB	GT24	105	3600	2 x 240
Berkshire Power	Agawam, MA	USA	ABB	GT24	105	3600	1 x 240
Electroandina	Tocopilla	Chile	ABB	GT26	152	3000	1 x 330
Enfield Energy Centre	Enfield	England	ABB	GT26	152	3000	1 x 330
American National Power	Midlothian, TX	USA	ABB	GT24	105	3600	4 x 240
Pt PLN	Batam	Indonesia	Siemens	V94.3A	150	3000	1 x 330
Island Cogeneration	Victoria, BC	Canada	ABB	GT24	105	3600	1 x 240
Scottish Power	Shoreham	England	ABB	GT26	152	3000	1 x 330

*In addition, 94 SSS clutches of less than 100 MW rating have been ordered for single-shaft combined cycle plant.

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