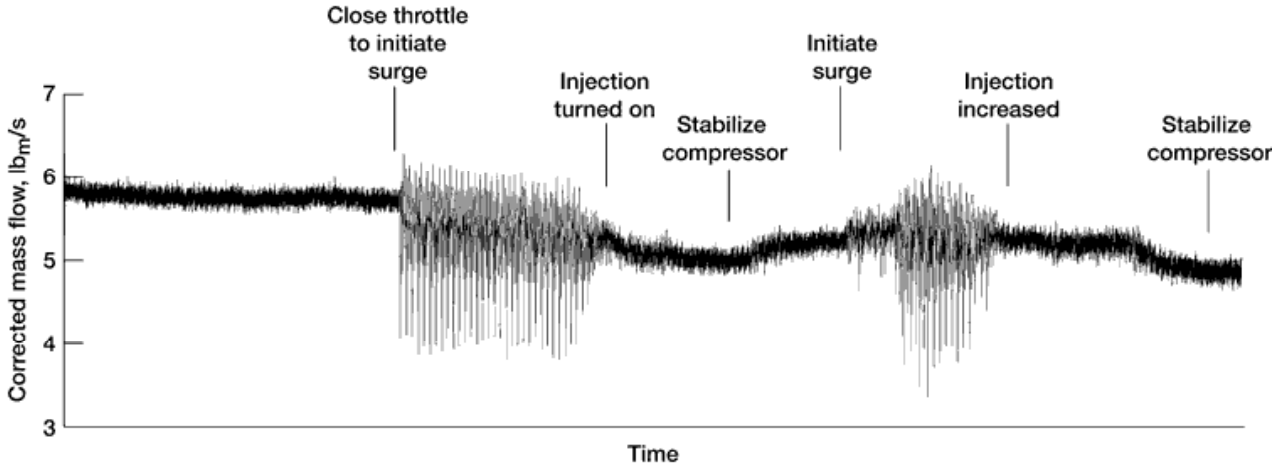
Centrifugal Compressor Surge Controlled



Controlling surge in a 4:1 pressure ratio centrifugal compressor operating at 80-percent of design speed.

The figure shows the variation in compressor mass flow with time as the mass flow is throttled to drive the compressor into surge. Surge begins where wide variations in mass flow occur. Air injection is then turned on to bring about a recovery from the initial surge condition and stabilize the compressor. The throttle is closed further until surge is again initiated. Air injection is increased to again recover from the surge condition and stabilize the compressor.

increased to again recover from the surge condition and stabilize the compressor.Compressor surge is a condition affecting both aerospace and industrial compression systems that employ turbomachinery. Surge is an unstable operating condition that can lead to the loss of an aircraft in aerospace applications and cause severe damage to industrial systems. Most compressors have a stability limit that is defined by a minimum flow rate on a pressure-rise-versus-flow-rate characteristic curve. Surge margin refers to a margin of safety between the normal operating point of the compressor and the stability limit. Events, both external and internal to the compression system, will occasionally move compressor operation to a point that is beyond its stability limit, causing a surge condition. Technology that increases the stable operating range of the compressor or provides a means to recover from surge will improve the safety and performance of turbomachinery-based compression systems.

Air injection has been demonstrated to improve centrifugal compressor stability at the NASA Glenn Research Center. In earlier work, air was injected through the hub surface of the vaned diffuser in a 4:1 pressure ratio centrifugal compressor to provide a 14-percent improvement in surge margin. Currently, the technology has been applied to the shroud surface of the diffuser and greater improvements have been achieved. The ability to

recover from surge has also been demonstrated.

Air was injected into the diffuser through the shroud surface of the flow path between the impeller trailing edge and the leading edge of the diffuser vanes. Eight injector nozzles were positioned quasi-uniformly about the circumference of the diffuser. The nozzle flow path and discharge shape were designed to produce a jet that remained attached to the surface as it traveled into the diffuser passage. Several orientations of the injected airstream and variations in the number of active nozzles were tested. Range improvements were demonstrated both when an external source was used for the injected air and when an internal source was used that took injection air from the compressor flow path.

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