SCROLL MATCHING

By Joseph Cruickshank, PhD

"Scroll matching" is a term that is often encountered in the field of centrifugal compressor design and applications. There is very often a mystery surrounding it because unlike other centrifugal compressor terms such as "impeller tip Mach number", "impeller diameter" or "surge flow", the component terms of the word "scroll matching" do not provide any intuitive explanation as to what the term could possibly mean no matter how well-versed in the use of the English language one is or how broad a background in the general field of mechanical engineering one might have. An obvious and quite legitimate question I have encountered is: "The scroll is being matched to what?" to which there can be no simple answer for the non-aerodynamicist. This is due in part to the fact that scroll matching is a made-up term and is based on a calculation using parameters that are not physically observable or obvious to most people unless they happen to be deeply involved in the aerodynamic analysis of centrifugal compressors.

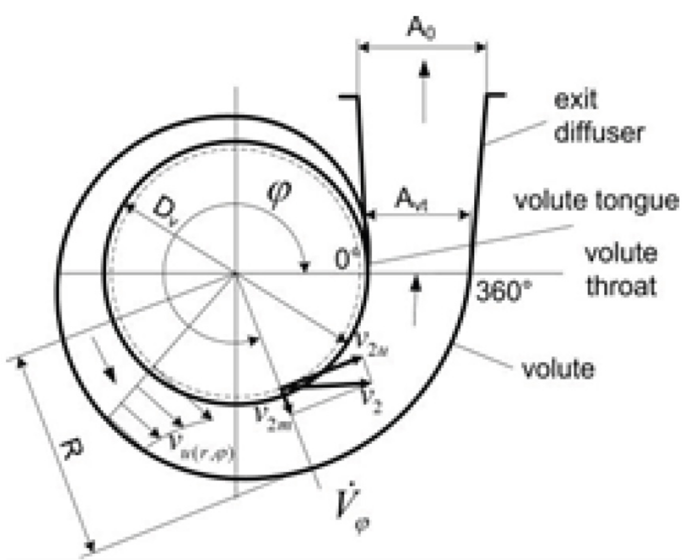

Figure 1: Typical cross section of a scroll or volute

Because of its relatively mysterious nature, I find that the concept of "scroll matching" is best explained using a concept with which we are all familiar: the flow of traffic from an on-ramp on to the freeway. Imagine a driver going on to the freeway. He has several choices as to how to merge with the traffic on the freeway. If he is a teenager driving a Mustang GT 5.0, chances are he will be merging at speeds far in excess of the average speed of the cars on the freeway. His entrance on to the freeway will be quite dramatic and highly disruptive as he hits his brakes to prevent crashing into the back of the "slow pokes" in the right lanes. This will have a ripple effect on all the traffic behind him as other drivers also hit their brakes to avoid crashing into him or the drivers behind him. Clearly this will result in inefficiencies in the flow of traffic on the freeway. At the other extreme we have the nervous and inexperienced driver, also merging on to the freeway, but at speeds well below that of the freeway traffic. Here again, his entrance will also be disruptive of traffic and will result in similar inefficiencies in the overall traffic flow.

Clearly the most efficient means of merging traffic from the on-ramp with traffic on the freeway is if the two speeds are reasonably well-matched.

The analogy with scroll matching follows from how the gas coming off the tip of the diffuser wall gets into the scroll. The tangential component of the absolute gas velocity at the diffuser exit is what drives the gas into the scroll or volute. This velocity may be thought of as the on-ramp velocity. At the same time the gas already in the scroll is heading in the same direction as this tangential velocity and the two are forced to merge. The scroll (volute) will experience inefficiencies if these two velocities are not well-matched similar to the freeway traffic.

The scroll matching parameter is generally defined as (approximately) the ratio of the average velocity in the scroll (based on the volume flow rate and scroll area just before the gas is discharged into the exit nozzle) and the gas tangential velocity at diffuser exit, all at design conditions. This means that an oversized scroll will have relatively lower scroll velocities (called under-loading) compared to the diffuser tangential velocity and the scroll matching will be less than 1.0. The opposite (over-loading) will be true for an undersized scroll and the scroll matching (again at design point) will be greater than 1.0.

There are similar disruptive effects from this over-loading or under-loading of the scroll and just as with our freeway analogy they result in inefficiencies in the performance of the scroll. This is why the scroll matching parameter is key in the assessment of compressor overall performance.

The scroll matching parameter is also very important in assessing the rerate possibilities of existing compressors. Most of the time, it is assumed during rerates that the scroll is not to be changed or modified in any way, therefore asking for an increase or decrease in the flow in an existing compressor will affect the direction (negatively or positively) of the scroll matching parameter and hence the predicted efficiency of the compressor. An originally over-loaded scroll will result in increased losses if a flow increase is desired (all other things being equal) and vice-versa for an under-loaded scroll.

When purchasing a compressor from an OEM, it is advisable that future rerate considerations should be taken into account, if possible, in discussing the scroll or volute employed in the unit under consideration to ensure optimal performance in the future when the inevitable rerate is undertaken.

For more information:
Email: RMS@rotatingmachinery.com
Tel: 484-821-0702

Headquarters
2760 Baglyos Cir.
Bethlehem, PA 18020

Houston Office
16676 Northchase Dr., Ste 400
Houston, TX 77060

Rotating Machinery Services, Inc.

rotatingmachinery.com
Tel: 484-821-0702
Parts: rms@rotatingmachinery.com