Synchronous Alternators
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A sustainable energy policy, based on renewable resources, will be crucial to the future and for coming generations. Hydropower is one of the front-runners among such renewable energies.

As a leading supplier of technology and equipment for small and medium sized hydropower plants, WKV has decided to make a significant contribution to such a sustainable future.

This basic philosophy is to be found throughout the complete production range of the WKV AG:

- The entire energy needed for the production process is generated in the in-house hydro power plant,
- Room heating is done by heat pumps utilizing even the exhaust heat of the test field,
- roof greening and solar collectors have a share in environmentally responsible air conditioning.

As a medium size enterprise, our main focus is only Germany as the location for factories in view of our social responsibility and obligation towards the country and future generations. Last but not least, a great portion of our success comes from our highly motivated, dedicated, devoted and committed work force receiving consistent advance training, education and up-dating in their respective fields in order to render a reliable and persistent service to our customers.

We are only caretakers of the world and its resources that we pass on to our children.

(WKV’s company slogan)
Background
Why WKV Alternators provide a better solution
The basics are unchangeable. The physical laws are permanent. So, it’s vital always to make the best out of them!

A highly skilled and talented team of engineers, designers and technicians at WKV AG is marching towards efficient and innovative solutions. Besides optimizing the alternators magnetically and electro-dynamically, our main focus is to provide a perfect fit to the requirements of our customers in terms of electrical and mechanical characteristics.

When taking your choice for alternators for hydro power and other prime movers, trust on the expertise and innovation of specialists – trust on WKV!

Sophisticated production technology and the know how of our work force guarantee highest quality products and reliably on-time delivery. We are combining most modern production technology with solid input of manual work, because:

Quality can just be planned, but finally it has to be realistic in production!
Technical brief description

The boundaries of possibility at WKV
The alternators can be designed according to all international standards such as BS 4999, IEEE, NEMA MG1 etc.

For marine and offshore application, design and manufacturing according to all international classifications such as ABS, BV, CCS, DNV, GL, LRS, MRS, RINa etc. can be offered.

Requests for alternative mechanical and electrical design, also multi-pole alternators for Kaplan drives are always welcome.

Whatever you need: We make it!
Mechanical Design
A piece of solid workmanship
General design

The alternators consist of the main internal-pole generator and the external-pole exciter machine. The entire design is configured for highest reliability, quality and durability.

Stator and bearing housings

The stator housing is a solid welded construction. The stator core is made up of low-loss laminations, pressed together by means of pressure plates to form a compact unit.

The stator insulation system is based on temperature class “H” materials for low voltage alternators and class “F” for medium voltage alternators, according to EN 60034-1/VDE 0530-1. The winding overhangs and connections are supported by fastening elements and firmly linked by mechanical means to guard against loads caused by electro-dynamic forces.

An auxiliary exciter winding located in the main stator slots provides power to the automatic voltage regulator. The exciter machine stator is fixed in the non-drive end bearing housing. The bearing housings are also made of rigidly welded construction with integrated machine feet, in order to ensure a perfectly stiff fixing to the foundation.

WKV will never consider inferior solutions!
Rotor and bearings

The main salient-pole rotor is made up of steel laminations or steel plates that are hydraulically pressed together. A copper damper cage, electrically interconnected within the pole shoes and from pole to pole, is installed as standard.

The main salient-pole rotor winding is made from copper profile and protected against deformation caused by centrifugal forces by suitable and generously sized spread supports.

The exciter rotor consists of dynamo lamination with the three-phase winding incorporated into its slots.

The rotor windings comply with temperature class H in accordance with DIN EN 60034-1 and VDE 0530-1.

As a standard for all frame sizes, high-quality sleeve bearings are used. Depending on operation mode and speed, oil cooling by embedded water cooling snakes or by separate oil supply system can be arranged.

Case-related, at small machines or at some vertical designs, also antifriction bearings or a combination of sleeve and antifriction bearings may be selected.

Oil supply and oil cooling systems complete with electric or shaft-driven mechanic oil pumps and monitoring for reliable operation are part of our scope of supply.
Connection boxes for power termination are usually located on top of the NDE bearing housing at IP23 generators or on the side of the NDE bearing shield at totally enclosed alternators with top-mounted coolers. Enclosure type for all terminal boxes is IP54.

The main terminal box is performed with 4 studs: 3 terminals for power connection L1-L2-L3 and 1 terminal for neutral connection. The neutral point is connected of the 3 neutral side winding ends after passing the neutral current transformers that are usually included for measuring and/or protection features.

If required, the terminal box can be modified for housing further CTs or VTs.

All low voltage and signal connections are performed in an auxiliary terminal box located at the frame side.
Enclosure, cooling, design structure
The optimum solution for every application
Enclosure type
EN 60034-5 / VDE 0530-5
Standard design is IP23. Application of air inlet/dust filters as well as higher protection mode as IP43, IPR 44, IPR 54, IP44 and IP54 etc. are possible on request.

Cooling mode
EN 60034-6 / VDE 0530-6
Standard design is IC01, direct air-ventilated. IC31 (cooling air channel connection), IC0161 (top-mounted air-to-air heat exchanger), IC8A1W7 (top-mounted water cooler) or any other solution can be offered on special request.

Design
EN 60034-7 / VDE 0530-7
The basic design modes are IM1001 (B3) and IM1101 (B20) for horizontal mounting and IM 3011 (V1) for vertical mounting.

Principally we confirm for WKV alternators: Every requested design our customers need is possible!
How does a WKV alternator actually work?

A perfect and reliable operation is not least based on qualified handiwork.
**Electric operation principle**

The auxiliary winding, via the AVR’s control circuit, feeds electrical energy to the exciter winding of the exciter machine. This eliminates the need of additional auxiliary exciter machines or the often used current transformer assemblies. Power supply to the AVR of course is performed also in case of short circuit at the power terminals, so that a sufficiently high short circuit current is produced for granting selectivity of the power plant.

The exciter power, transformed to the 3-phase rotor winding of the exciter machine, is converted to DC power by means of a rotating diode bridge consisting of generously sized diodes and protective elements and then supplied to the rotor of the main generator. Permanent magnets that are located in the stator of the exciter machine ensure the self-excitation of the system.

The voltage control of the main generator at fluctuating loads is performed by changing the exciter current in the stator winding of the exciter machine via the power section of the automatic voltage regulator.
Excitation and voltage regulation

Using the world’s best components
Basic, a digital automatic voltage regulator (AVR) “ABB Unitrol 1010” or approved equal is used. The AVR shows, among others, below listed functions:

- Voltage regulator with PID control algorithm
- Cos phi and reactive power regulator with PID control algorithm
- Exciter current regulator (manual control) with PI control algorithm
- Various limiting and protection functions
- Commissioning and maintenance software is included

Optional functions are, among others:

- Reactive power sharing between parallel machines
- Voltage matching prior to synchronizing
- Automatic synchronizing
- Monitoring of rotating diodes
- Serial communication (MODBUS)
- Power System Stabilizer (IEEE 2A/2B)

The AVR is mounted into the auxiliary terminal box of the alternator but can also be delivered loose for location into the control cubicle.

If requested, we are of course prepared to use any other approved AVR system or to deliver a special exciter data sheet along with the alternator, to enable our customers to use their own AVR system.
Operating performance

Details provided by experts for adepts
Voltage setting and operation range
The output voltage is steplessly adjustable by ± 5% of the rated voltage (EN 60034) for rated operation. An increased voltage setting range is of course possible for special application, by specially designing the machine.

For testing or synchronizing purpose, the setting range is increased to ± 10%. The voltage operating range according to EN 60034 is (0,95 ... 1,05) x rated voltage between no load and full load, considering limitations as set by the EN rules.

Various grid codes (special rules of some mains operators for voltage and frequency stability or power factor range) can be considered by special design if requested.

Static voltage performance
The static voltage accuracy is ± 0,5% ... ± 1% at:
- no load up to rated load,
- PF = 0,8 ind – 1 – 0,95 cap.
- cold and warm machine speed drop of about 3%.

Transient voltage performance
Magnetic circuit and windings are optimized for low voltage transients. Usually, the transient voltage dip at rated load connection is below 25%, the transient time until reaching rated voltage is around 0,5 s. Machine size and speed have an influence to these values.

Voltage waveform
The Optimization of the geometry of the stator magnetic circuit leads to a sinusoidal voltage waveform. The wave form characteristics are defined by:
- Telephone Harmonic Factor “THF” Values as per EN 60034 are easily undercut
- Harmonic content Values between phases ≤ 2% at no load up to rated load and PF = 0,8 ... 1, when loading with linear and symmetric consumers.
Unbalanced loads
- 60% of the rated current between Ph-N
- 35% of the rated current between Ph-PH
- Relation between counter system current $I_2$ and rated current $I_N$: 20%, what is more than required by EN 60034.

Every non-symmetric load causes a voltage asymmetry:
- $\Delta U_N$ approx. ± 6% at 60% current Ph-N
- $\Delta U_N$ approx. ± 4% at 35% current Ph-PH.

For avoiding additional losses especially in the damper cage, the loading should be as symmetric as possible. WKV recommends a limitation of $I_2/I_N \leq 0,08$ as ruled in EN 60034.

Overload capability
- As per EN 60034 1,5 x rated current for 30 sec.
- In addition, 1,1 x rated current for 1 hr every 6 hrs.
- and 1,8 x rated current for approx. 10 sec, for switching sequences

Short-circuit current
WKV alternators are short circuit-proof. The initial short-circuit current is limited by proper layout of the influencing parameters. The sustained short-circuit current is guaranteed by proper machine and AVR layout at min. 3 x rated current for max. 10 sec.
You tell us what you need – we shall do it. Without ifs and buts.

**Parallel operation**

Tolerances for synchronization to be met:
- Max. voltage gap: 5% of $U_N$
- Max. frequency gap: 2% of $f_N$
- Phase sequence and phase angle shall match.

Special design for operation with big additional flywheel shall be separately discussed prior to offering.

The distribution of **active load** is defined by the speed performance of the prime movers.

The distribution of **reactive load** is depending on the voltage regulation behaviour of the alternators and is normally performed by power factor controlling or, very seldom, by static voltage droop equipment.

**Non-linear loads**

Polluted networks and static converters as consumers with non-linear currents are causing voltage harmonics as a reaction. For this reason, high value is set on lowest-possible voltage harmonics and low subtransient reactance $X_d^*$. WKV therefore shows high flexibility and complies with project-specific requirements, in order to reach balance between passably big short-circuit current and the needed voltage values, for realizing the overall conditions as required by the project.
Insulation and protection devices

Nothing lives forever, but we are pretty close.
**Alternator protection**

**Thermal winding protection**
Generally min. 2 x 3 PT100 probes for protection of the stator winding against thermal overload.

**Protection of bearings**
Generally each one PT100 probe radially and, if applicable, axially. Optionally, vibration detection of bearings or around bearings will be performed.

**Anti-condensation heater**
Used generally for protection against condensate. Connection voltage 230V single phase or to be agreed. The rated heater power is depending on the frame size of the alternator.

**Transformers for protection and measuring**
The terminal boxes of WKV alternators are generally large enough for housing minimum one set of neutral CTs. The mounting of further current and voltage transformers can be done on request.

**Further protection**
The application of more protective devices such as vibration sensors, speed measurement, brakes, rotor and stator earth fault protection etc. can be done again on request.

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**Insulation system**

WKV alternators are produced according to international rules and regulations. For ensuring the best-possible operating reliability considering various operating conditions, our engineers have, based on long experience in building electric alternators, developed and adjusted the insulation system in close cooperation with notable manufacturers.

Thanky to our most-modern impregnation plant, WKV offers VPI impregnation (today our standard system) as well as Resin Rich impregnation.

All coils are produced in our own plant and tested individually and later again in mounted condition.

A sophisticated tape binding of the winding overhangs prevents movement or deformation of the coil heads even at extreme loading.

The complete insulation system is matching with temperature class “H” (all rotors and low voltage stators) resp. “F” (medium voltage stators).

Examples for optional equipment:
- Speed detection (top), hydraulic brake (top middle), sliprings for rotor earth fault detection with magnetic brush lifting device (top right).
Quality assurance, factory testing

Trust is good, control is better
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The WKV test facilities in Gutach/Germany with a total prime mover capacity of 1,200 kW, most-modern measurement technologies, a comfortable visitor’s area with every convenience and a highly motivated team of assayers offers optimal conditions for both standard testing and sophisticated FATs.

After manufacturing, every WKV alternator is taken to our most-modern test facilities. Our customers are provided with a comprehensive test report for every single alternator.

Customers are always welcome to inspect the factory test procedure and to check all the complete measuring and test reports that have been compiled during the entire production process.

Last but not least:
Enjoy the typical Black Forrest hospitality on a factory tour associated with the testing of “your” machine!
World-wide after sales service
If the worst comes to the worst
Service for customers

We at WKV would wish to support you from the beginning, during the preparation process, project work towards creating a technically optimized solution.

On request, your technical staff will receive a systematic training-on-product during the FAT. Of course, also for commissioning of your power plant we will provide support if required.

WKV alternators are produced in accordance with internationally proven WKV quality standards. However, even the best product can get damaged or might need a technical check. For this reason, our responsibility does not end with the delivery of a top-class premium product. The WKV AG is operational worldwide with a network of distribution and sales partners that is standing for quick and reliable support in case of any technical problems.

Wherever we have no representation, we travel. Immediately.

That is our promise.

Our obligation to you, our customers, does not end when delivering a top-quality product!
You will find our equipment in more than 40 countries all over the world.