International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

An Optimal Technique to Limit the Harmonics Level in Brush Less Alternators

M.Yogesh, **B.S. Nagaraja**, **Nandan. N,**
Assistant Professor, Dayananda Sagar College of Engineering,

ABSTRACT: *Harmonic parameters of synchronous machine greatly affect its performance during steady state operation and also during faults and transient. The Harmonics in generated voltage waveforms are often the cause for excessive heating and tooth tip saturation and compel de-rating of such machine, because of this problem it needs to analyze the harmonic content for improving the quality of performance. This paper is focused on investigation and evaluation of harmonics levels, for calculation of proper design input parameters. Hence in this paper we discusses a novel technique to overcome this problem at the design level itself, by introducing the software tool for predetermining the design input data.*

Keywords: Harmonic distortion analysis, Design input data, soft ware tool, Brushless alternators.

INTRODUCTION

Several different technologies are used in alternators to analyze harmonics. Here using a brush less alternator to analyzing the harmonics and minimization of its effects. Majorly harmonics generated in voltage waveforms and in slot tooth.

In the first case harmonics can be minimized by using distributed winding instead of concentric winding; hence we can obtain distribution factor and chording factor for different harmonic orders.

And also the slot harmonics has to be limit to achieve limited total harmonic distortion. This slot harmonics are mainly depends on the slot pitch. By varying slot pitch we can get different harmonic orders and proper design data regarding slots.

In order to achieve this proper design input data I am introducing a new software tool technique, in this I can predefine the design data for different harmonic orders.

BRUSHLESS ALTERNATOR:

All synchronous generators function as magnetic energy conversion devices to convert mechanical power into electrical power by means of magnetic fields. The input torque provided by the prime mover (the turbine) is balanced by the magnetic torque between the stationary and rotating structures in the generator.

Several different approaches are possible to accomplish this power conversion function. For the larger synchronous generators that are primarily discussed in this section, the magnetic fields are typically established by electrical currents circulated in stationary ac windings, and rotating dc windings, and these magnetic fields are circulated within the generator through highly permeable steel structures. In such a generator, the ac winding is electrically connected to an electrical power system and physically mounted on the stationary member of the generator (the stator), and the dc winding is electrically connected to a dc power source and physically mounted on the rotating member of the generator (the rotor). Because of the prevalence of poly phase power generation, distribution, and utilization, the ac winding in all but the smallest synchronous generators is generally a poly phase winding.

The most common number of phases is three. All larger synchronous generators include an ac armature winding and a dc field winding. The electromagnetic interaction of these two windings provides the basis for ac power generation. In some of the smallest synchronous generators, with ratings below a few hundred kilowatts, the magnetic function of the dc field winding is provided by permanent magnets. In all large synchronous generators, the dc field is provided by a dc field winding.

This section is limited to discussions of generators, with an ac armature winding and a dc field winding. In most large synchronous generators, the ac armature winding is located on the stator of the machine, and the dc field winding is located on the rotor, as illustrated schematically in Fig. 2-1. An important exception is a special synchronous generator that is generally known as a brush less exciter.

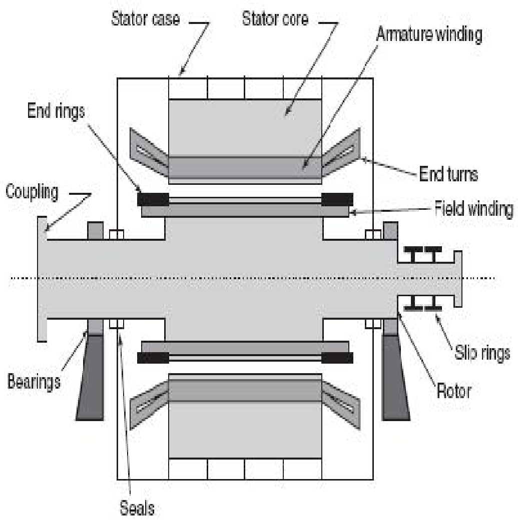

Fig 2.1 shows the elements of the Synchronous generator

HARMONICS:

A harmonic of a wave is a component frequency of the signal that is an integer multiple of the fundamental frequency, i.e. if the fundamental frequency is f, the harmonics have frequencies 2f, 3f, 4f, etc. The harmonics have the property that they are all periodic at the fundamental frequency; therefore the sum of harmonics is also periodic at that frequency.

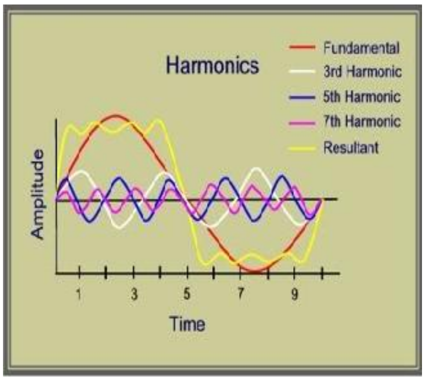

Fig shows harmonics wave forms with fundamental wave forms.

Harmonic frequencies are equally spaced by the width of the fundamental frequency and can be found by repeatedly adding that frequency. For example, if the fundamental frequency is 25 Hz, the frequencies of the harmonics are: 50 Hz, 75 Hz, and 100 Hz etc. In modern test equipment today harmonics can be measured up to the 63rd harmonic.

All the odd harmonics (third, fifth, seventh, ninth, etc.) are present in the phase voltage to some extent and need to be dealt with in the design of ac machines. Because the resulting voltage waveform is symmetric about the center of the rotor flux, no even harmonics are present in the phase voltage.

In Y- connected, the third-harmonic voltage between any two terminals will be zero. This result applies not only to third-harmonic components but also to any multiple of a third-harmonic component (such as the ninth harmonic). Such special harmonic frequencies are called triple harmonics.

HARMONIC EFFECT

The performance of any machine can be depends on total harmonic distortion. The flux distribution along the air gaps of alternators usually is non-sinusoidal so that the emf in the individual armature conductor likewise is non-sinusoidal.

Due to the effect of harmonics production of oscillating torque, copper and core losses ,Efficiency will be reduced and the additional power losses occur by the harmonics also affect the overall temperature rise and local overheating.

MINIMIZATION OF HARMONICS

The different methods for minimization of harmonics from the generated voltages and slots.

- Distributed windings
- Fractional coil pitch
- Fractional slot windings
- Large length of air gap

The table below shows the example values of winding factors

Harmonic	k_p	k_d	k_w
1	0.9659	0.9577	0.9250
5	0.2588	0.2053	0.0531
7	0.2588	−0.1576	−0.0408
11	0.9659	−0.1261	−0.1218
13	−0.9659	0.1261	−0.1218
17	−0.2588	0.1576	−0.0408
19	−0.2588	−0.2053	0.0531
23	−0.9659	−0.9577	0.9250
25	0.9659	−0.9577	−0.9250
29	0.2588	−0.2053	−0.0531
31	0.2588	0.1576	0.0408
35	0.9659	0.1261	0.1218
37	−0.9659	−0.1261	0.1218

Table shows the winding factor of 3 phase alternator for nth harmonics

Observe that the winding factors k_w for the harmonics 23 and 25 have the same value as the fundamental voltage. This is so for all harmonics whose numbers are equal to (integer multiple of number of slots per pair of poles).

TOOTH RIPPLE EFFECTS

The voltage waveform predicted neglects the effect of armature teeth and slots on the air-gap flux. The resulting modulations of the air-gap field's dc not generate voltages in armature conductors directly, rather induce currents in the field winding, any damper windings that may exist, and in the rotor body itself and slot wedges. These currents produce flux components, which in turn produce voltages in the armature winding.

SLOT HARMONICS (TOOTH HARMONICS)

In addition to the EMFs generated in the windings by those space harmonics of flux which move at the same velocity as the fundamental flux relative to the conductors, certain harmonic voltages of a particularly

undesirable order may be produced by the effect of the openings of the slots in which the conductors themselves are located.
But it is important to note that, since the ripples are due to slotting, they do not move with respect to the conductors but glide over the flux distribution curve, always opposite the and teeth which cause them.

AIR GAP

The air gap constitutes the division between the rotating parts of the machine the rotor, which carries the field winding and the stationary part of the machine the stator, which carries the armature winding in ac generators, the air-gap dimension is determined by the electrical characteristics of the machine.
There is a trade-off between excitation mmf (toward a small air-gap dimension) and armature reaction flux (toward a large air-gap dimension). This trade-off generally results in an air gap, which is substantially larger than mechanical considerations such as machining tolerances or wind age loss would dictate.

The air gap flux density fundamental *Bg1* is as follows:

- ***Bg1* = 0.75 – 1.05 T for cylindrical rotor SGs**
- ***Bg1* = 0.80 – 1.05 T for salient pole rotor SGs**

RESULTS

The tables below gives the distribution factors of winding for n[th] order of odd harmonics and the pitch factor of winding for n[th] order of odd harmonics.

Hookup table for Distribution factor of 4 poles 3 phase machine.

Distribution factor according to harmonics order									
	No.slots / phase /pole								
Harmonics order	2	3	4	5	6	7	8	9	10
1	0.966	0.960	0.958	0.957	0.956	0.956	0.956	0.955	0.955
3	0.707	0.667	0.653	0.647	0.644	0.642	0.641	0.640	0.639
5	0.259	0.218	0.205	0.200	0.197	0.196	0.194	0.194	0.193
7	0.259	0.177	0.158	0.149	0.145	0.143	0.141	0.140	0.140
9	0.707	0.333	0.271	0.247	0.236	0.229	0.225	0.222	0.220
11	0.966	0.177	0.126	0.109	0.102	0.097	0.095	0.093	0.092
13	0.966	0.218	0.126	0.102	0.092	0.086	0.083	0.081	0.079
15	0.707	0.667	0.271	0.200	0.173	0.159	0.150	0.145	0.141
17	0.259	0.960	0.158	0.102	0.084	0.075	0.070	0.066	0.064
19	0.259	0.960	0.205	0.109	0.084	0.072	0.066	0.062	0.060
21	0.707	0.667	0.653	0.247	0.173	0.143	0.127	0.118	0.112
23	0.966	0.218	0.958	0.149	0.092	0.072	0.063	0.057	0.054
25	0.966	0.177	0.958	0.200	0.102	0.075	0.063	0.056	0.052
27	0.707	0.333	0.653	0.647	0.236	0.159	0.127	0.111	0.101
29	0.259	0.177	0.205	0.957	0.145	0.087	0.066	0.056	0.050
31	0.259	0.218	0.158	0.957	0.197	0.097	0.070	0.057	0.050
35	0.966	0.960	0.126	0.200	0.956	0.143	0.083	0.062	0.052
37	0.966	0.960	0.126	0.149	0.956	0.195	0.095	0.067	0.054
39	0.707	0.667	0.271	0.247	0.644	0.642	0.225	0.145	0.112
41	0.259	0.218	0.158	0.109	0.197	0.956	0.141	0.081	0.060
43	0.259	0.177	0.205	0.102	0.145	0.956	0.194	0.093	0.064
45	0.707	0.333	0.653	0.200	0.236	0.642	0.641	0.222	0.141
47	0.966	0.177	0.958	0.102	0.102	0.196	0.956	0.140	0.079
49	0.966	0.218	0.958	0.109	0.092	0.143	0.956	0.194	0.092
51	0.707	0.667	0.653	0.247	0.173	0.229	0.641	0.640	0.220
53	0.259	0.960	0.205	0.149	0.084	0.098	0.194	0.956	0.140
55	0.259	0.960	0.158	0.200	0.084	0.086	0.141	0.955	0.193
57	0.707	0.667	0.271	0.647	0.173	0.159	0.225	0.639	0.639
59	0.966	0.218	0.126	0.957	0.092	0.075	0.095	0.193	0.955
61	0.966	0.177	0.126	0.957	0.102	0.072	0.083	0.141	0.955
63	0.707	0.333	0.271	0.647	0.236	0.143	0.150	0.222	0.639

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Hookup table for Distribution factor of 4 poles 3 phase machine.

Distribution factor according to harmonics order									
	No.slots / phase /pole								
Harmonics order	2	3	4	5	6	7	8	9	10
1	0.966	0.960	0.958	0.957	0.956	0.956	0.956	0.955	0.955
3	0.707	0.667	0.653	0.647	0.644	0.642	0.641	0.640	0.639
5	0.259	0.218	0.205	0.200	0.197	0.196	0.194	0.194	0.193
7	0.259	0.177	0.158	0.149	0.145	0.143	0.141	0.140	0.140
9	0.707	0.333	0.271	0.247	0.236	0.229	0.225	0.222	0.220
11	0.966	0.177	0.126	0.109	0.102	0.097	0.095	0.093	0.092
13	0.966	0.218	0.126	0.102	0.092	0.086	0.083	0.081	0.079
15	0.707	0.667	0.271	0.200	0.173	0.159	0.150	0.145	0.141
17	0.259	0.960	0.158	0.102	0.084	0.075	0.070	0.066	0.064
19	0.259	0.960	0.205	0.109	0.084	0.072	0.066	0.062	0.060
21	0.707	0.667	0.653	0.247	0.173	0.143	0.127	0.118	0.112
23	0.966	0.218	0.958	0.149	0.092	0.072	0.063	0.057	0.054
25	0.966	0.177	0.958	0.200	0.102	0.075	0.063	0.056	0.052
27	0.707	0.333	0.653	0.647	0.236	0.159	0.127	0.111	0.101
29	0.259	0.177	0.205	0.957	0.145	0.087	0.066	0.056	0.050
31	0.259	0.218	0.158	0.957	0.197	0.097	0.070	0.057	0.050
35	0.966	0.960	0.126	0.200	0.956	0.143	0.083	0.062	0.052
37	0.966	0.960	0.126	0.149	0.956	0.195	0.095	0.067	0.054
39	0.707	0.667	0.271	0.247	0.644	0.642	0.225	0.145	0.112
41	0.259	0.218	0.158	0.109	0.197	0.956	0.141	0.081	0.060
43	0.259	0.177	0.205	0.102	0.145	0.956	0.194	0.093	0.064
45	0.707	0.333	0.653	0.200	0.236	0.642	0.641	0.222	0.141
47	0.966	0.177	0.958	0.102	0.102	0.196	0.956	0.140	0.079
49	0.966	0.218	0.958	0.109	0.092	0.143	0.956	0.194	0.092
51	0.707	0.667	0.653	0.247	0.173	0.229	0.641	0.640	0.220
53	0.259	0.960	0.205	0.149	0.084	0.098	0.194	0.956	0.140
55	0.259	0.960	0.158	0.200	0.084	0.086	0.141	0.955	0.193
57	0.707	0.667	0.271	0.647	0.173	0.159	0.225	0.639	0.639
59	0.966	0.218	0.126	0.957	0.092	0.075	0.095	0.193	0.955
61	0.966	0.177	0.126	0.957	0.102	0.072	0.083	0.141	0.955
63	0.707	0.333	0.271	0.647	0.236	0.143	0.150	0.222	0.639

CONCLUSION:

The concern about the content of harmonic in power supply equipment is more appreciated now a day's due to technology advancement. Hence concern about purity of power supply is highly appreciable due to demand of power supply of high quality for precision measuring equipment's used for manufacturing and analysis. Hence forth it is necessary to keep the harmonic distortion to low value for maintain desired accuracy.

The purpose this work is to suggest that required to set up the desired level of source harmonics studies with emphasis on simulation. The propagation of harmonic voltages in an induced voltage in synchronous generator, and the resulting total harmonic voltage distortion, depends on characteristics of harmonic sources as well as the frequency response of the system components.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

The various harmonics and consideration have been summarized for changing the design input of rotating machine design program. different approaches to conduct analysis were discussed in a common frame work. this work gives the study of design input for brushless alternator and the software tool will suggest change in design input to achieve the desired total harmonic distortion level. According to this software tool we can achieve the proper design parameters with respect to the particular harmonic level and we can get the suggestions to change design.

References:

1. Analysis of Harmonic Transfer in an A.C. Excited Generator Including Speed RippleHarmonic Analysis of the Exciter's Exciting Current of a Brushless AC Generator with a Rotary Rectifier
2. Tian Mingxing, Li Qunfeng. “Model and simulation of the synchronous generator with rectified loads baaed on Matlab .Jam1 of Xi’m Jiaotong Universiry.2004 (I)
3. The book “A course in ELECTRICAL MACHINE DESIGN” by A.K. SAWHNEY
4. The book “THE PERFORTMANCE AND DESIGN OF ALTERNATING CURRENT MACDHINES” by M.G.SAY.
5. The paper “DESIGN OF SYNCHRONOUS GENERATORS” by Taylor & Francis group
6. The paper “Development of salient pole rotor “by saurav man Singh besnet
7. The paper “Software Development for Harmonic and Transient Measurements “by Łukasz Hubert Kocewiak, Jesper Hjerrild, Claus Leth Bak
8. The book “A TEXT BOOK OF ELECTRICAL TECHNOLOGY” by B.L.THERAJA
9. The book “MAT LAB An Introduction with Applications” by Amos Gilat.
10. Paul Nicastri, Henry Huang. “42V PowerNet: Providing the Vehicle
11. Electrical Power for the 21st Century”. 2000 Society of AutomotiveEngineers.2000
12. Comanescu Mihai, Keyhani Ali, Min Dai. Design and Analysis of 42-V Permanent-Magnet Generator for Automotive Applications. IEEE Trans.on Energy Conversion. Vol.18,pp.107-110, 2010.
13. M.Ehsani,A.Emadi,and H.Gao. “42V automotive power systems,
14. “Brushless Alternators” N.E.L.A.PublicationNo.239, 2010.
15. BARR, J. R., and ARCHIBALD, R. D.: "The Design of Alternating Current Machinery" (Pitman, 2008), pp. 219-223.