schemer wrote:
>
> Hi Mike,
>   I have a set of plans for Hugh Piggotts Brakedrum Wind Generator and
> found some dead links on your pics of the replacement parts for the hard
> to find laminations. Did you ever get those tested and working or was
> Hugh right on the problems? I am having trouble finding the laminations
> for the North American version...and may have to make my own...
>
> Thanks,
> schemer
> Dave Ksobiech
> In Florida

I have been shifted on to hotter projects for now. The choices as I see it are:

1) Wind around a form some annealed bailing wire mixed with epoxy. Build this up to whatever diameter needed. After hard, use a metal cutting saw blade cut slots for the wires to lay in.

2) Mix some Iron powder (or whatever you can find that is best) with epoxy and spin the drum with magnets and coils in place until it hardens. Possibly no forms are needed. Just a spacer between the coils and the magnet for an air gap and to allow it to be taken apart.

3) Wind a stator of correct size using iron strapping material mixed with epoxy. This theoretically should have more eddy current losses than 1 or 2 above and would be the last choice.

MikeL

Breakdrum design notes

Subject: Brakedrum wind mill notes and more
Sent: 7 Jan 2001

The authors home page
http://homepages.enterprise.net/hugh0piggott/

Link to Canadian Workshop (Bob Budd)
http://www.windmill.on.ca/

Interesting tower design
http://www.windmill.on.ca/Tower.htm

Some parts are available at:
http://www.windmill.on.ca/newpage1.htm

Permanent magnets:
http://www.magnetsource.com/permmag.htm
http://www.magnetsales.com/

----
hugh piggott wrote:
>
> >With the goal to get both sides of the pick up coils laying flat in the
> >air gap between the magnets and the stator, minimize air gap, and yet
> >have a wire size large enough to minimize internal resistance loss.
>
> I am not sure why this is a problem. If you follow my plans you can
> have 3 phase output, with all the coils lying flat in the air gap.
* Maybe I did not make this clear enough.

You have made this quite clear several times. For some the power you designed for will be enough. Your 12" Breakdrum design using 21 gauge wire provides the following and is well matched for the size prop you built.

RPM	Power Loss	Input Power	Amps
100	0	0	0
200	22	93	5.8
300	210	424	17.8
400	587	944	29.7

For others like me who feel more power is possible for this (mechanical Breakdrum) configure then your design will not be enough. By applying the principal's suggested earlier in our discussion more power/RPM would be possible with lower internal losses. A slower speed alternator with decent enough power and low internal loss being the goal. Note that recommended amperage carrying capacity of 21 gauge wire is in the range of about 2 amps. Your design would run hot around the windings and depend on wind to cool it. How would this work for hydro or no air circulation?

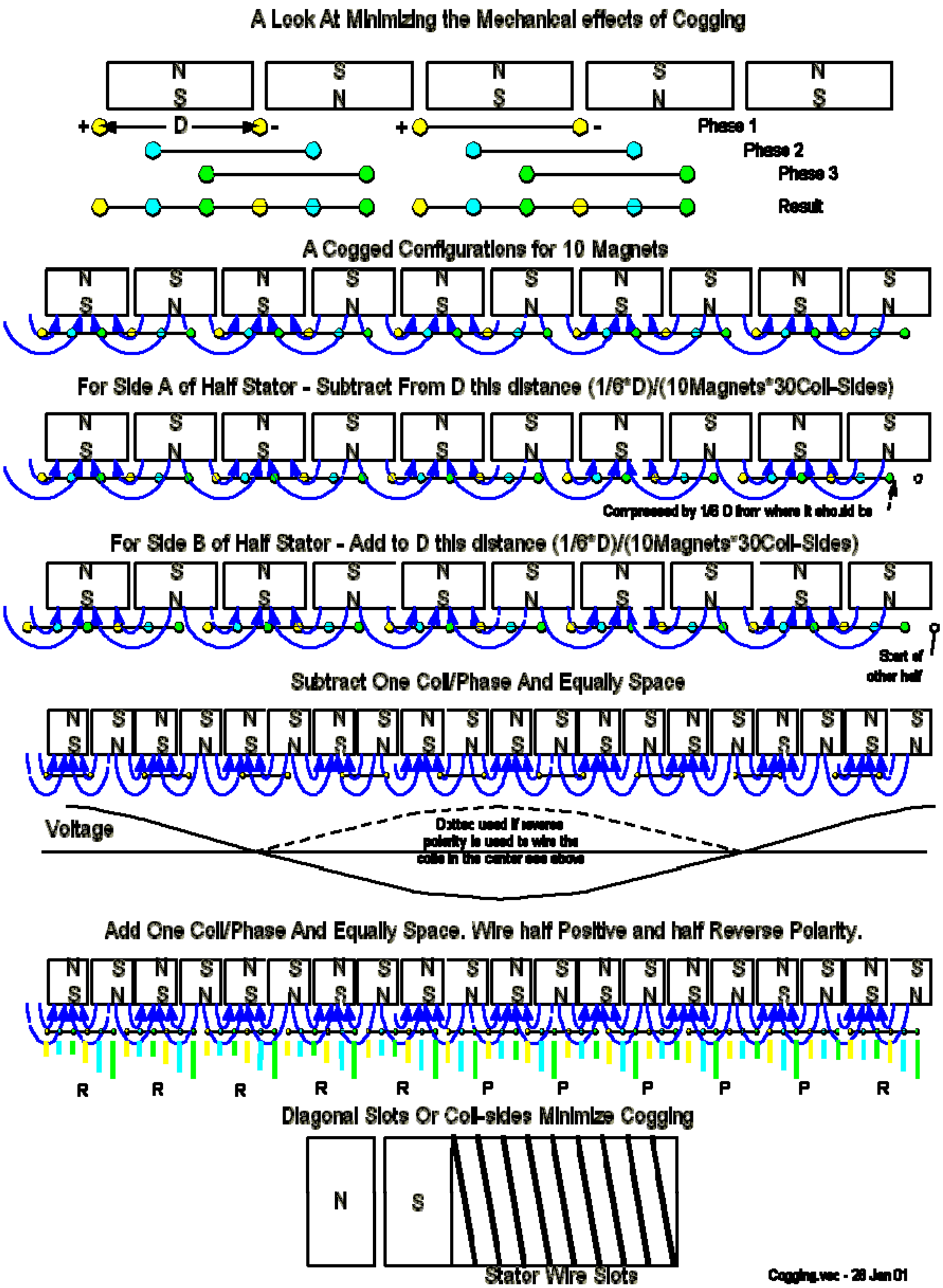
I consider bigger wire and closer air gap is a must. So as a result I don't consider it practical to lay it on the surface of the Stator. The air gap would get too big, thus the discussion of other techniques like slots to improve performance.

>
> Wire size is a matter of the number of turns. The more turns you
> have the smaller the wires. So you can have high voltage or high
> current, but never both.

Your thinking is limited by putting the coils in the air gap.

> Note that the coils as shown are not 3 phase unless the connections
> to the middle coil (shown blue) are reversed.

The diagram would have been too complex to show all of the wiring necessary. Thus some shortcuts were taken. Note that I only connected one end of the coil to the different phase wires. This was to indicate when coils are reverse connected. P= positive connection and R= reversed connection note how the first end to The series connection to the previous winding was not shown because of space and size limitations. I assumed my earlier drawing would show the detailed method of coil wiring in series. Now that I think about it perhaps I should leave out the three phase wires. See if this is not clearer



>
> >

> >The simplest method would be to slightly expand the distance between
> >coil sides for one half of the stator and compress the distance for the
> >other one half of the stator.
>
> I'm afraid I cannot understand this part at all.

Looking at the stator end on - divide the stator into right half and left half - now slightly expand the spacing of coil slots on the left half side and slightly compress or make shorter the distance between the slots on the right side. I don't know how to say it any simpler.

> > Does anyone
> >else have any other workable solutions that will archive anti-cogging
> >effect?
>
> A very common solution is to align the slots slightly skew in the
> core. When you build your stack of laminations, rotate it slightly
> so that the slots have a gentle spiral. Each slot needs to move
> about one slot pitch from one end to the other of the core.

The result is diagonal slots when facing the perimeter of the Stator. This is a simple idea to implement. If I am understanding you correctly, my best estimate is if one slot-pitch (1/3D) is used, the overall voltage would be lower by about 1/6 (17%) maximum cogged theoretical voltage. I think one slot-pitch less the width of the wire grove would work just about as well and loose a little less voltage. See the bottom of drawing.

MikeL

Sent: 27 Jan 01
Wind and hydro

With the goal to get both sides of the pick up coils laying flat in the air gap between the magnets and the stator, minimize air gap, and yet have a wire size large enough to minimize internal resistance loss.

One option is to cut shallow slots in the stator for the copper wire. This increases the tendency to cog or be stiffer to turning at given angles of rotation. The effect is due to attraction to the iron poles and the repulsion of coil wires with induced current flowing. The following drawing illustrates the effect and investigates two possibly methods of minimizing this effect. see: the above cogging diagram.

The simplest method would be to slightly expand the distance between coil sides for one half of the stator and compress the distance for the other one half of the stator. The amount of distance over the full half of the perimeter of the stator I believe can be as small as 1/2 the distance between coil sides. For three phase coils this becomes (1/2)*(1/3)D or 1/6D. Where "D" is the distance between center of each side for any one coil. The actual distance between each coil-side for 3 phase would be equal to (1/6D)/((Number of magnets per half-stator)*(Number of coil-sides per half-stator))

Note that a full one cycle of AC voltage-current is produced in approximately 2D distance around the perimeter. Thus the approximate estimated voltage that this method will produce would be approximately (1/6D)/(2D) or 1/12 lower in voltage then the fully synchronized Cogged method. I consider this an acceptable loss.

The Coil-side wonder for each half stator could be up to a distance of 1/3D. This would result in about 1/6 lower voltage then the cogged method. This to me is too much voltage loss. I believe the 1/6D to be sufficient to produce the Anti-Cogging effect.

The next method to archive anti-cogging would be to add or subtract one set of coils (all phases) and equally space all coil-sides. With each coils connected with same polarity, if one analyzes the position (of one phase only) all the way around the stator for a 20 magnet configuration one gets zero net voltage. When half the coils are producing positive voltage the other half are producing negative voltage. Since this is all wired together the net result is zero volts.

Now if we wire half the coils with a reverse polarity then we get two contributing peak points where the voltage is pushed positive. Since this all happens along the same wire or phase I would expect the resultant voltage to average about 40% lower than the peak achievable using the synchronized cogged method. This to me is an unacceptable loss of power.

Note: If one chooses to use this method the number of magnets needs to be odd number times two other wire one ends up with an odd number of coils. 20 magnets gives 9 or 11 coils and this is not an even number thus one can not split it equally into two. But 18 magnets gives 8 or 10 coils that can be split evenly in half.

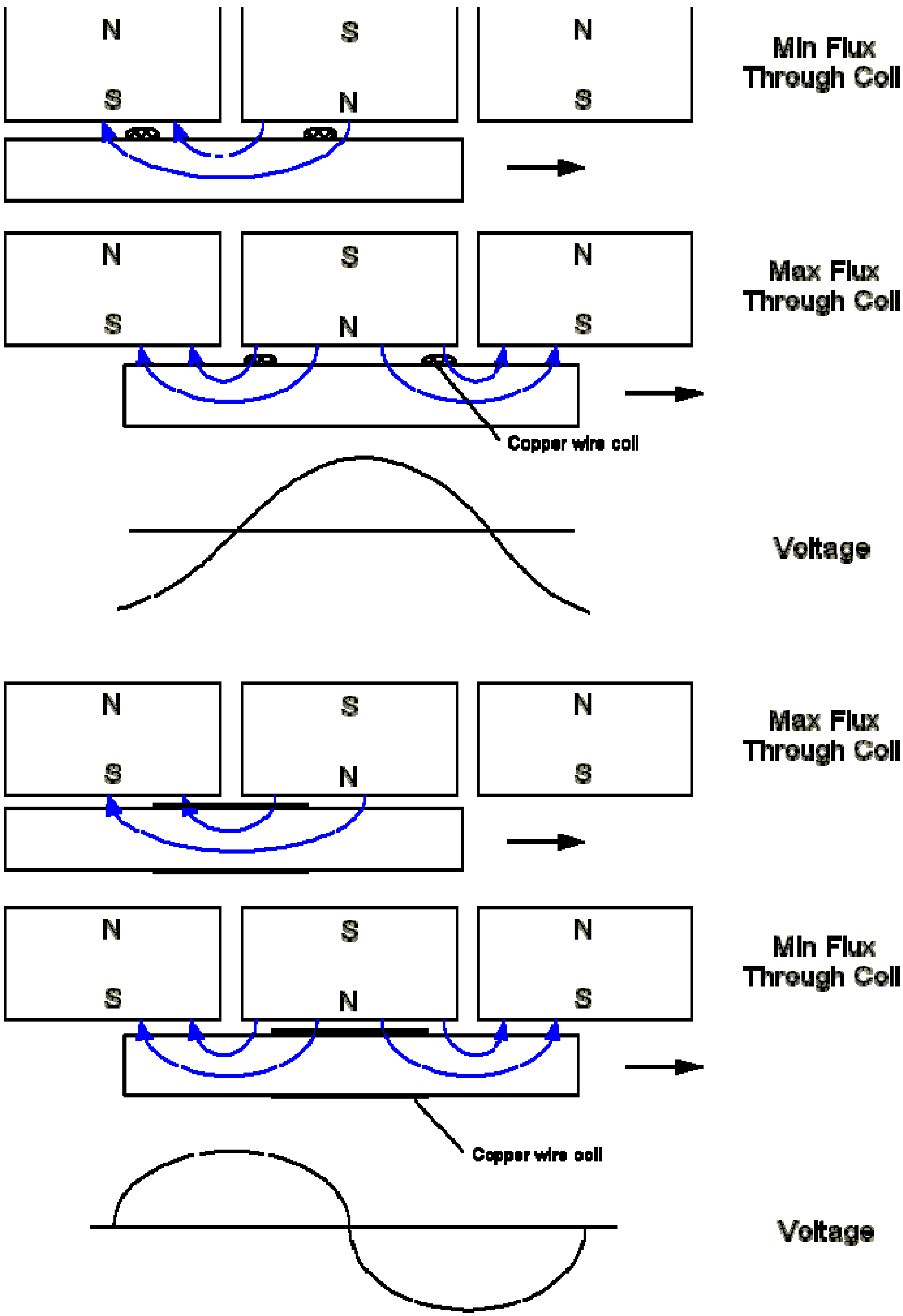
I attempted to individually wire each coil to the most optimum phase but had no luck with any configuration that made any sense. Does anyone else have any other workable solutions that will archive anti-cogging effect?

MikeL

Sent: 24 Jan 01

After making a near to scale drawing I see what you mean. See:

Two Coil Orientations With The Differences



FluxLinesAC.vsd - 27 Jan 01

Depending on the separation of the windings that lay flat on the stator one could get a maximum of nearly twice the number of flux lines through the cross section of the coil. This is assuming the Air gap to be the same for both.

If the air gap is smaller on the second approach then the factor is less than 2 but I doubt it would ever be equal to. I will next use the best techniques discussed and go back into a redesign stage. Thanks for your comments.

MikeL

Sent 23 Jan 01
hugh piggott wrote:
>
> OK, the biggest hole in your logic is the number of turns per coil.
> If you use fewer turns per coil (and each turn only crosses the air
> gap once) then you drastically cut down the voltage you can produce
> at a given speed. There is no free lunch to be obtained by using
> thicker wire and fewer turns. You will get lower resistance, but you
> will get less voltage too.

You should be comparing the total turns per phase instead of turns per coil. If you do this for a 10" drum you get:

	coils/ phase	Turns	Turns/ Phase	Gauge Wire	Magnetic Air Gap
Your design	10	24	240	20	4-4.5MM
Idea 1) DC	15	22	330	18	3.1 MM
Idea 1) AC	15	27	405	16	3.3 MM

I did some test measurements and the best I can tell by decreasing the distance about 1 mm from you design the magnetic flux density should increase by about 1.5 times what it would be at 4 MM to 4.5 MM. Of course type and size of magnet would make a difference. I was using small ones for the test.

> Actually the flux passing along the core is only half the flux from
> one magnet. (The flux splits and travels 2 ways within the core.)
> To get the full flux from a magnet, you will need a coil which
> crosses the airgap twice - once on each side of the magnet. Wire
> which does not cut flux does not contribute to voltage.

I need to make a drawing of this and study it a bit; I will comment later on this.

> >> You can buy things call 'C cores' which do this job. With the right
> >> type of steel.
> >
> >This sounds like an interesting idea. Where would one purchase this or
> >find these?
>
> Try electronic equipment suppliers. Or school laboratory equipment
> suppliers. Or cut up some transformers.

Ok, I know what you are talking about. I talked about half-laminations used in transformers in the first e-mail on this subject. I just didn't recognize your terminology. :)

> >Not sure I understand the part about "10 magnet pairs and 9 C-cores".
> >Can you explain more about this. How does the voltage add up correctly?
>
> They don't. You can either run them all into 9 parallel rectifiers,
> or group them into 3 phases (the normal procedure in such cases),
> even though the coils within any one phase are not perfectly in phase
> with each other. I've never used it but it's a good trick.

Interesting - I think I will try this sometime.

> OK rare the earth magnets are a good idea. But leakage depends as
> much on the area of the pole as it does on the air gap. And you get
> leakage between the ends of the 'half washers' too. On the whole the
> leakage for this configuration is high, with only the reduced air gap
> mitigating against it.

Yes, it will be interesting to see which factors are the most dominate once this is built and tried out. The best I can estimate right now, the flux density in the air gap should go up by about 2 times or more by changing the gap from 4MM to 2MM. This smaller gap should be possible with this design.

MikeL

Sent : 28 Jan 01
hugh piggott wrote:
>
> I welcome any and all suggestions for improvements.

These ideas are freely given in hopes that it will help others to build better and better breakdrum alternators. I have no vested interest in selling books or anything. I believe the bearing and the drum as a foundation are nearly indestructible. I think a good design would make an industrial class solution resulting in very low maintenance with decent power that is well matched to the wind and hydro needs. Thus the reason for this discussion.

> Looking at the pictures in your link for idea 1, it appears that you
> suggest putting copper wire in the air gap. This is what I suggest,
> too. I am aware of the disadvantages, but there are also some
> advantages, such as easy startup.

True about the ease of startup, however this is at the expense of maximum output power. If I remember correctly you fill about half of the air gap or about 2 MM to 2.5 MM with 20-gauge copper and epoxy. In Idea 1) I suggest using bigger wire of 16 gauge for AC with over twice the current carrying capacity, yet it only uses one winding of thickness (.053" or 1.3MM. For DC I suggested using 18 gauge for DC with winding thickness of .042" or 1.07MM. The result is I recommend cutting your gap for wire in approximately one half. The bigger gauge wire that I suggest has many advantages in lowering internal power loss, reducing internal heating, and being able to deliver more power or current to the load outside the alternator.

> While I welcome debate on the subject,

I have no intention to debate the subject. Discussion of possibilities is the intention. What works and what doesn't work and why is welcome. Please, no generalities without the why see the following statement as an example.

> I would strongly question
> whether the proposed solutions would actually improve the
> performance.

Note, that no "why" is given. Yet I have indicated the magnetic gap decreases, the size of wire goes up and stronger magnets than ceramic are available. I see no technical reason for your opinion.

> I would recommend some experimentation before
> publishing detailed proposals like this, in case readers waste time
> trying them.

I two recommend experimentation and this is the why to freely publish these ideas at this time. Someone else may get to try it before I get to it. In this way we all learn faster. Also, by publishing in the idea stage it gives a chance to find weaknesses in the design and do changes before building it. I have nothing to hide and nothing to profit from. I clearly state these are two ideas. I believe others can benefit from the discussion and use what they see will work.

> >Use this form to wind many layers of metal strapping material or
> >annealed iron baling wire.
>
> This will lead to high iron losses.

I disagree that the losses will be as high as you seem to think, for the speed is low. I do agree there will be some eddy current losses and hysteresis losses. I believe that the annealed iron baling wire would make a lower loss core and might be the best to use in preference to strapping material. I think in a cost or availability pinch either would work.

> Winding coils through the hole in the center of the core is not a
> good idea. The legs of wire inside the hole will not generate any
> power, but will increase the length and so the resistance of the
> copper winding. In my design you are getting power from both sides
> of each coil. This means that the resistance is much lower for each
> volt generated using my system.

I disagree with you on this one. Analyze the change of flux lines through the cross sectional area of each coils (this is what determines resultant coil current) for yours and my approach for a given small increment of turn - say north magnetic field pointing in to south magnetic field pointing in to north magnetic field pointing in - or one cycle. I get as a result about the same number of lines of flux within the coils cross sectional area and about the same reversal rate/rotation as you would get for your approach. I see no advantage to what you have done other than have twice as much wire in the gap than you need.

> You can buy things call 'C cores' which do this job. With the right
> type of steel.

This sounds like an interesting idea. Where would one purchase this or find these?

> >If using ceramic magnets wrap fishing line (or strong string) around
> >the perimeter of the stator unit so as to fill in the remanding
> >half-hole in the washer.
>
> why? You would do better to allow cooling air flow in this half hole.

Good point what I was thinking was if one doesn't use the cable or wire approach to hold this together and is using weak magnets then fishing line as suggest above would work. I agree the air circulation around the coil would be cut down. So it probably would be better to plan on using the wire or cable approach and forget about the fishing line around the notches.

> I would go for a smaller gap. To avoid cogging (as much as possible)
> I would use a completely different number of C-cores from magnets.
> For instance use 10 magnet pairs and 9 c-cores

Not sure I understand the part about "10 magnet pairs and 9 C-cores". Can you explain more about this. How does the voltage add up correctly? Also, what does a C-Core look like?

> unfortunately the flux will also be much less too, since the magnets
> are smaller and there will also be a large amount of leakage.

The flux for each magnet, would be less than half your design if ceramic magnets of the same width were used. Note that the magnetic air gap is much closer. Being closer there should be less leakage thus increasing flux lines in the core. Magnetic lines of force like iron thousands of times better than air. Also, I was planning on using the stronger small rare-earth magnets, which would fit the area better.

MikeL

Subject: Slow speed Alternator construction
Sent to wind: 21 Jan 01

After studying "Brakedrum Windmill Plans year 2000 edition" By Hugh Piggot I believe several innovations can be accomplished to make the alternator easier to build, much easier to find parts, lower the cost, and result in more efficiency or less loss of power to resistance.

When and if I find a used 3 phase 5 hp induction motor I would rather turn it directly into an AC generator rather than scrap all but the field coil laminations. Gluing the alternator coils between the stator laminations and the magnets only increases magnetic air gap, and forces one to use small gauge wire, lowering efficiency. Using a different design that would allow for shorter and thicker wire would lower internal losses decreasing the over all power loss.

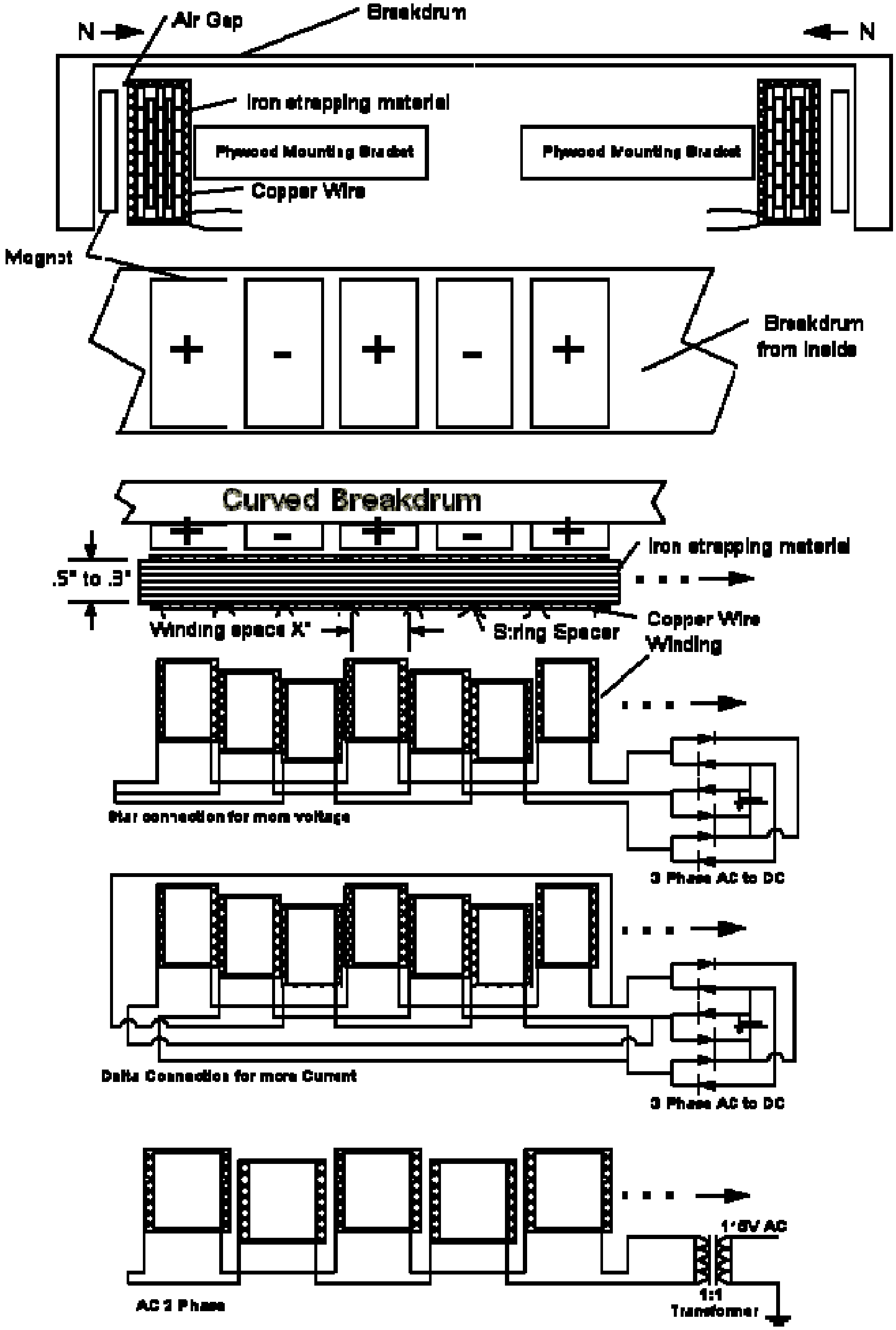
Flexibility on magnet size and shape would be more desirable and should be possible. According to my under standing of the above plans if one bought used breakdrums that are each undercut by a different amount then the magnets thickness for each drum would need to be different and need to be specially cut. A design that uses off the shelf magnet sizes without dependence on drum diameter would be more desirable. More power at lower speed would be desirable. If all of this is possible then use for slow speed hydro and wind power generation becomes more viable. All of these are possible.

The following discussion presents two possible solutions. The intention is to open up a discussion of the possibilities. The following is short overview for the technically inclined. Don't get me wrong the above book is an excellent reference on blade and tail design, to describe basics of alternator construction and to get one started. As Piggot says "I should be very surprised if anyone follows these plans exactly..."

Idea 1) After finding an even number of commercial cut magnets and installing (epoxy glue) them on the inside of the breakdrum, cut a form to the right diameter, about 1.2" to 2" less then internal diameter of the breakdrum. If using Neodymium magnets (or new strong magnets) use a thicker stator. If ceramic magnets are used, then a thinner stator will work. In either case make the stator 1.5 or thicker than the break drum flange thickness. Make this form out of a round circular disk made out of plywood, starfoam, bucket, end off a large pipe, or anything that is accurately circular of about the right size.

Use this form to wind many layers of metal strapping material or annealed iron baling wire. Metal strapping most commonly is found in 1/2 inch and 3/4 inch widths with thickness .02". Use the narrower or 1/2" wide to wind layers so as to reduce eddy or induced currents. This makes the laminated stator field see

Breakdrum Strapping Material
Permanent Magnet Alternator



As each layer goes on, paint the coil with slow hardening epoxy. This would be brought up to a diameter that allows for proper air gap plus one to three layers of copper wire as the design indicates. Once the epoxy sets up sand or grind the end to make a taper, grind the perimeter for accurate roundness so the air gap including wrapped copper wire can be maintained at no more than .8" (2 MM).

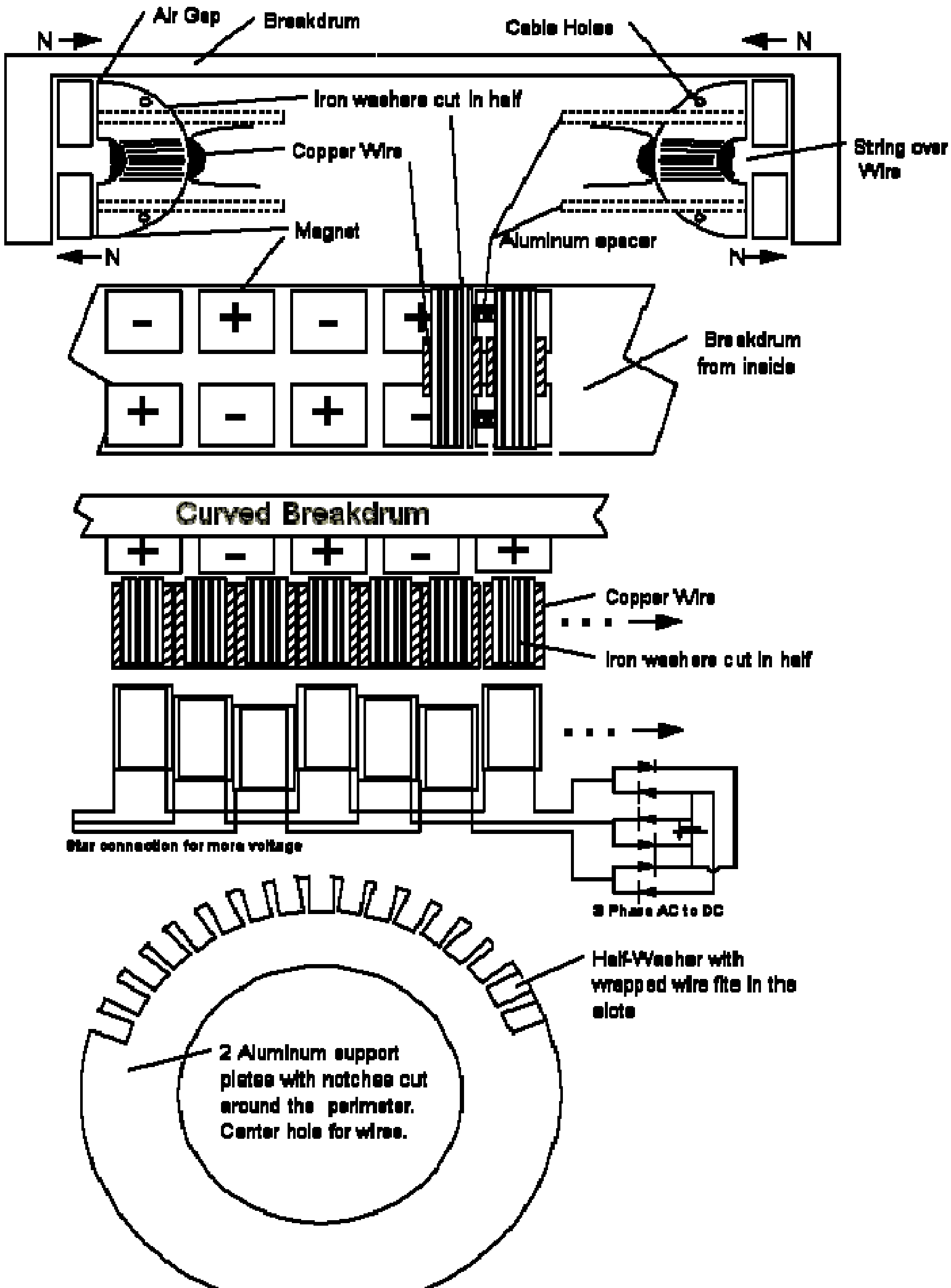
Wire is then wound around this stator to form the coils needed for each phase. A spacer of thin string can be used to separate the coils, but is not a necessity. The Copper coils can be wired in such a way that no splices are needed. Starts with 3 spools of wire and winds one coil then lays the wire flat (insulator on each side) along the inner perimeter of the stator so as to allow winding of the next coil over the top of this connection wire. In this way no messy splices would be needed except at the ends of each set of phase coils.

For 3 phase AC to 12 Volt DC slow speed battery charging: I calculate if one used 30 magnets that take up about 1" wide by 2.5" long with a 10" diameter breakdrum with 18 gauge wire, 22 turns per coil (will fit the area), for 15 coils/phase will give about 21 volts for each 100 RPM. This will charge 12-volt battery at 100 RPM and 2 12-volt batteries in series at 200-RPM etc. Internal power loss is estimated to be about 36 Watts when 550 watts is delivered.

AC generator (10" breakdrum): I calculate if one left out one phase or set of coils equally space the other two phases, and drove it at 240 rpm using 16 gauge wire with 27 turns (one layer just fits the space) for 15 coils/phase (30 magnets) equally spaced around the perimeter will give about 120 Volts AC 60 cycles at 5.5 amps. This configuration should give about 650 watts with about 40 watts wasted internal resistance. The actual results will depend on strength and closeness of the magnets and could be much better than the above estimates.

Idea 2) Description of Brakedrum-Half-Washer-PM Alternator: Use a breakdrum off the front or rear (two support bearings) from a large old car or truck. An even number of Permanent magnets is epoxied to the inner of the Breakdrum. Large iron washers with the outer diameter a little less than the width of Brakedrum flange, between 2.5" to 4" (depending on the drum) with inner hole about .75" to 1.5" are cut in half and each surface painted with epoxy or varnish. Use a stack of one or more half-washers and wrap with insulated copper magnet wire around the center where the half-hole is, see

Breakdrum Half-Washer Permanent Magnet Alternator



BreakdrumHWPMA.vsd - 21 Jan 01

Notch a sheet of aluminum (or other non-magnetic metal or high temperature isolator) to act as a spacer between each of the half-washer units. To assemble place a thin .04-.08"(1-2MM) flexible sheets of rubber between the permanent magnets and half-washer unit to get the proper air gap. If using large flat magnets use a multi-layer-spacer approach or thicker spacer near the gap between the two magnets around the perimeter. This is to take into account the flatness of the magnet will cause a out of round stator core (center part) if equal spacers are used.

Assemble the unit using the two aluminum separator plates and the strength of the magnetic field holding the half-washer units in place. Use epoxy to hold it together to make a cylindrical shaped stator. Once hard take the stator out and sand or grind off the high spots until it is uniformly round.

If using ceramic magnets wrap finishing line (or strong string) around the perimeter of the stator unit so as to fill in the remanding half-hole in the washer. Apply epoxy to this string. Sand or grind off any out of round-ness of the half-washer stator unit as needed. If using the stronger Neodymium magnets use two strong cables or wires to help hold it together see previous picture for where the holes are in the washers. Do this wiring after the epoxy that holds the individual parts in place is set.

Note that in this approach the air gap does not have to have a coil of wire between the magnets and the stator, thus can be magnetically closer. End up with an air gap of about .08" (2MM) depending on "the free play" or tightness of the bearings. Make a bigger gap or bigger propeller if having trouble starting in light wind. This also will decrease power output.

Number of coils per each phase should be equal to half the number of magnets. Bigger wire and stronger and smaller magnets can be used to achieve more power output. With this design it is possible to use many small magnets and use one to two or more half-washers for each coil. The higher the number of turns/phase the more voltage or the slower the RPM to produce the same voltage.

The half-washers could be replaced with cutoff sections of 3/4-inch strap with a notch ground in the center for the copper wire to be wrapped on it. The half-washers could be replaced by purchasing pre-cut laminations based on half a transformer core. This would depend on availability.

It should be easy to decreases magnetic air gap by half or more over Piggotts design of 4-4.5MM. Since the half-hole in the half-washer can be made big enough for any wire size. Several gauge sizes bigger will result in about half the power of internal resistance loss. The overall wire length for the same number of turns should go down by about 1/2 to 1/3 due to the change in geometry of coil size. This decreases power loss even more to give an accumulative effect of about 1/4 to 1/6 of current design.

Neodymium magnets are becoming common place (showing up in surplus market for about 1$/each) and should work better than ceramic magnets being much stronger. The more the magnets around the perimeter the slower the speed to get the same voltage. I believe with these changes one could deliver usefully power in the 100-200 RPM range whether the need be hydro or wind driven AC or DC.

I personally like Idea 1 better than Idea 2. Metal strapping is readily available and on Idea 2 the cutting of this many washers would be a lot of work. However, both have the advantage of common every day availability.

Interested in comments and Ideas.

MikeL