

Electronics Enclosures Thermal Issues
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Indian Institute of Science, Bangalore

Lecture – 24
Prior art

If we see the working of this module; I will see if we have the VLC media player probably it will work.

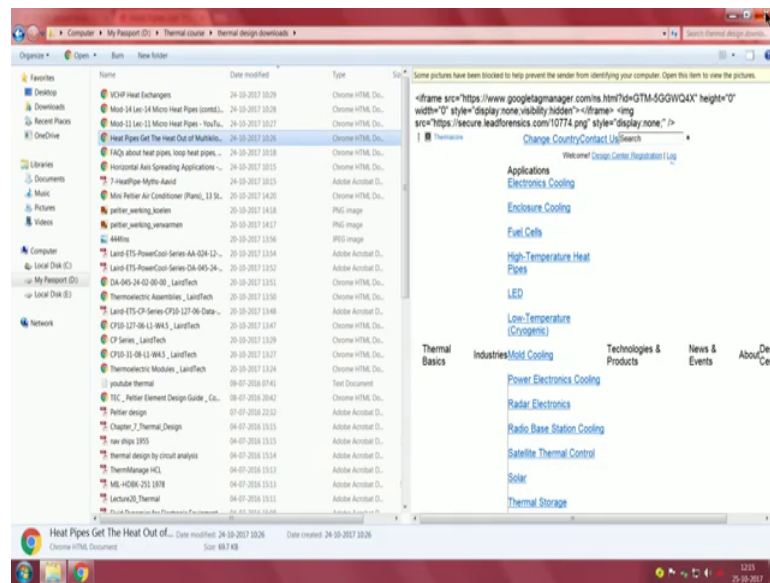
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Have a look at it [FL] ; see what is happening is [FL] 1 bit of the device is being picked up ; I think I need to replay the video [FL] ; I think it did not get copied and anyway let it be [FL]. So, it fix up and then it will put it back into a homing position wherever it likes to put [FL]. And then I think there is a problem I will try to bring it back later.

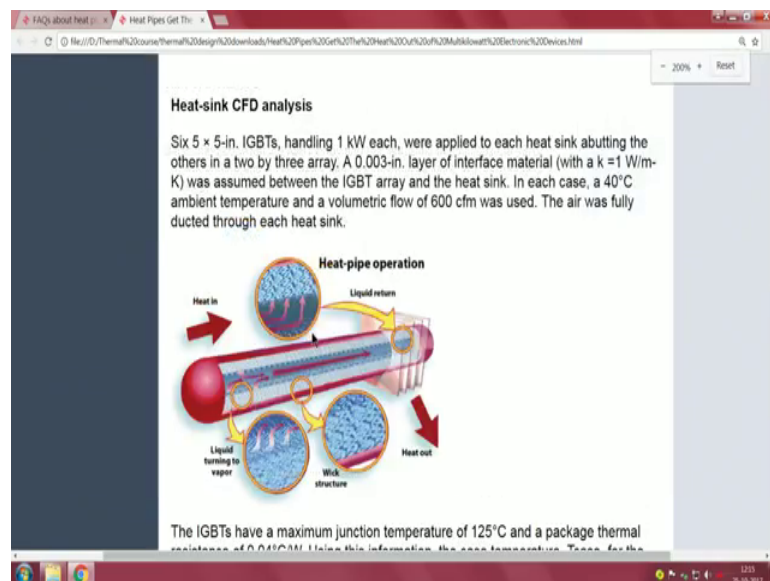
The issue being that each of these wells we can maintain it to any temperature we like. And then we can have these what do you call thermo electric modules built into it there one place we can probably have the thing copied and whole thing to be kept in a place as we like.

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I will now move on to another important thing called heat pipes.

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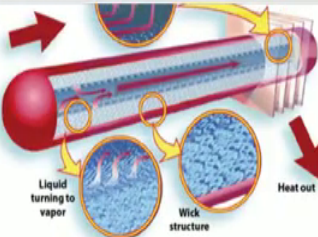


In passing, if you remember I had mentioned to you about a nice way of cooling things which are in a way relatively passive. The idea of passive is in the case of peltier we need to supply huge amount of power to it. So, my own what you call empirical thing is that 3 to 4 times amount of total energy is required to cool a given unit.

This I think so, many times even earlier I have explained to you saying at one point this is a working fluid inside a normal what do you call pipe. Instantly the pipe can even bane

insulator it need not necessarily be made of copper, but the end where which is collecting the heat needs to a conductor, other end which needs to be cold needs to be another conductor; in between you have this wicks. So, working medium boils condenses here.

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The IGBTs have a maximum junction temperature of 125°C and a package thermal resistance of 0.04°C/W. Using this information, the case temperature, T_{case} , for the IGBTs is $125^{\circ}\text{C} - 40^{\circ}\text{C} = 85^{\circ}\text{C}$. If the incoming ambient air is 40°C, the remaining temperature drop to dissipate the heat is $T_{case} - T_{ambient\ air} = 85^{\circ}\text{C} - 40^{\circ}\text{C} = 45^{\circ}\text{C}$. This information was used as input for the CFD analysis. In all situations, the model options selected included steady turbulent flow and conduction, negligible radiation heat transfer and negligible buoyancy effects. The air properties varied with temperature.

Now, read this. So, you will notice that when we talk about power electronics we end up with very very small raise in temperature with given voltage. Now, we will come back to the beginning of it and see what it is that they are talking about.

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Home > News & Events > Articles >
Heat Pipes Get The Heat Out of Multikilowatt Electronic Devices

Heat Pipes Get The Heat Out of Multikilowatt Electronic Devices

October 21, 2010

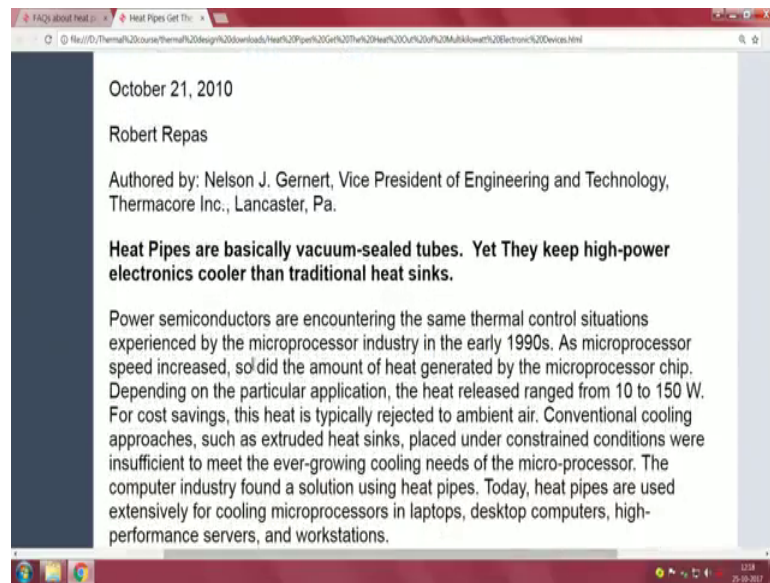
Robert Repas

Authored by: Nelson J. Gemert, Vice President of Engineering and Technology, Thermacore Inc., Lancaster, Pa.

Heat Pipes are basically vacuum-sealed tubes. Yet They keep high-power electronics cooler than traditional heat sinks.

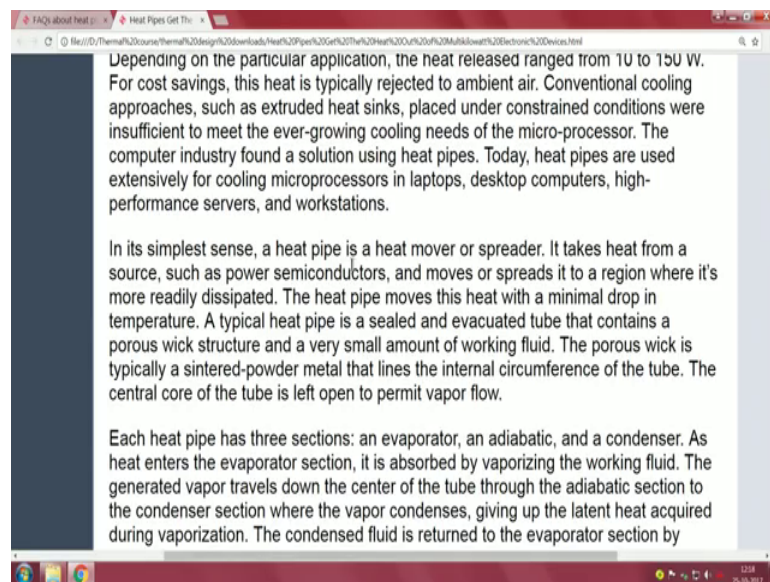
Power semiconductors are encountering the same thermal control situations experienced by the microprocessor industry in the early 1990s. As microprocessor

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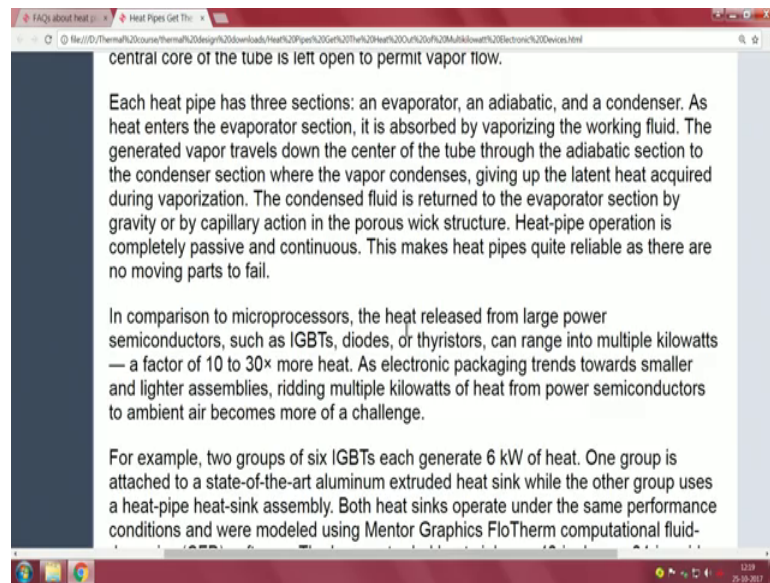
Volt heat pipes are basically vacuums sealed tubes; they keep high power electronics cooler than traditional heat sinks. So, if you go down.

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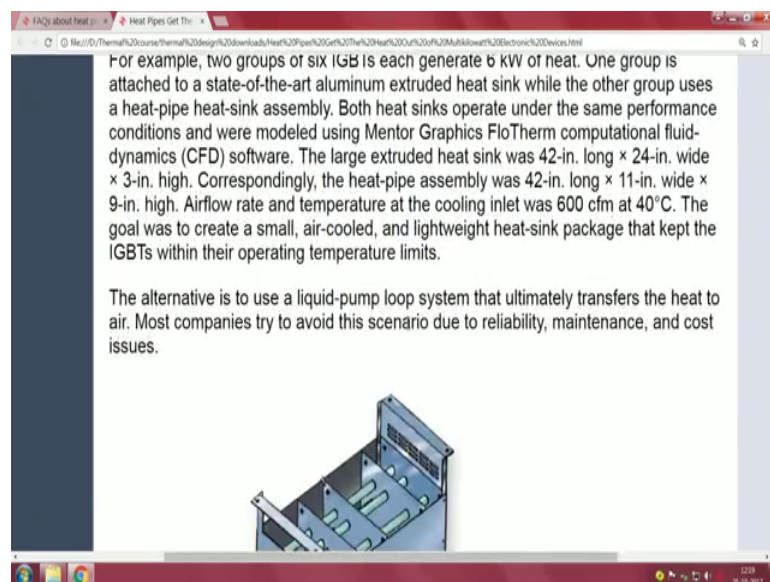
In its simplest a heat pipe is a heat mover or spreader takes heat from a source such as power conductors and moves it to a region where it is more readily dissipated. Heat pipe moves this heat with a minimal drop in temperature; typical heat pipe is a sealed and evacuated tube that contains a porous wick structure and a very small amount of working fluid.

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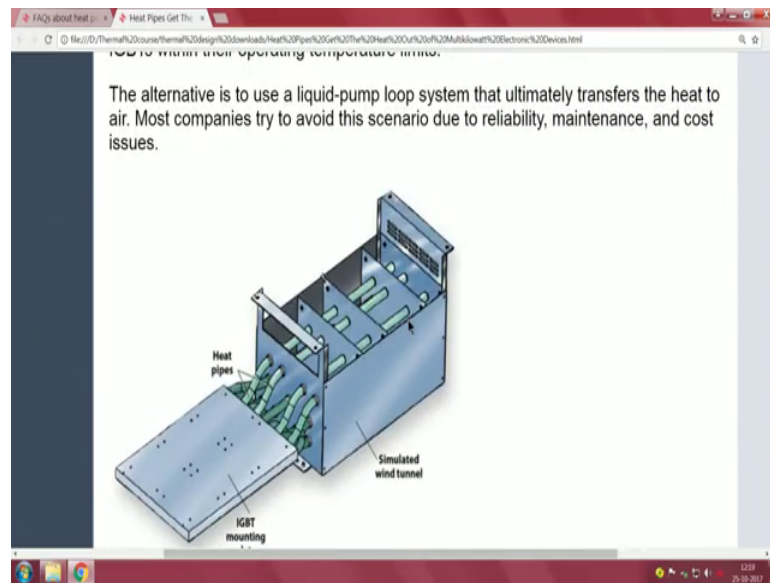


Porous wick is a sintered powder metal that lines internal circumference of the tube; the central core is left open to permit vapor flow an evaporator an adiabatic and a condenser as heat enters and so, on you read it for yourself.

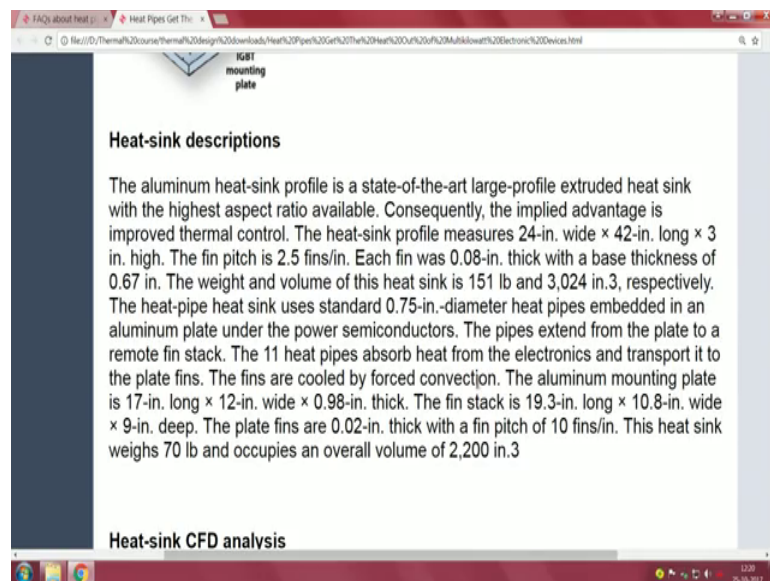
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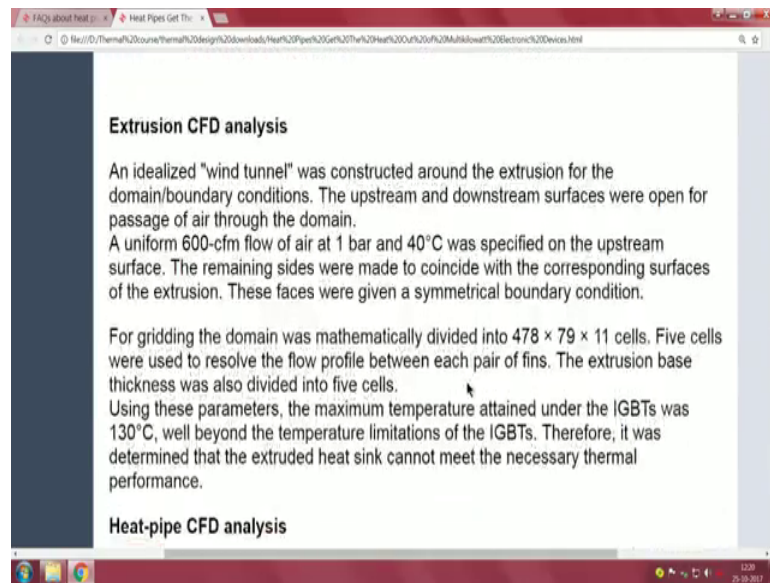


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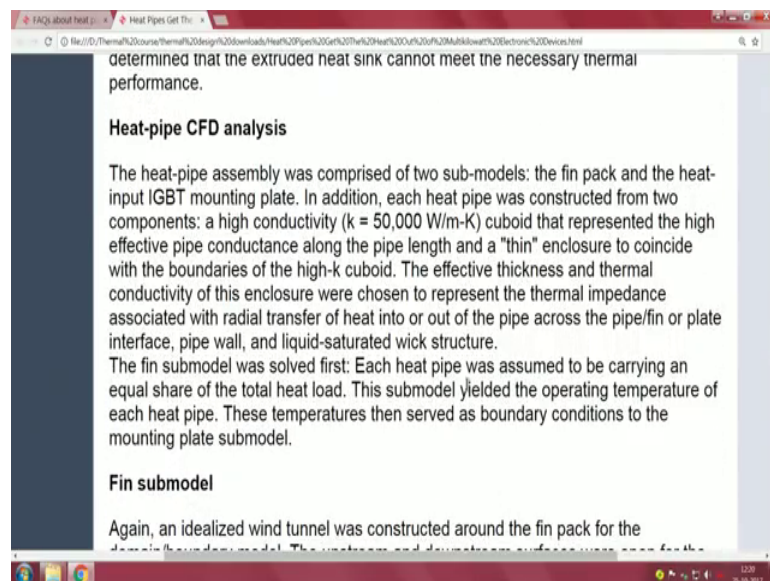
So, yourself you can go to thermal things and see things that have been given here as it is.

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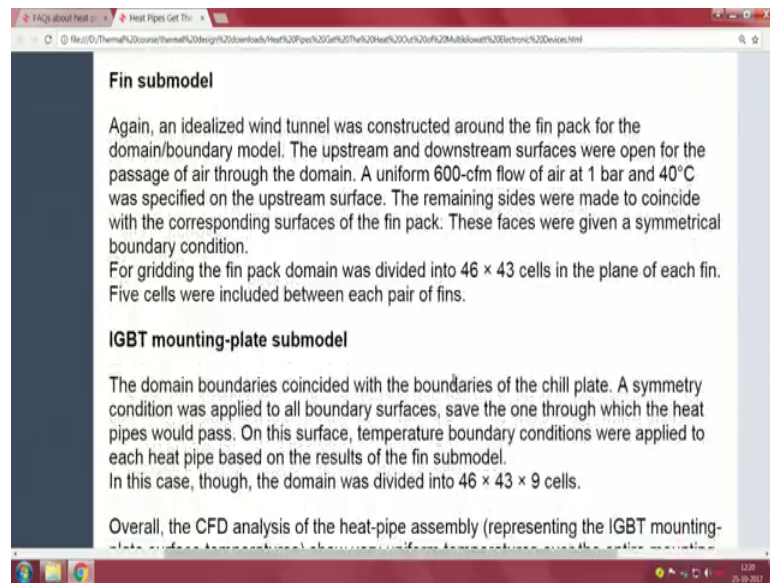


So, lot of analysis has been carried out.

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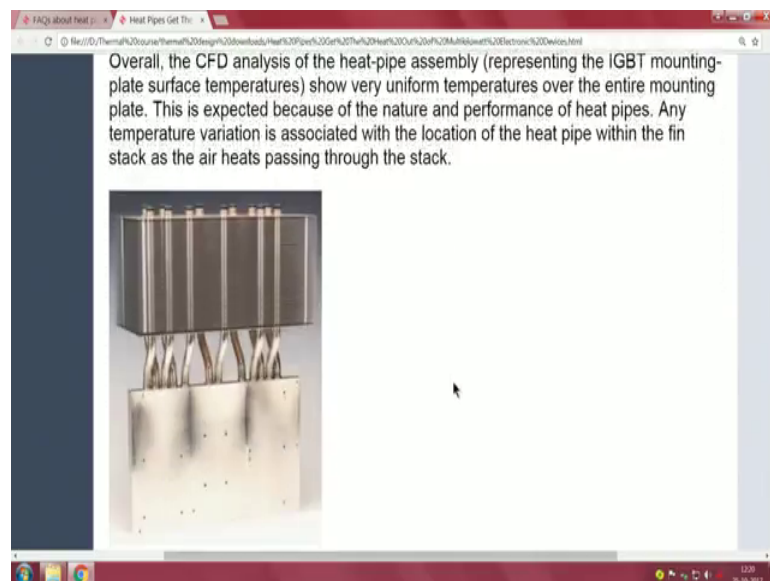


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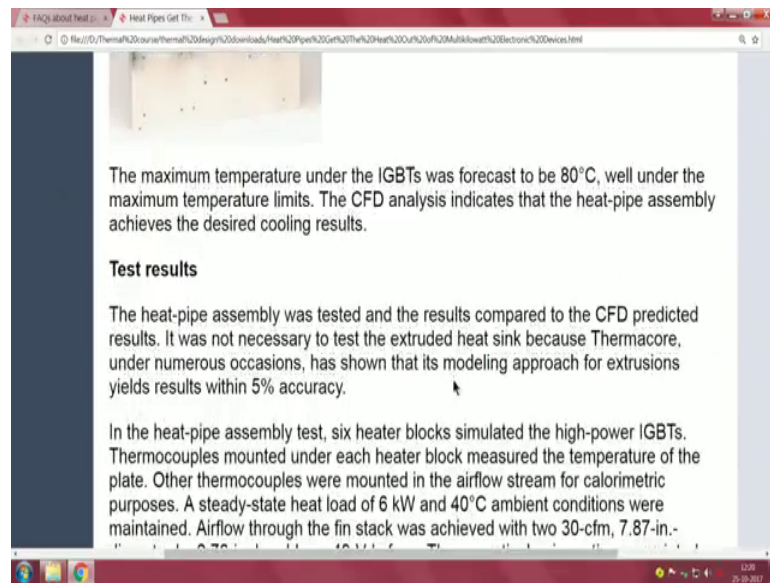


So, it is a matter of I think you know it your leisure you can read things.

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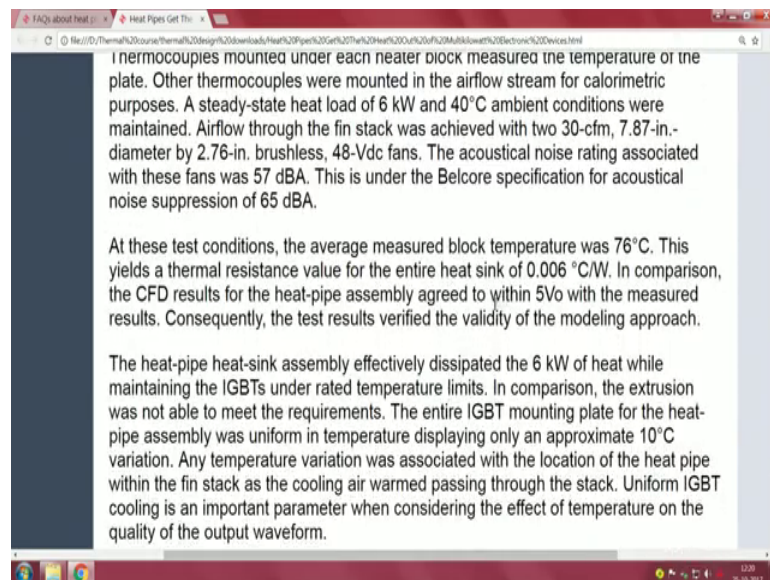


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Test results heat pipe assembly was tested compared to the CFD predicted; six heater blocks simulated the high power IGBTs; thermocouples mounted and so on; acoustical noise is a thing.

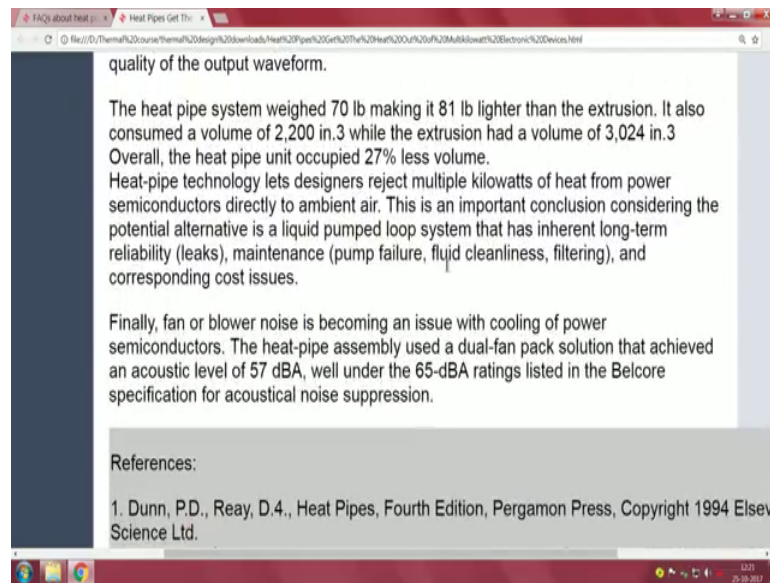
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At this stat condition the average measure block temperature or 70 to 76 degrees; this yields a thermal resistance value of the entire heat sink of 0.006 degree centigrade per watt.

So, this is the sort of things which we were talking about all the time.

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quality of the output waveform.

The heat pipe system weighed 70 lb making it 81 lb lighter than the extrusion. It also consumed a volume of 2,200 in.³ while the extrusion had a volume of 3,024 in.³ Overall, the heat pipe unit occupied 27% less volume.

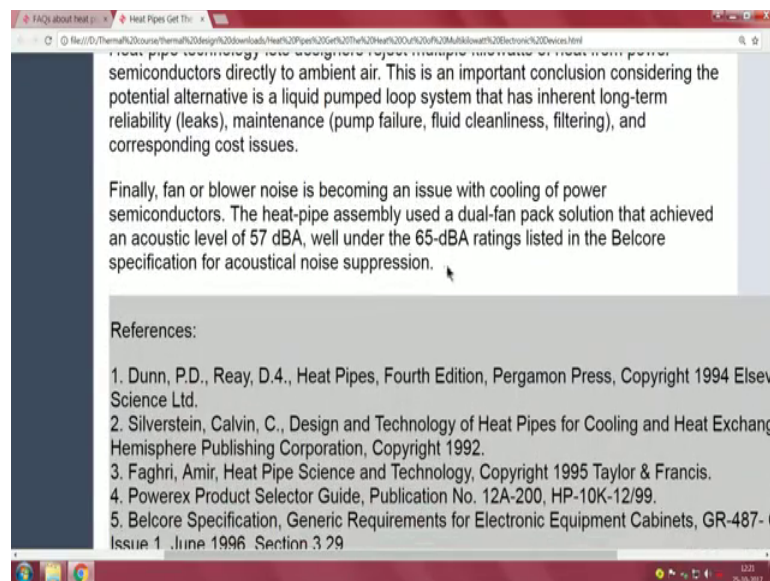
Heat-pipe technology lets designers reject multiple kilowatts of heat from power semiconductors directly to ambient air. This is an important conclusion considering the potential alternative is a liquid pumped loop system that has inherent long-term reliability (leaks), maintenance (pump failure, fluid cleanliness, filtering), and corresponding cost issues.

Finally, fan or blower noise is becoming an issue with cooling of power semiconductors. The heat-pipe assembly used a dual-fan pack solution that achieved an acoustic level of 57 dBA, well under the 65-dBA ratings listed in the Belcore specification for acoustical noise suppression.

References:

1. Dunn, P.D., Reay, D.4., Heat Pipes, Fourth Edition, Pergamon Press, Copyright 1994 Elsevier Science Ltd.

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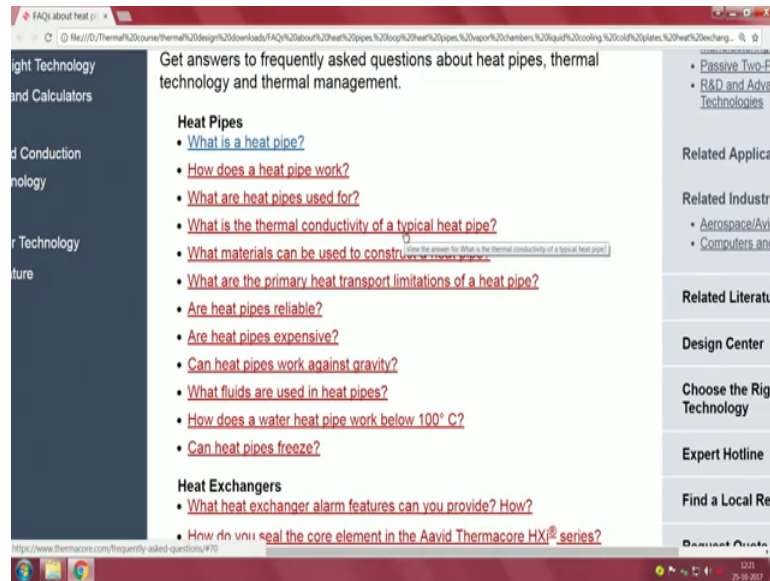
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References:

1. Dunn, P.D., Reay, D.4., Heat Pipes, Fourth Edition, Pergamon Press, Copyright 1994 Elsevier Science Ltd.
2. Silverstein, Calvin, C., Design and Technology of Heat Pipes for Cooling and Heat Exchange, Hemisphere Publishing Corporation, Copyright 1992.
3. Faghri, Amir, Heat Pipe Science and Technology, Copyright 1995 Taylor & Francis.
4. Powerex Product Selector Guide, Publication No. 12A-200, HP-10K-12/99.
5. Belcore Specification, Generic Requirements for Electronic Equipment Cabinets, GR-487- Issue 1, June 1996, Section 3.29

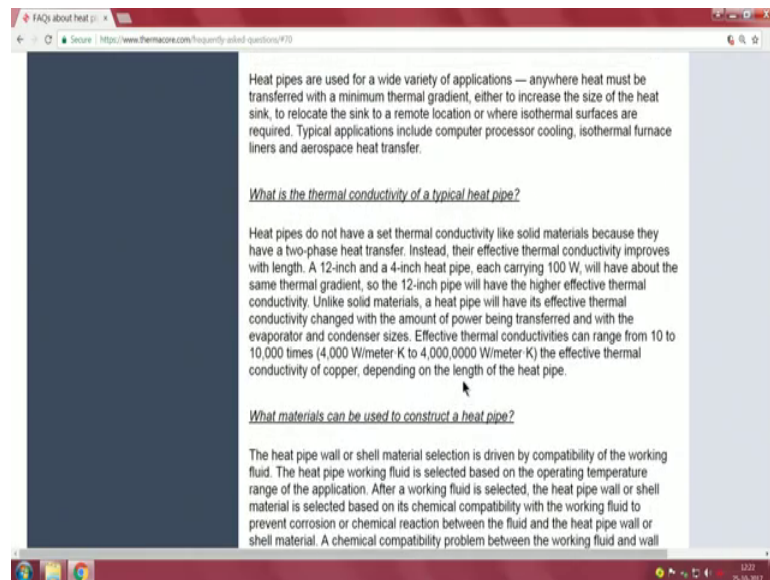
Somebody has made this what do you call presentation; I suggest you can try to read about it.

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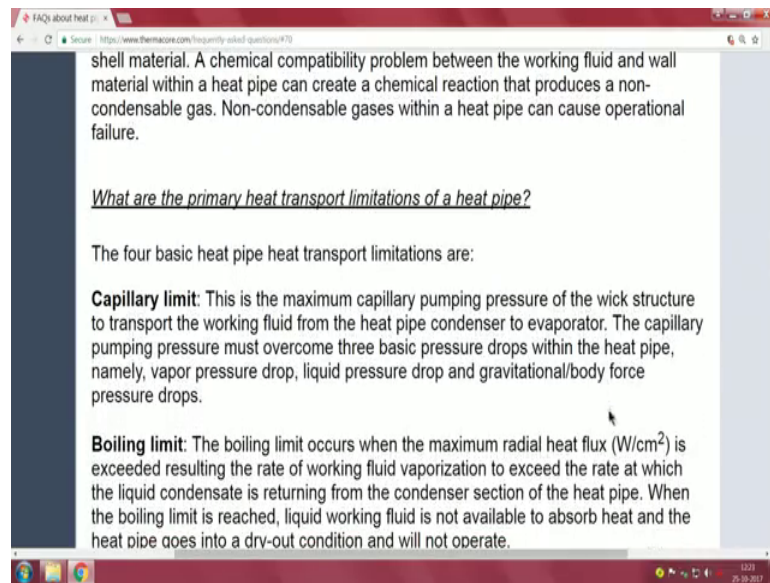
Typically heat pipe work; I have used what is the heat pipe I have showed you what are the used for I mean it is there absolutely.

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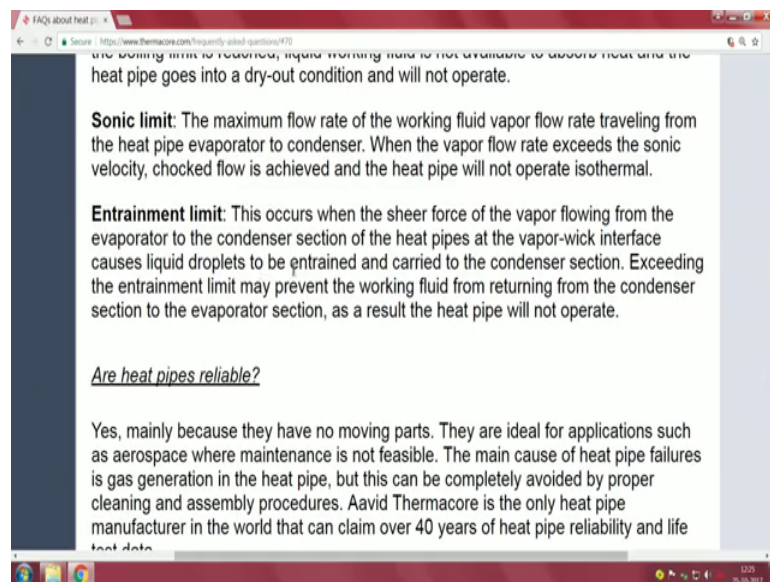
This is a very interesting thing; seen that the intentionally, I wanted to show you in print. Effective thermal conductivities can range from 10 to 10000 times; the effective thermal conductivity of copper. So, figures do not lie these are not statistic; so, they are not you know other type of lives also.

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So, we have here lot more what are the 4 basic heat pipe heat transport limitations are capillary limit.

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This is the maximum capillary pumping pressure of the wick structure transport the working fluid from the heat pipe condenser to the evaporator. Capillary pumping pressure must overcome the basic pressure drops within the heat pipe; vapor pressure drop, liquid pressure drop and gravitational body force pressure drops.

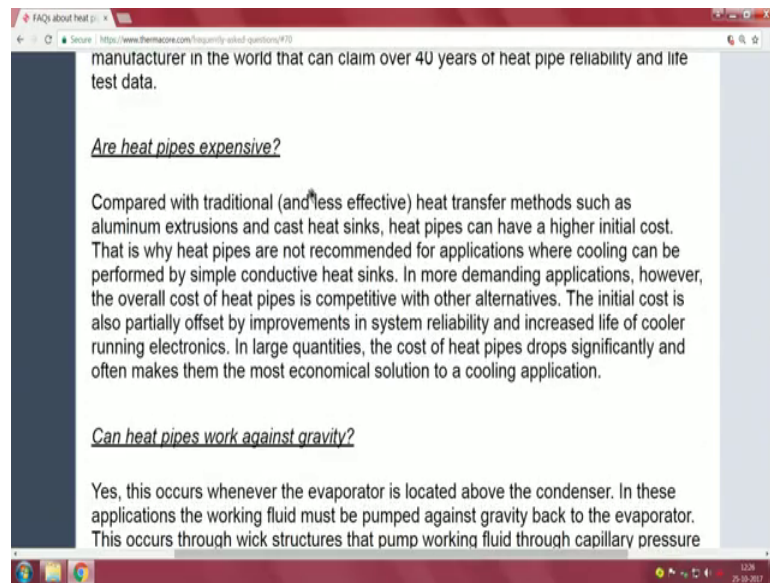
So, orientation also seems to make a difference; next comes to boiling limit. Boiling limit occurs when the maximum radial heat flux is exceeding resulting the rate of working fluid vaporization to exceed the rate at which liquid condensate is returning from the condenser section to the heat pipe. It is a little like your mud pots there is general I do not know its myth or what do you call nice dream; aerometric dream that if you take a for its pot and then put water into it, it becomes cool.

There are people who claim I find it as called as a refrigerator; that is if you have a good cooling system I mean what you call this evaporative cooling versus a bad what you call normal refrigerator; probably there about the same, but it never can beat a you know power in devise. And the rate of diffusion of the liquid through the; what you call that material of the pot has to match with the evaporative capacity is everything is matched you get the cooling which you are talking about.

So, it involves two things dryness of the air outside and the amount of the air that is flowing and so, on. Same thing happens here rate of working fluid vaporization and liquid condensate returning from the condenser section of the heat pipe. And the boiling limit is reached liquid working is not available to absorb heat; the heat pipe goes into a dry out condition will not operate; it is the whole thing becomes hot and it is not able to this thing what you call operate.

Maximum flow rate of the working fluid traveling on the heat pipe evaporator condenser; and the heat flow exceeds the sonic velocity choked flow is achieved and the heat pipe will not operate and entrainment.

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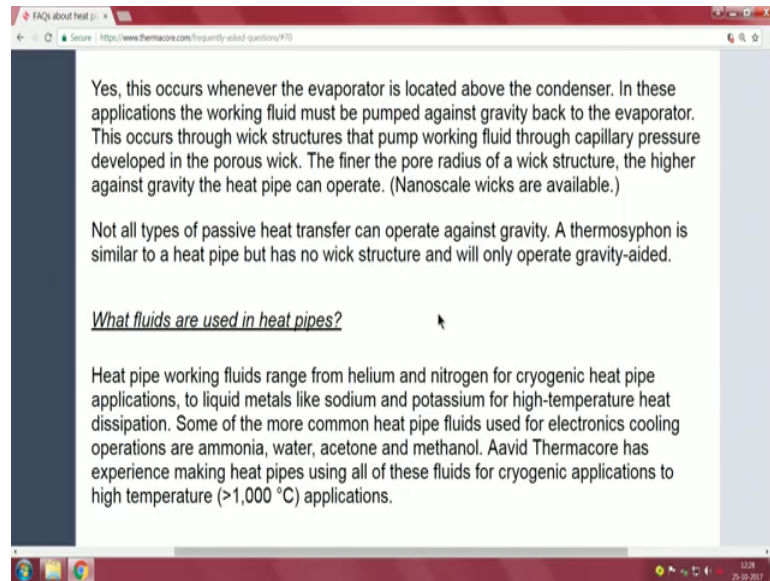
When the shear force of the vapor flowing from the evaporator to the condenser or the heat pipes at the interface causes liquid droplets to be entrained and carried to the condenser exceeding the entrainment and so, on.

In certain conditions it will not work; so, it is unlike putting simple copper tube and expecting to work. So, at the reliable of course, yes they have no moving parts ideal for applications such as aerospace where maintenance is not feasible. Main cause of heat pipe failures is gas generation in the heat pipe can be completely avoided by proper cleaning and assembly procedures and so, on and so, on are expensive.

Yes, initially they are very expensive to start with as (Refer Time: 13:15) not the design cost and this thing do not simple to design those things. If cooling can be performed by simple conductive heat sinks that is the best way to do it. In more demanding applications overall cost of heat pipes is competitive with other alternatives; initial cost is partially offset by improvements in system reliability and increased life of cooler running.

Large quantities the cost of heat pipes drops significantly and often makes them the most economical solution to a cooling application. Specifically in that what do you call IGBT cooling and all that and I have also shown you in the earlier picture, a game console such places you have a margin in the reality is there.

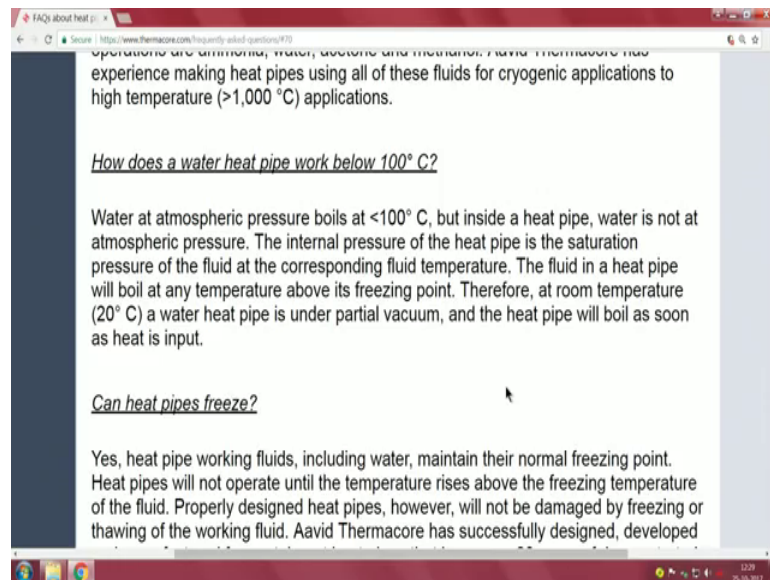
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But then remember some of the game places even first liquid cooling is used. And we come to important thing can they work against to gravity are it has to be horizontal. The pictures they have shown there is shown horizontal; in these applications working fluid must be pumped against gravity back to the evaporator. This occurs through wick structures and pump working fluid through capillary pressure; finer the pore radius of a wick structure the higher against gravity nanoscale.

Not all types of heat transfer can operate against gravity; a thermosyphon is similar to a heat pipe, but has no wick structure and will only operated in gravity aided. So, depending on it is natural if the condensing section is on top and the heating section is on the bottom; obviously, it can work if it is upside down it will work slightly you know differently.

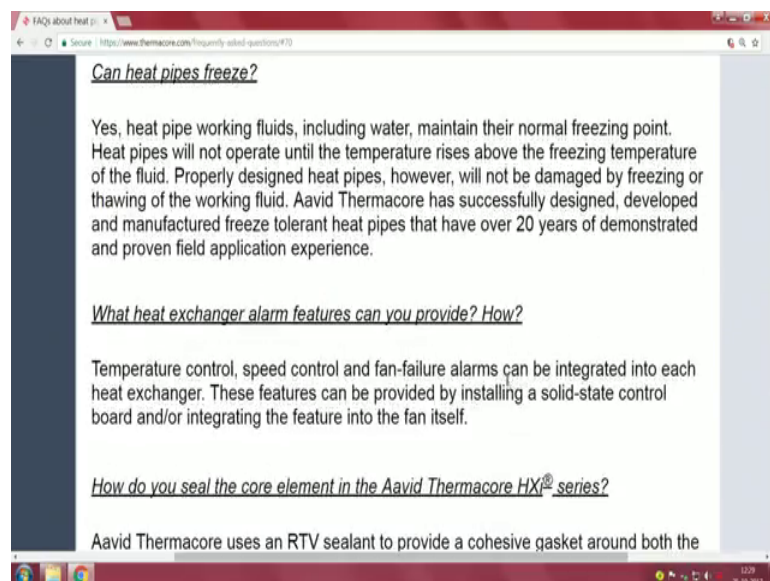
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So, we have working fluid helium and nitrogen for cryogenics to liquid like sodium and potassium metals for high temperature heat dissipation; more common heat pipes used ammonia, water, acetone and methanol. You can make it yourself you go to YouTube I will show you one or two pictures of those things.

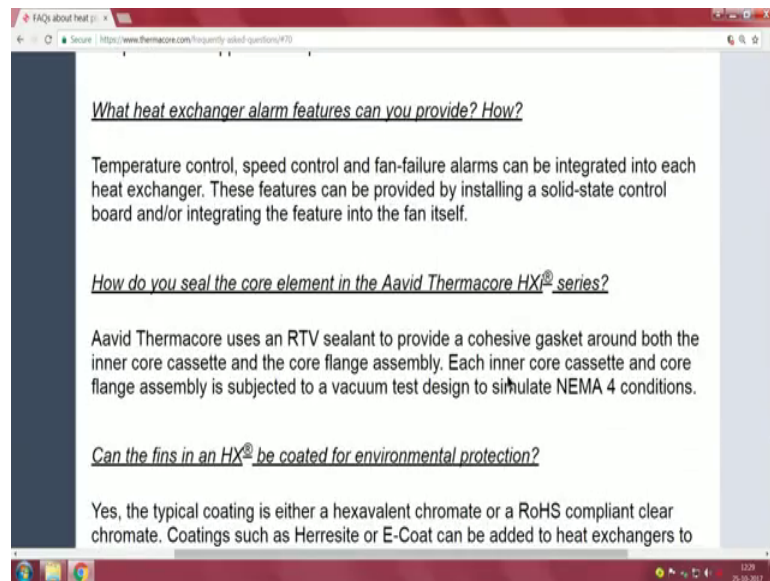
What we have is probably normal alcohol that is what you call methyl alcohol. And these are acetone is a common solvent; so, you have mixture of all these things. So, we have all this stuff here.

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So, all these things if I suggest know we will get back if there is a way of coming back.

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What heat exchanger alarm features can you provide? How?

Temperature control, speed control and fan-failure alarms can be integrated into each heat exchanger. These features can be provided by installing a solid-state control board and/or integrating the feature into the fan itself.

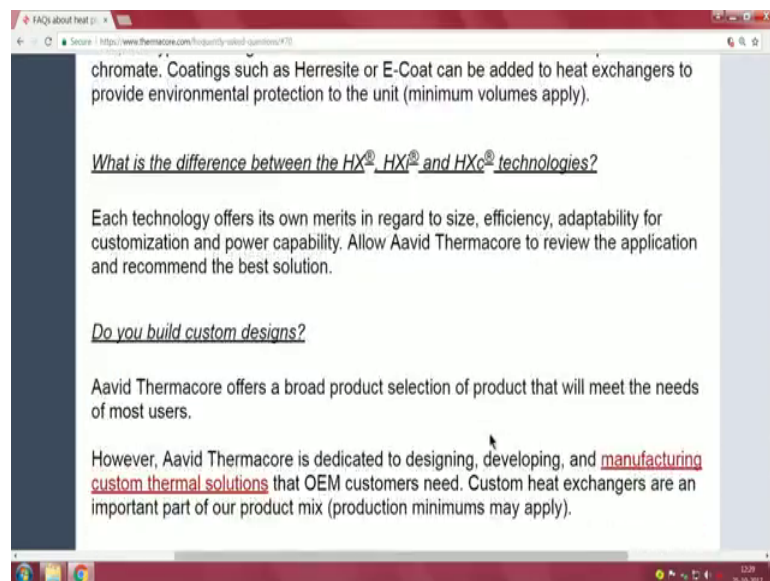
How do you seal the core element in the Aavid Thermacore HX[®] series?

Aavid Thermacore uses an RTV sealant to provide a cohesive gasket around both the inner core cassette and the core flange assembly. Each inner core cassette and core flange assembly is subjected to a vacuum test design to simulate NEMA 4 conditions.

Can the fins in an HX[®] be coated for environmental protection?

Yes, the typical coating is either a hexavalent chromate or a RoHS compliant clear chromate. Coatings such as Herresite or E-Coat can be added to heat exchangers to

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chromate. Coatings such as Herresite or E-Coat can be added to heat exchangers to provide environmental protection to the unit (minimum volumes apply).

What is the difference between the HX[®], HXc[®], and HXc[®] technologies?

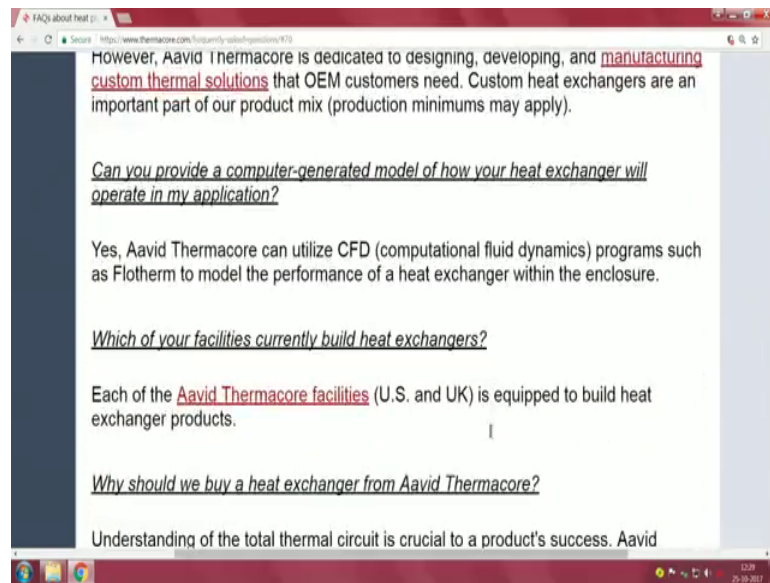
Each technology offers its own merits in regard to size, efficiency, adaptability for customization and power capability. Allow Aavid Thermacore to review the application and recommend the best solution.

Do you build custom designs?

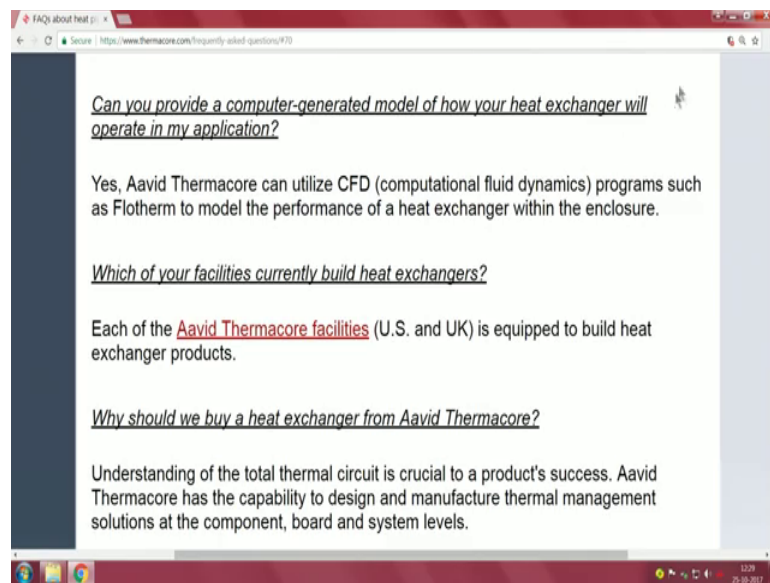
Aavid Thermacore offers a broad product selection of product that will meet the needs of most users.

However, Aavid Thermacore is dedicated to designing, developing, and manufacturing custom thermal solutions that OEM customers need. Custom heat exchangers are an important part of our product mix (production minimums may apply).

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So, we have so, many things which are mentioned here.

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7 Common Myths & THE TRUTH ABOUT HEAT PIPES

Heat Pipe Basics

Developed in the 1960's, heat pipes are becoming more and more prevalent in today's cooling systems.

Many engineers that have worked with thermal management are familiar with the basic concept: heat pipes transfer heat from the source to a location where it can be safely or more easily dissipated.

All heat pipes work with the same basic cycle:

1. Heat is absorbed from the device at one point on the heat pipe
2. The absorbed heat evaporates local liquid into a vapor
3. That vapor travels to a cooler region of the pipe
4. The vapor then cools and condenses back into liquid
5. The liquid travels back down the wick to the heat source through capillary action

Let me show you a little more about few other things I could not retrieve the thing in time.

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3. That vapor travels to a cooler region of the pipe

4. The vapor then cools and condenses back into liquid

5. The liquid travels back down the wick to the heat source through capillary action

As there are no moving parts, this cycle can repeat indefinitely. Additionally, because of the latent heat of vaporization, fluid can absorb and carry more energy or heat during phase change from liquid to a vapor. This provides a much higher effective conductivity than the metals typically used for heat sinks or single phase cooling.

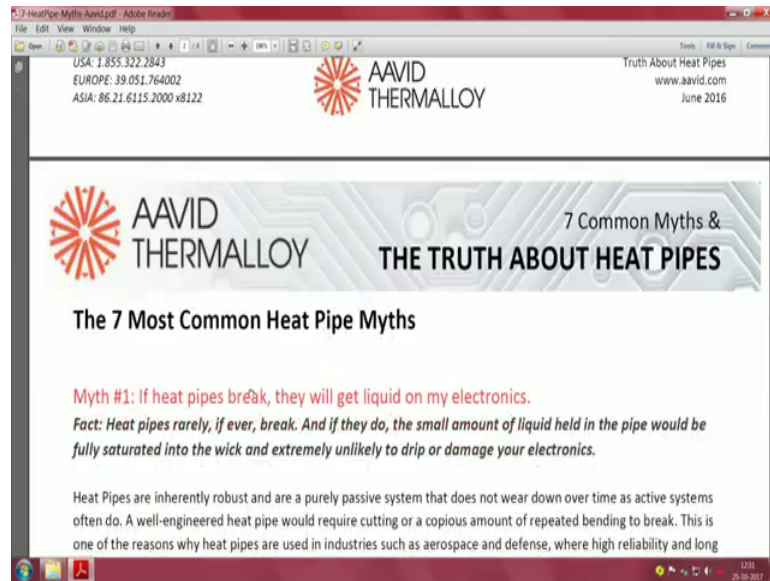
Sounds simple. However, heat pipes still remain a commonly misunderstood technology.

Aavid has been on the cutting edge of heat pipe technology for over 20 years and as the industry leader is responsible for many of the most advanced integrated heat pipe assemblies in use today. We have developed heat pipe solutions for a wide range of devices across all industries, from small consumer electronics to aerospace applications.

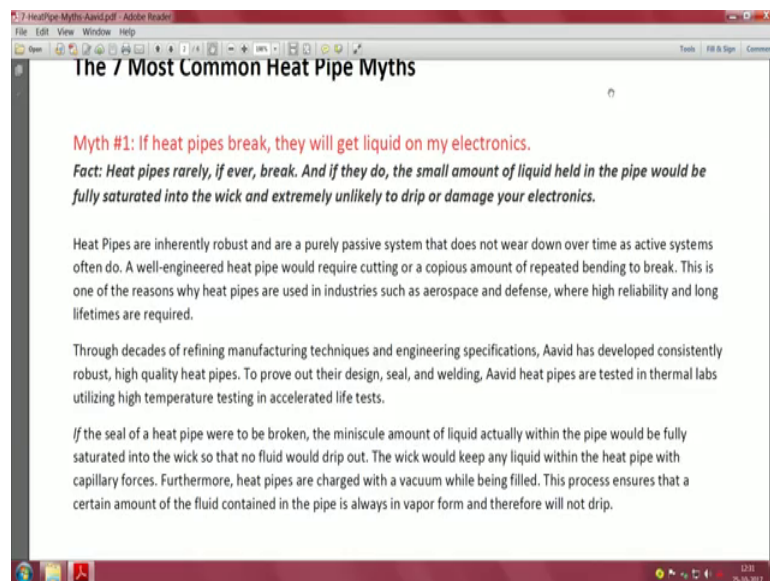
As we continue to develop innovative cooling solutions utilizing this technology, we've come across a number of widespread industry myths about heat pipes. It is time they were dispelled.

So, these are all basics and you will notice that these are all probably spinners of various what you call government sponsored or things here. So, this basic working and you see here we have beautiful assemblies which have all these things.

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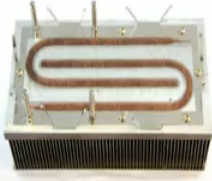
Now, myths I think you should read it yourself; it is not liquid cooling it does not need type of pressure tight what you call design. And it is generally being under vacuum and the moment any leakage comes no liquid will ever come out and likely to short circuit your device as compare to water cooling or other things ok. The miniscule amount of liquid actually within the pipe would be fully saturated into the wicks or now fluid will drop out.

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certain amount of the fluid contained in the pipe is always in vapor form and therefore will not drip.

Myth #2: Heat pipes are heavy.
Fact: Heat pipes can remove more weight than they add to an assembly.

Aavid engineers often integrate heat pipes into custom cooling solutions in order to decrease the weight or volume of the overall solution. Although most often made of copper, heat pipes are hollow and can decrease the weight of your solution while improving thermals in a variety of ways. In many assemblies, heat pipes are used to transfer heat to a cooler, more open area of the device, where a fan can be added to decrease the size and weight of your cooling solution.



Another common example is replacing a traditional copper spreader with an aluminum heat sink base that has embedded heat pipes. These heat pipes can be arranged to target spreading to specific locations while reducing the amount of copper needed and therefore reducing the overall weight and cost of your solution.

Above: Embedded heat pipes to enable a much smaller heat sink.

Second myth heat pipes are heavy; the moment you talk about piping you probably you know confess with it plumbing ; not necessary what looks like a simple copper tube with two projections are both ends, the reality is it is not true.

So, if you were use a copper pipe which has the equivalent thermal conductivity and huge heat sinks; that would be much much heavier than a heat pipe; because basic place which we take away heat from that will be small and be working fluid and that will be small. The last heat spreader will be about the same because we need to spread heat to the ambient.

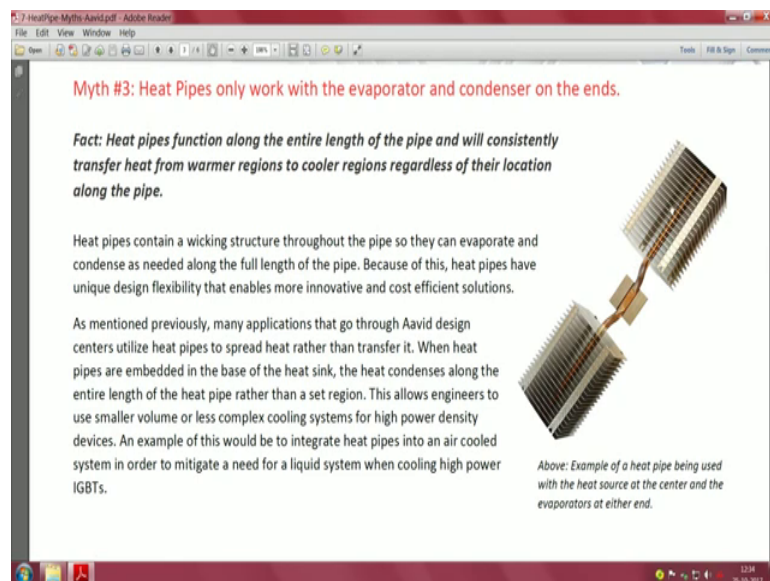
And then the temperature only thing is you have a little bit of control; you make the heat sink run at a higher temperature. The more ΔT with ambient that is heat sink surface temperature to the ambient the bet of the heat transference. As I have explained to earlier cold the heat sink is not doing anything it just you know made for the creative purposes. And another important thing is there is a more open area of the device where a fan can be added to decrease the size and weight of your cooling solution.

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So, if you take away the heat way convenient point then.

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Very interesting thing here; so, far things we have shown are there is a long tube in which there is warm and cold region and hence know it should be long thing. Heat pipes have design flexibility they can have more cost effective solutions heat pipe being used with the heat source at the center and the evaporators at both the ends ; you have seen that no? The heat is being spread into two structures; so we have here heat source which you know sends it to the various you know places and where the evaporation can take place.

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Myth #4: Heat pipes only spread heat in a straight line. If I want to spread heat along the whole base, I need a vapor chamber.

Fact: Heat pipes can be bent and used in a manner similar to a vapor chamber but with more structural integrity.

Although a heat pipe only moves heat along its axis, this axis can be bent or used with multiple heat pipes to act effectively as a planar spreading mechanism similar to a vapor chamber. Aavid engineers accomplish this through years of experience designing and modeling heat pipe bends and arrays that effectively translate heat pipes from a one dimensional heat transfer unit into a two dimensional heat spreader.



While they can be designed to mimic the function and performance of a vapor chamber, heat pipes are less expensive and offer increased structural integrity. When embedded correctly, heat pipes can accommodate a significant amount of mounting force in applications where vapor chambers proved too delicate.

Above: Example of heat pipe spreaders within a heat sink base to mimic a vapor chamber

Heat pipes only spread heat in a straight line; if I want to spread it along the whole base I need a vapor chamber. And here it is given here saying heat pipes can be bent and used in a manner similar to a vapor chamber with more structural integrity. Vapor chamber is what elsewhere it will; it is small you know thing which is mounted on top of a chip so, that the you know boiling and condensation can be taking place at the border time. So, we have here a heat pipe which looks little like a vapor chamber.

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Truth About Heat Pipes
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7 Common Myths &
THE TRUTH ABOUT HEAT PIPES

Myth #5: It has to be very hot for heat pipes to work.

Fact: Manufacturing techniques enable heat pipes to function even with small temperature rises.

Because heat pipes are charged with a vacuum prior to sealing, the fluid exists as both a liquid and a vapor at its saturation point. This is similar in principle to boiling a liquid at higher elevations with lower pressures. It takes much less heat for the molecules to be energized enough to change phase from a liquid to a vapor. Therefore the temperature of the heat source does not need to reach the standard room temperature boiling point to cause the liquid to vapor phase

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Myth #6: Heat pipes cannot be used in freezing conditions.
Fact: How a heat pipe operates in environmental conditions is dependent on materials and design. Heat pipes can be developed to function in extremely rugged conditions such as freezing environments.

Although copper and water is the most popular combination, other materials can be used based on specialized requirements. Liquids such as ammonia, methanol, and acetone can all be combined with compatible metals to develop heat pipes that can function in temperatures well below -60°C.

Even with copper and water, the solution can be designed to


Next it has to be very hot for heat pipes to work; that is another thing which is true in the case of actual simple convective heat sinks, but in the case of what you call heat pipes we have a control of it. The temperature of the heat source does not need to reach the standard room temperature boiling point to cause the liquid to change. In fact, a few difference is needed between hot and areas of a heat pipe to make it function one of the advantages.

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Even with copper and water, the solution can be designed to mitigate environmental conditions. By utilizing the proper thermal technologies and techniques, thermal solutions with integrated heat pipes can even enable device functionality such as cold start for applications such as outdoor telecom, industrial, and military. With the correct design parameters, heat pipes can also withstand a large number of repeated freeze/thaw cycles without any bursting or failures.

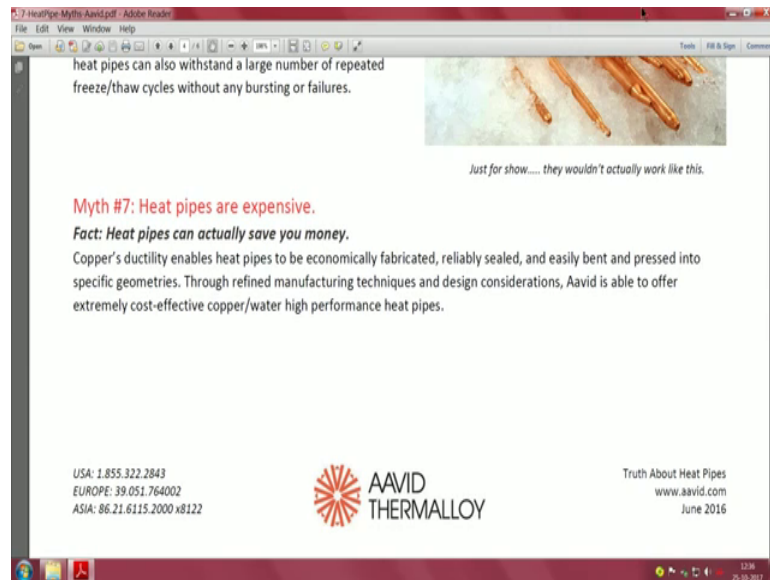


Just for show.... they wouldn't actually work like this.

Myth #7: Heat pipes are expensive.
Fact: Heat pipes can actually save you money.
Copper's ductility enables heat pipes to be economically fabricated, reliably sealed, and easily bent and pressed into

Than heat pipes cannot be used in freezing conditions; how heat pipe operates in environmental conditions is dependent on materials and design. Heat pipes can be developed to function in extremely rugged conditions such as freezing environments also.

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Expensive no because he is the merchant to selling in and for given application, it is not necessarily to be that expensive. We have various options here to worry about are rather know start making things as we like.

Now, I thought I will take you to some links which I have saved. I hope I am able to retrieve it here, it has to connect to the, what you call internet. So, one of our Professor Das Gupta and Doctor Somanath Gangully of IIT Kharagpur, they have made this video and some reason it does not seem to be loading fast enough.

So, next round when I get a chance I will oppose this links to you. And I am sure you will be able to retrieve these things and show them how well they work. So, at this point probably I will give a break and we will try to get back and see how best we can; there are some problem with the there is some problem with the video, I am not able to show in eventually I will show it. So, thank you after I download the videos; I will try to show you so.

Thank you for a while now.