Part # 44
Carb Ice: The Threat And The Theory

by Mike Stratman
with Dennis Pagen

Throttling back from cruise you set up a long glide to your home field in the distance. As you descend you can feel the air change temperature as you pass into a new inversion layer. The air is now cool and moist. After several minutes the engine starts to lose rpm, you increase the throttle setting without a response. The engine begins to run rough and shake. You work the throttle furiously to no avail. Despite your best efforts the engine quits. Have you just been a victim of Carb Ice?

For years the debate on the facts and fiction surround Carb Ice in Rotax engines has raged. Many pilots, especially from a general aviation background, are used to dealing with certain procedures while in flight and find our cavalier "lack of concern" about carb ice troubling. For reasons that we will discuss this month, carb ice is a not always a problem in Rotax aircraft engines. Verifiable or documented cases of carb ice on Rotax engines are actually quite rare. What do I mean by "Documented Carb Ice?" Your engine quits in flight, you land, pull off the air cleaner, and the venturi is clogged with ice. If you have actually had this happen to you I would like to hear from you. According to the experts I have talked to, you may likely be a very small minority. To this date only one 277 pilot has seen these phenomena and reported it.

When research on this subject started, it became obvious that Carb Ice was an engine problem created by micrometeorology conditions. So in pursuit of the truth it was logical to start with the expert on micrometeorology, Ultralight Flying! magazine contributing editor, Dennis Pagen. Dennis was nice enough to share with me his "fact sheet" on Carb Ice. Here are some of the conditions that Dennis feels make for carb Ice.

1. Carburetor Icing can occur from 20F to 90F but is most likely in the 35F to 65F with around 60F being the most suspect (from airplane records).
2. The problem isn't the temperature so much as humidity. Humidity over 50% is especially conductive to icing. Icing possibilities increase as the humidity increases.
3. Lower temperature usually results in air too dry for icing to occur.
4. A humid cloudy day is most likely to result in icing.
5. Flying in clouds or fog (a violation of FAR Part 103 regulations) is more likely to produce icing in our type of flying.
6. Ice usually forms past the venturi and can interfere with throttle and/or cut off the air passage. This is most drastic when the engine is idled back for landing (like the guy in our opening paragraph).
7. One sign of icing is a gradual slowing of the RPM without changing the throttle.
8. Inversion layers may exist whereby icing conditions are more in evidence than lower down, so we can climb with plenty of power and suddenly experience icing in an inversion. In the East inversions can be any height in a high pressure system (clear cool day). In a low pressure system inversions don't usually occur, but plenty of humidity abounds so icing can be a problem. In the West, inversions are more likely due to local effects and terrain allowing different layers of air to move into an area. Whether or not these inversions present an icing problem depends on where the air mass originates. The generally drier air in the West reduces the problem greatly.
9. Ice forms for two reasons: drop in temperature due to the drop in pressure in the venturi (about a 5 degree drop in temp) and due to evaporation of gasoline as it mixes with air (this drop can be 60F or more) The total drop in temperature can be up to 70F below the ambient air.

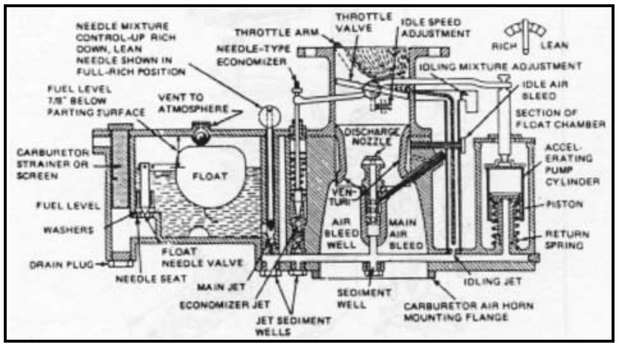

Figure #1 - Carburetors using a butterfly valve are more prone to icing of these parts that may lead to a compromise of engine performance.

Yes, that's a lot to absorb. It does give you a good idea under what conditions carb ice may become a factor. What we need to do is apply these conditions to our Rotax engine by examining the three different types of icing as recognized by the FAA.

Impact Ice: This type of hazard is just what it says. Ice or snow that is ingested into the air intake by impact. In general aviation this can become a problem in actually blocking the air intake with ice and snow. This is obviously not possible in the kind of conditions that sport aircraft are flown. If you flew in these extreme conditions, blockage of the air cleaner would be not be your primary concern!

Throttle Ice: This type of ice is the actual freezing and/or blockage of the butterfly valve located before the venturi. See figure #1. Here is where slightly warmed intake air is the correct answer as we discuss a little later. Bing Carburetors have no butterfly valves so this is not a possibility on Rotax two cycle engines. The Rotax 912 does use a Bing "Constant Compression Carburetor" that is basically a variable-venturi carb that also has a butterfly valve. See figure #2. Reports have indicated that when equipped with a Carb Air Temp Gauge (CAT) the temp never approached the magic 32F needed for throttle ice even after several transcontinental trips under a wide range of conditions..

Fuel Vaporization Ice: By theory this is the only type of icing that the Rotax could fall victim to. This is caused when the fuel/air mixture reaches a freezing temperature as a result of the cooling of the mixture during the expansion process between the carb and engine manifold. On some types of aircraft engines this distance could be considerable giving the mixture the time and surface area needed to freeze and stick. On the Rotax engine this area is the relatively small area from the carb slide to the intake manifold. The temperature of the surround metal parts would also have to reach 32F for the ice to actually stick and form a blockage instead of being ingested. The close proximity of the engine heat makes this even more difficult. The relatively large diameter of the slide (in comparison to a butterfly valve) added to any movement of the slide makes ice difficult to form in this area.

Different Venturi Configurations: One important consideration is the type of Carburetor used on the engine. On general aviation engines a butterfly valve controls the air flow through the venturi area. The venturi area is a fixed passage and the air is regulated by a throttle valve further upstream. The fuel is drawn into the venturi by the low pressure it creates. This is where the icing will take place. In short, on this type of carb the venturi air flow is not consistent with the size of the venturi. See Figure #3.

On the BING carb the venturi area varies by the throttle setting because of the slide movement. In other words we have a "variable venturi carb" design. See figure #2. Here lies the big difference that makes the BING carb on the Rotax engine not prone to carb icing. The following is a direct quote from Aircraft Powerplants Fifth Edition by Bent/McKinley, a recognized text approved by the FAA.

"The variable-venturi and the pressure injection carburetors are relatively free from Carburetor icing troubles."

You don't have to just take my word for it.

Ways to Deal with Carb Ice: As outlined above the attention to carb ice is important on general aviation powerplants because of the type of carb used as previously mentioned. The method that is commonly used is a cockpit controlled "Carb Heat." This is usually a push-pull control that directs warm air from the exhaust system into the air intake. This increase in air temperature does several things. First, the increase in air temp will help eliminates the conditions necessary for icing. Second, if ice has already started to form it can be eliminated. Lastly, the engine RPM will drop due to the increase in air temp. This is why the standard GA procedure for applying carb heat includes a throttle adjustment to compensate. This very same design was used in the Rotax 582 displayed by the factory at Sun 'N Fun several years ago. See Part # 29 " The New Rotax 582 Turnkey Powerplant" of the C&F series.

In some parts of the world, experimental aviation is controlled with the same regulations as certified aircraft. This means that some sort of carb heat is required weather it is needed or not. (The bureaucrats have not been reading the C&F series.) Cyclone Airsports LTD of Wallingford, England makes two types of Bing Carb heaters. Both use a heated ring that slips between the carb and the air filter, heating the engine carb body. See Figure #4. One type uses wattage from the engine's power output and one type uses hot water from the cooling system. While both systems will effectively prevent carb ice, they must be operated continually to be effective. Either system would likely not be able to eliminate carb ice if turned on after the fact. The warm water system is preferable on liquid cooled motors because no power is required. The electrical type

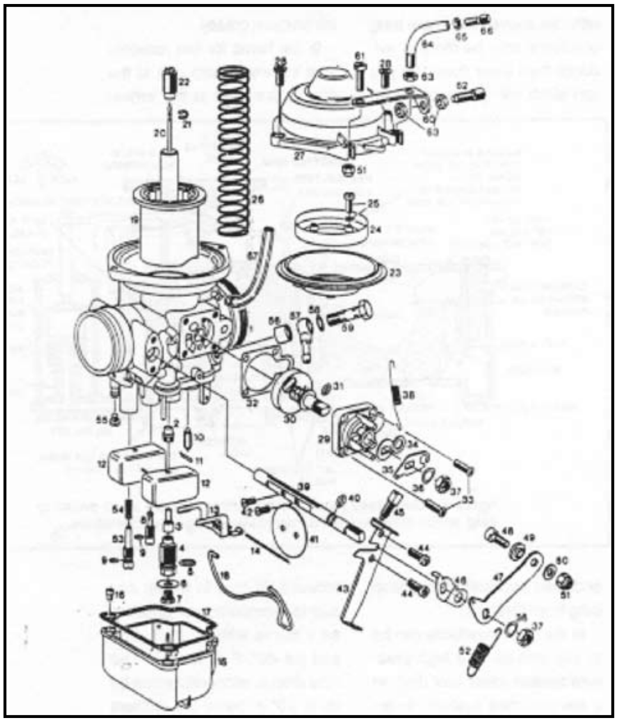

Figure #2 - The Rotax 912 uses a Constant Compression Carb that uses a butterfly valve and a moving slide to regulate the incoming air. This design is not prone to carb ice.

is your only option on the air cooled motors. As with any electrical heating device they take both a certain amount of time and a fairly high amp draw to function.

Conclusions: In the final analysts you need to weigh the remote possibility of carb ice against the complexity of the systems needed to defeat it. In drier climates like in the Southwest desert regions it is safe to say that carb heat is a complete waste of money. In humid climates where icing is more likely you may want to consider taking some of the steps outlined here. A carb air temp gauge (CAT) would probably be sufficient to satisfy the most safety conscious operator. Some of the new digital instruments like the EIS have enough capability to dedicate a function to CAT. See Part #43 "Automated Engine Monitoring."

While the possibility for carb ice remains small by theory, the field of operation can be more revealing. I would like to hear from any readers who have experienced "documented carb ice" as outlined at the beginning of this month's article. Give me a call at CPS. I will report back any findings in a future C & F article.

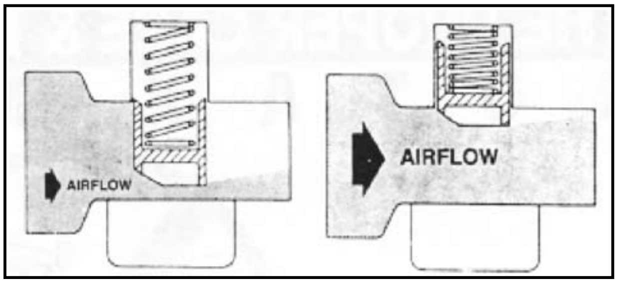

Figure #3 - The Bing Carb uses a moving slide to regulate air flow. This makes for a variable venturi that is not susceptible to icing.