Stephen O. Dean: 'Nuclear fusion is ready for the engineering stage now'

Dr. Stephen O. Dean is the president of Fusion Power Associates of Gaithersburg, Maryland. He was in government service with the Atomic Energy Commission, the Energy Research and Development Agency, and the Department of Energy for 17 years, and held the post of director of Confinement Systems Division of the Office of Fusion Energy in the U.S. Department of Energy until early 1979. Dr. Dean was interviewed for EIR *by Steven Bardwell.*

EIR: At the International Atomic Energy Agency's Ninth conference on Plasma Physics and Nuclear Fusion in Baltimore during the first week in September, new results in tokamak physics were reported. Will you summarize what you see as the most important developments?

Dean: I think this meeting was particularly interesting in that advances were reported on problems which the tokamak was perceived to have by some people, on issues associated with whether they would make attractive commercial reactors, specifically the problems of raising the power density in these machines and, secondly, finding a means of running them in a continuous, (rather than pulsed), mode. I think the most important and impressive results were the ones reported by General Atomic. They reported 4.6 percent beta, [the critical determinant of commercial power density in a fusion reactor] which is about twice what the previous record had been, of about 2.5 percent.

I think the importance of their result was not just that it was a higher number but that the earlier experiments seemed to be showing some kind of saturation or beta limit. General Atomic went well beyond the values at which the other experiments were saturating with modest amounts of input power. They still have a couple of megawatts reserved there so they may go up even further, and they have now reached values which are about what's needed to build the fusion engineering device. This is still somewhat short, in my opinion, of what will be used in a commercial reactor, but even within a factor of two of what I think would make a very nice, reasonable, compact and high-powered type of tokamak, the conventional type of tokamak.

EIR: Were these in the ballpark of what was predicted for noncircular cross-section machines like the D-shaped Doublet III at General Atomic?

Dean: Nobody really knew what kind of beta values would be reached in these various machines. The power that's available for these machines is sufficient in the long run to run the machines up into the 10 to 15 percent range. We don't have full power on any of the machines yet, so we haven't really gotten to those values. I think in terms of expectations this is consistent with the original expectation for this amount of power input, but it is beyond what most people thought was going to happen in view of the saturation factor that was being observed elsewhere. I feel that for those reasons the General Atomic results bode well for continued progress toward a higher power density plasma. They also saw evidence that the non-circularity of the plasma was in fact contributing to enhanced plasma conditions and hence confinement, and I think there again it was the first time we have seen definite results that show the advantages of non-circularity.

In addition, on the question of continuous operation, results from MIT, where they showed lower hybrid coupling of radio frequency waves into the plasma at higher density, show that perhaps we can drive the currents in tokamak by non-inductive means so that we could imagine perhaps eventually a steady-state tokamak or one which doesn't require pulsed transformers. This has important engineering implications.

EIR: At this meeting I noticed there were a number of results relating to the question of lower hybrid heating, ion cyclotron resonance heating, and other radio frequency heating. Can you give any idea of the relative significance of these?

Dean: I think what these results show is that only in the past couple of years have we started to seriously investigate putting large amounts of radio frequency power in a variety of frequencies into plasma. We've almost always simply used neutral beams for heating. Now, all over the world, we're starting to see the effect of putting large amounts of radio frequency power at various frequencies into the plasma. I think without exception we are finding better conditions as we do this. I don't know what frequency we'll eventually choose in a reactor, but I think the significance is that we may have a variety of possibilities. If it doesn't work well at one frequency, we'll be able to use a different frequency. We'll be able to tailor the plasma to behave in a variety of ways.

EIR: There are two results of other magnetic confinement machines which generated considerable interest at the IAEA meeting. One is the progress of the mirror machine, and the other is the dramatic change in the assessment of the significance of reverse field pinches.

Dean: The mirror experiments I think presented a nice step forward in demonstrating that in the larger tandem mirror we are able to enhance confinement time by something like a factor of three beyond that in the smaller tandem mirror, which of course was itself a factor of a couple above what had been achieved in simple mirrors. So, the mirror program, as we make the machines bigger and change their design, is showing the ability to enhance the confinement and reduce the end-losses.

We don't yet have a full demonstration of thermal barriers, and this is the objective of the mirror program at Lawrence Livermore Laboratory during the next six to eight months. At that point we will be able to make an assessment of what a real tandem mirror reactor will look like. Right now we don't have sufficient fundamental data to verify our assumptions on thermal barriers. But that should all clear up in the next year, and certainly I think we are going in a positive direction. . . .

On the reverse field pinch, we've had the emergence, as a surprise in the last year, of a fairly small experiment doing considerably better than it was designed to do, for reasons which weren't predicted in advance and aren't fully understood but are quite dramatic. One of these is the "dynamo effect," in which the plasma seems able to continue to exist because of its own dynamics in a confined state, independent of what we're doing to it from the outside.

EIR: I was impressed by the statements of Dr. Donato Palumbo, the head of the European Community's fusion program, and Dr. Shigeru Mori, the head of the Japanese fusion program, on their continued optimism on the prospects for commercial fusion development and on the broad-based commitment that they've made to fusion research. They reported on a number of impressive experiments. How do these programs fit together with the prospects for progress in the United States?

Dean: I think that it's clear that both the Japanese and the Europeans are now committed to fusion as a development program, as opposed to just a research program. They both have program plans that lead to power reactors; both seem to have a more reliable financial commitment to carrying these programs out than we have in the United States. . . . Palumbo said, for example, that he has a five-year budget and he knows that his available funds will not be less than specified in this budget during that entire five years. . . . This gives him the ability to plan his program with some confidence. Mori stated that in Japan, fusion was elevated a few years ago to what they call a national project, and that means that it's not something that is played around with in the budget every year. It means that the country is committed to funding it at the levels required to carry out the objectives of the project and those objectives are quite ambitious.

I think that both the Europeans and Japan have their programs on a par with, at least, and maybe somewhat more aggressive than what the United States has, even though I think Americans could still argue that we are turning out more interesting results by and large. This is more because we've put more commitment in the past rather than where we stand today. The new European and Japanese machines are comparable to or maybe bigger and better than our TFTR, and they are clearly organized to go the rest of the way.

However, I don't think that there is any likelihood that Japan and Europe will break into the lead in terms of building a power reactor several years before the United States. I think that they are not quite confident of themselves to run away from us in that regard.

EIR: You have alluded several times to the uncertainties and the fluctuations in U.S. political commitment to fusion power. In the last year, budget cuts have hit the inertial confinement programs even harder than the magnetic confinement programs, although both areas have suffered cuts in real dollar levels of funding. Will you hazard a guess as to what the future funding profile for U.S. fusion research and development might be?

Dean: I am optimistic that things are beginning to improve. I think that it is typical of a new administration that it comes in not knowing what it likes and doesn't like, or liking some things and not having heard of other things. Fusion was one of those areas of ambiguity, and we suffered in the first year of the Reagan administration. But our situation will improve in the third and fourth year as the administration gradually becomes aware at the highest levels what a good program fusion is, and how much it has to benefit in its international activities by pushing fusion. Fusion has a very good reputation internationally, at the highest levels of government in Europe and Japan, and that information is filtering back to the United States' system through the State Department and other channels. There are many international meetings on technology going on right now, and fusion keeps coming up as the example of a good program, well managed, in which there is something to benefit from pushing. This is starting to have an effect on the attitudes of the administration. . . .

So I am optimistic that things are slowly but steadily improving. And there is one thing that I would like to add. Consider the invention of the laser: the laser could have been invented in 1910 by Western man, instead of 1960. And the new developments in polarized fusion could have been realized when the fusion program was started 25 years ago, but they weren't. This and many other things are starting to bubble up now because people are thinking about the program and they will all become incorporated as the program evolves. Fusion still needs much improvement before we can credibly claim that this technology is going to produce electricity more cheaply than coal or nuclear power. But I think what we definitely don't want to do is to wait until all these things sort themselves out at the laboratory level before moving ahead with machines that produce large amounts of fusion power. By moving ahead as quickly as possible, we will put ourselves in the position to really start to learn of the more interesting potentials of the technology, its power handling, and its impact on the engineering.