DOUAUD André, 2001-06-25

- Individus -

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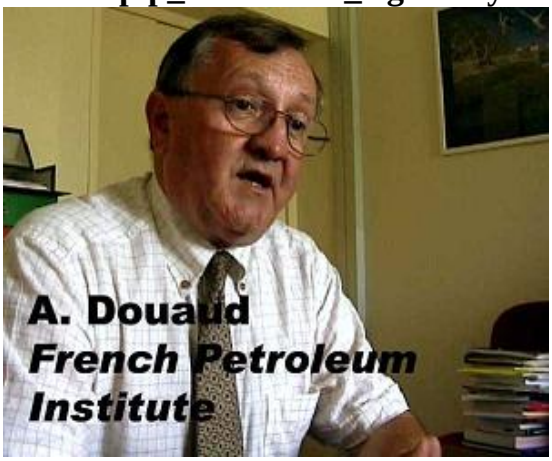

The French Petroleum Institute (IFP : Institut Français de Petroleum) is a national institution created in the aftermath of World War II in order to develop all the potentialities of petroleum. Financed by a percentage of French taxes on gas, the IFP activities are mainly devoted to research and training.

André Douaud is in charge of the IFP's R&D strategy on engines and energy. He was trained as an engineer at the Ecole Centrale, Paris, and has worked at the IFP for 30 years.
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Pour citer l'entretien :

« Entretien avec André Douaud », par Bernadette Bensaude-Vincent, 25 juin 2001, *Sciences : histoire orale*, https://sho.spip.espci.fr/spip.php?article58.

BERNADETTE BENSAUDE-VINCENT (BBV) : ***To begin with, could you say a few words about your own trajectory and how you came to the subject of fuel cells.***

ANDRE DOUAUD (AD) : I was trained as an engineer at the Ecole Centrale and I entered the French Petroleum Institute (IFP) thirty years ago as a researcher. I introduced computer science and engine-modelling. Then I became head of a project in basic research, then manager of a laboratory which consists of about 14 engine labs. Now I am in charge of the strategy of R&D on engines and energy.

BBV : ***Is it a division of the IFP ?***

AD : Yes, it is one of the five divisions and it is about 15% in size of all the research conducted by the IFP. We are about 200, 250 people. We work on internal combustion engines, on fuel and we are also very interested in the alternative technologies, including alternative engines and alternative fuels. We are of course interested in fuel cell technology, mainly the type using hydrogen as a fuel.

BBV : ***Thirty years ago, when you started what was the motivation for the IFP's concern with fuel cells ?***

AD : More than 20 years ago the IPF built a big motor research fuel cell. We were so to say pioneers in this domain. The basic idea at the time was to use oil or petroleum products to feed fuel cells. So we led an extensive research program on the cell itself in the 1960s and finally we came to the conclusion, well-known today, that the only reasonable fuel for fuel cells was hydrogen. At the time we developed a number of fuel cell prototypes for very special and expensive applications such as underwater exploration or military applications. Of course our primary goal was to make use of fuel cells for large amounts of energy such as are needed in automotive applications. After extensive research we concluded that it was premature to apply fuel cells to automotive vehicles.

BBV : ***Could you be more specific about the reasons for this conclusion ?***

AD : In fact, the basic idea was good at that time. In the 1970s, the internal combustion engines were highly polluting. The rate of pollution of a car was about 100g/km ; so it was a very good idea at that time to look for a zero emission car. This was the basic goal of fuel cells.

BBV : ***Wasn't it also connected with the oil crisis ?***

AD : In the beginning the main concern was about pollution. It was rather another way to use oil intelligently. It had no connection with oil crisis. When the oil crisis came it was an additional reason to pursue research on fuel cells, which are inherently very efficient.

BBV : ***Let's go back to the pollution concern. You said "at that time" the internal combustion engine was highly polluting. What has changed ?***

AD : Since 1970 tremendous work has been done all over the world to get clean cars. We started from 100g of polluting emission per km ; we are now below 1g/km and by 2005 we will be around 0.1g/km. So we considered that the local pollution, city pollution by automotive vehicles is a problem solved in the near future, by 2010. Today the basic factor limiting the benefits of this progress is the lifetime of a car : 5 to 10 years. It takes a long time to spread a new technology to an entire car fleet. It extends to 15years. The European Community and policy makers agree that in 2010 the air quality of all the cities in Europe will be excellent. It will be better than the World Health Organization standards. Today we consider that the problem of local, city pollution is solved. So it is difficult for a zero emission electric vehicle or fuel cell car to find some gap because of the huge advancements in the internal combustion engine over the past few years.

BBV : ***However there has been a lot of public and industrial interest in fuel cells. They were largely publicized in the media. What is the main motivation for this renewed interest in fuel cells over the past decade ? Is there a new problem to face ?***

AD : The next problem to face is the global warming and the CO2 emission. Today all conventional technologies like all alternative technologies must be evaluated with respect to their CO2 emission. The overall CO2 emission of a car is the combination of the carbon content in the fuel with the efficiency of the vehicle. If we look at alternative technologies, such as natural gas it is highly efficient because it extracts a lot of energy from small amounts of carbon. So, if we combine natural gas with a highly efficient engine then the CO2 emission from well to wheel - as we say - is very good. We have the same good efficiency with advanced Diesel engines. They are very efficient and the CO2 emission of the complete Diesel chain is very low. If we look at fuel cells, the fuel is hydrogen. Hydrogen is not available on earth. It has to be produced from some primary energy. So if you consider the complete energy chain, you see that the overall CO2 of the fuel cell is not very good. At IFP we have been among the first to make a CO2

study of the complete energy chain of hydrogen. And we were among the first to demonstrate that if you start from fossil fuel then fuel cell vehicles emit little less CO2 than any alternative or conventional fuel engine on the market. It will be slightly better but very close to the CO2 chain of a conventional engine. So we consider that to have the real benefit of fuel cells it is necessary to produce hydrogen from other sources than fossil fuel.

BBV : ***Which are the other sources ?***

AD : Other sources are nuclear energy, hydraulic energy and renewable energy. These alternative sources are well known. Nuclear energy is highly developed in France but it is no longer accepted in many countries. Germany has decided to stop. Today, nuclear energy is the biggest source of non-carbon energy. Hydro-electricity is specific of Canada but on a worldwide basis it is less than 10%. Bio-energy is less than 5% of the overall energy needs. It could be developed but we have to be careful about the consequences of a massive use of bio-energy.

BBV : ***Which are the main types of fuel cell studied at IFP ?***

AD : At IFP, we focus on the production of hydrogen. We rely on partnerships for the fuel cell technology. Fuel cells were invented before the internal combustion engine. The most popular technology is the low temperature fuel cell with a polymer membrane. It requires highly pure hydrogen. On the other side, we have high temperature fuel cells in the range of 500-700°C, which use solid oxide. The latter is not as advanced as the former but it is more tolerant to the composition of the fuel. It accepts a mixture of hydrogen and CO. But the very high temperature operating range raises a number of problems for automotive applications.

BBV : ***What is the problem with temperature - since internal combustion cars also operate at high temperature ?***

AD : Yes but it is inside in the metallic box of the engine. Keep in mind that the high temperature in an engine is obtained only during a few milliseconds in the engine cycle. The high temperature of a fuel cell is a permanent temperature. For instance, it raises the problem of starting. It takes a few minutes to reach the required temperature. You cannot start your car unless you have developed a system to store electricity in a battery. We call that hybrid technology.

BBV : ***So are you in favor of a polymer membrane fuel cell ?***

AD : Personally I just observe that a number of applications in this field use low-temperature fuel cells.

BBV : ***What kind of polymer do you use ?***

AD : It's a brand name produced by a company on the market. But at IFP we don't control the technology of polymer membranes. We focus on the production of hydrogen.

BBV : ***Why did IFP focus on hydrogen production ?***

AD : Because historically it is a basic problem of oil refineries to produce hydrogen. Hydrogen is a basic product used in the refinery to make clean fuel from oil. We had the tradition of producing and handling hydrogen, not on the road

but in factories.

BBV : ***I had thought that your interest in fuel cells came from your expertise in catalysis.***

AD : Yes also ; at the IFP there is a great number of specialists in catalysis but we haven't worked to apply this expertise to the fuel cell domain until now.

BBV : ***You mentioned that IFP's initial interest in fuel cells was to find smart applications for petroleum. Then you realized that the fuel cell was beneficial only when hydrogen came from a non-carbon source. So there is a paradox in your conclusions.***

AD : We started 30 years ago before any concern with CO2. The green house effect was not an issue 30 years ago. In fact producing big amounts of hydrogen will require storing CO2 in factories. This kind of research is currently under elaboration. There is a lot of interest worldwide to see how to store the CO2 from industrial processes. Of course you cannot recover CO2 from the tail-pipes of cars - there are too many cars giving out small quantities of CO2. But it is conceivable to recover CO2 from big factories.

BBV : ***Are you considering research on this topic at the IFP ?***

AD : Yes we are considering that.

BBV : ***Do you see CO2 storage as an alternative strategy for the future ?***

AD : Well as we say in French : Don't put all your eggs in the same basket. I think that all research should be considered for CO2 control. Among them there is the high efficiency of the final converter. This is the smartest way to limit the CO2 emission : to improve the efficiency of the engine. Everything that can limit CO2 in the energy chain is also worth considering. And CO2 sequestration is a third way to control it. If the world decides to make a large effort to limit the green house effect, then all lines of action should be considered. In fact we favor the energy efficiency because it is beneficial for everyone, for the energy resources on the planet and for the individual consumer. For the same result, there is nothing more important than saving energy thanks to high efficiency process.

BBV : ***I noticed a touch of skepticism in your judgment about the energy efficiency figures of fuel cells published in conferences ?***

AD : In order to integrate fuel cells in a car you need to design a number of components - to get big power from small space. For instance, you have to compress air to increase the energy density of the fuel cell. It costs a lot of energy. Then you have to cool the air since most fuel cells are low-temperature systems. So you lose part of the energy gained by compression in the cooling process. All that should be included in the energy efficiency cost. You have to pay for a number of questions to be solved for practical applications. In fact such questions are similar to the questions raised by an internal combustion engine. The maximum efficiency of fuel cells is better than the IC. But the cascade of losses is impressive for both of them.

BBV : ***Could you be more precise about the comparison of energy efficiency in the internal combustion engine and fuel cell ?***

AD : I think we have to be very careful when we compare energy efficiency because of the gap between the

theoretical energy efficiency of the heart of the fuel cell or the theoretical efficiency of the gas engine and the final efficiency at the wheel of the car. In both cases we start with very high efficiency level - above 50% - but an engine has a maximum power much higher than the power we use everyday. There is a kind of oversizing of the engine. So every time a device is oversized and used at part-load there is a tremendous loss of energy in the process. And this is equally true for the internal combustion engine and for the fuel cell. Both fuel cell and internal combustion engine are highly energy efficient and in both cases there is a tremendous loss compared to the high value of the theoretical energy. It is true that the comparison should be to the benefit of the fuel cell. But the efficiency has to be demonstrated on the road, which is not the case today.

BBV : ***Are there any trials or experiments conducted to compare internal combustion and fuel cell efficiencies on the road ?***

AD : There are many conferences and a huge literature on fuel cells. But very few of them provide practical results about cars on the road. We could expect to have as many technical results on fuel cell as on internal combustion engines. I observe it is not the case. There is a lot of communication about fuel cells and few hard results. Especially the major question is never addressed : what is the source of hydrogen. As long as we do not include the energy cost of hydrogen processing we cannot compare the different types of engines.

BBV : ***Are you aware of any breakthroughs in fuel cell technology in the past ten years ?***

AD : Certainly breakthroughs are always possible but usually in order to apply any technology to cars on the road you have to solve lots of problems to optimize the system. The progress will not be a 50% advance on one item. Rather it will be 5% advances on many items. Breakthroughs are very rare in this domain. Rather there are many incremental advances.

BBV : ***Finally what system will be the winner ?***

AD : I am not convinced by the figures presented in conferences. Looking at the cost of equipment, at hydrogen distribution, I cannot imagine that by 2010 we'll see fuel cell cars on the roads. Consider the huge effort expended on alternative fuels (natural gas, GPL...), however there is less than 2% of energy derived from alternative fuels which is nothing compared with the big effort expended in the past decade. The progress of the conventional engine has been so impressive over the past ten years that it is very difficult to look through the crystal ball for the future of alternative technologies and to predict the winning technology in the near future.

BBV : ***What kind of technical instruments of prediction do you use at IFP ?***

AD : We look at the trends in the emission norms and in the energy constraints. You have to keep in mind that automotive industry is a domain with a very long time constant. It is in tens of years. There are 1 billion cars on earth so you cannot change the technology in one year because of the lifetime of cars, of road infrastructures, power distribution, etc. Since the progress in conventional engines is so intense, any alternative technology will have to rank high in terms of local pollution, in terms of energy saving, and - the most important - in terms of cost and the acceptability of the cost by the consumer. All these parameters are so optimized in the conventional engine that a revolution in the near future is hardly conceivable.

BBV : ***Is the battery-driven engine a serious competitor ?***

AD : At IFP we are not specialists in this domain. We could rebuild the world assuming that the consumer instead of

wishing to drive a car 500km without refilling will accept to drive only 50km. Unfortunately this is not the case. This is the reason for the failure of the electrical vehicle.

BBV : ***Do you make any connection between the failure of the battery driven engine and the renewed interest in fuel cells over the past ten years ?***

AD : Of course, this is a major reason for the renewed interest in fuel cells. This is the positive aspect of any failure : the problems with pure electrical vehicles were a strong impulse for improvements in the conventional engine and the fuel cell. The hybrid vehicle might have a future.

BBV : ***So the future lies in hybrid vehicles ?***

AD : Yes, if the cost can be reduced because under the hood of a hybrid system you have to add the cost of the internal combustion engine to the cost of the electric motor. So it is extremely expensive. If the cost can be optimized then the electrical vehicle is a good transition to change the internal combustion engine. If it is necessary.

BBV : ***Do you finally suggest that hybrid technology is the main motivation for research efforts of car companies and IFP on fuel cells ?***

AD : Any hybrid technology should be controlled whatever the nature of the components. The system approach of hybrid technologies is a very good approach. No one can pretend to be expert in all parts of a hybrid system. How we should design a combustion engine for a hybrid system is a very important question.

BBV : ***What is the importance of computer simulation in this research ?***

AD : Simulations are very important because they dispense with a lot of trials. However Toyota has already a commercial hybrid vehicle.

BBV : ***Do you think that the hybrid vehicle will replace the internal combustion vehicle ?***

AD : It will not replace it. There will be a number of hybrid functions on board and you will not even notice the change. The design of the car will not change. At IFP we are not specialists in architecture of cars but when you look at the volume of the components you see there are serious problems.

BBV : ***Do you contemplate other applications of fuel cells ?***

AD : Sure. In fact, even though the efficiency of fuel cells is good, it is not 100% : the fuel cell produces electricity along with heat. So it is very efficient for industrial applications needing both power and heat, such as small de-localized power plants using natural gas to generate hydrogen. I believe that there will be practical applications of fuel cell power plants before the massive applications in automotive industry. Finally I am skeptical about the massive use of hydrogen fuel cells for automotive applications. It is a very difficult task to make hydrogen available, with low CO2 emission, at low cost. Safety problems are not completely cleared. Also, the competition is severe because the conventional internal combustion engine car is so efficient in terms of cost and low emissions. Unless there is a strong political measure that makes fuel cells a passage obligé [obligatory passage point], I cannot imagine that they will find massive applications in car industry. If we were starting 100 years ago on a white page, maybe the fuel cell would be the winner. One hundred years ago the fuel cell was the loser. Will it be the winner tomorrow ? We never

know.

BBV : *Isn't it because petroleum is a wonderful material ?*

AD : It is difficult for me to answer since I am working at the French petroleum institute. It is true, however, that not only petroleum but all liquid energy like vegetable oil contain a huge amount of energy within one liter. It is one hundred times bigger than the energy in a comparable volume of an electric battery. Moreover, it is easy to control the release of its energy by the mixture with the oxygen of air - the combustion process. It is true that liquid energy is highly suitable for transportation.

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Post-scriptum :

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