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ROMANIAN RESEARCH & DEVELOPMENT INSTITUTE FOR GAS TURBINES
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Common strategy to prevent the Danube's pollution technological risks with oil and oil products - CLEANDANUBE

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STUDY 6

COMPLETION OF A COMMON STRATEGY TO PREVENT TECHNOLOGICAL DANUBE POLLUTION WITH OIL AND PETROLEUM PRODUCTS. WIDELY DISSEMINATION OF THE PROJECT'S RESULTS

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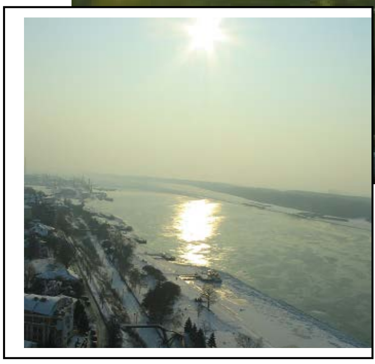


"Common strategy to prevent the Danube's pollution technological risks with oil and oil products" – CLEANDANUBE

March 2012

Strategy

Summary:

Chapter 1

Strategy objectives and principles

The reports of recent years have shown that although economic activity of the Romanian- Bulgarian border decreased, technological risk of Danube water contamination with petroleum products increased. This fact was the basis of many attempts to develop solutions aimed at prevention and removal of pollution of the Danube, primarily petroleum products. Among these we mentionWANDA project, an attempt in recent period to address and solve the problem of ship generated waste along the Danube, attempt which we consider a first step, but not primarily addressing water pollution problem. INCDTurbomotoare COMOTI and “Anghel Kancev” Unviversity from Russe, renowned institutions and interests in the area, studied in detail the situation which the extent that has taken lately attracted the attention of all European forums that have the measure of firm, reliable, immediate results. In this context the two institutions mentioned above in partnership have promoted the project “Common strategy to prevent the Danube’s pollution technological risks with oil and oil products” – CLEANDANUBE

The main project objective is:

- The development of a joint Romanian – Bulgarian strategy for preventing Danube pollution technological risks by petroleum and derived products

The project also aims to achieve two intermediate objectives which supports and makes credible the main objective:

- Prevention – to limit Danube pollution with petroleum and derived products
- Development of a new processing technical solution of petroleum and derived products contaminated water and their separation in a single component step.

All solutions proposed so far by the authorities and institutions working in this field, both Romania and Bulgaria have failed, or the results are not significant. The solutions tackled do not have the goal of disposing of pollution, being only limited to purging the infested waters of petroleum and derived products and storing them; the means by which these waters can be purged, and in practice nothing is undertaken, the polluted waters eventually reaching the Danube. Emergency situations are not taken into consideration, which leads to bona-fide ecological disasters, such as beached, sunken barges or other ships transporting petroleum and petroleum derived products. Given all these considerations, their partners in the new strategy set the following objectives:

Prevention of pollution of Danube water with petroleum and derived products.

Petroleum and derived products pollution limitation in case of accidents and special circumstances.

Processing waters polluted with petroleum and derived products via single - step centrifugation, extendable to organic products (water and solids), that can be restored immediately to the environment at the necessary quality to promote industrial activities.

These objectives practically cover all the range of events leading to the pollution of Danube waters but, most importantly, preemptive (before they reach the Danube) and real-time (in the case of accidents, shipwrecks, stranding) polluted waters processing is foreseen.

To our knowledge, the partners involved with the “Common strategy to prevent the Danube’s pollution technological risks with oil and oil products” – CLEANDANUBE project, it is the first time anyone has sought such objectives.

These objectives, in the analysis conducted by the partners, even if they can be achieved, cannot produce maximum effects unless enclosed in a strategy. Developed strategies through this date, even if they tried to present applicable and viable solutions have not led to significant results, the Danube water pollution problem with petroleum and derived products remains current. One of the principles that have generated these strategies, “polluter pays”, elaborating national development concepts, is outdated in the opinion of partners: INCDTurbomotoare COMOTI and Anghel Kancev University from Russe, given the new European order, the EU’s vision on environmental protection, which is why we consider it necessary to elaborate a new strategy that can create premises for viable and effective activities that will lead to solutions to environmental problems in the Romanian-Bulgarian border area.

Principles governing the new strategy, developed in the project are:

- Common problems – common solutions
- The problem addressed – completely solved problem
- Environmental protection – it is our generation’s life and our future generation that cannot be valued
- Best solutions are sustainable solutions promoting sustainable development

Based on these principles, the strategy that partners in the “Common strategy to prevent the Danube’s pollution technological risks with oil and oil products” CLEANDANUBE project, propose to promote by establishing:

A. Handling by a Romanian – Bulgarian common unit of the Danube water pollution with petroleum and derived products problems. Pollution, by all means and in any circumstances , equally affecting both countries, both Romania and Bulgaria, regardless of who caused it, actions taken against pollution, such as prevention, mitigation or remediation must be undertaken in a very short time, once an event has taken place, which is a prerequisite. Experience has shown that as long as two states act separately through “elaboration / development of national concepts”, the pollution problem will not be efficiently solved as long as the same phenomenon affects communities on both banks of the Danube, inasmuch the problem must be solved jointly through a common concept, developed jointly as appropriate, required for both states, applied in common.

   This principle promoted by the new strategy approaches and resolves an aspect not addressed in a constructive way, pollution, emergencies, accidents, diving and standing ships carrying petroleum and derived products. In these cases, pollution is severe, difficult to handle, produces real environmental disasters and the “polluter pays” is cumbersome, often impossible to approach. Specifically for emergency situations action should be taken quickly, if there is a good organization, even instantly, by a joint resolution that requires a common unit of intervention that must act wherever the affected area lies in the Romanian or Bulgarian.

B. The second principle on which the new strategy is based involves solving the problem completely, specifically polluted water is not collected and it is not moved to another location for storage and possible future purge. Experience has shown that even if fully collecting polluted water succeeds (in which case tankers and tank vessels are washed) it is stored in places more or less set up, its treatment is executed much later (if at all) being stored in such large quantities. In case of accidents, polluted water is not collected, with serious environmental consequences. The strategy proposed in the project involves on-site processing the petroleum contaminated water and reintegration into the natural circulation of water and solid components, the petroleum obtained is stored in special tanks, the problem will be totally and immediately handled. This is possible using special equipment for processing petroleum polluted water by centrifugation. Such a device was calculated and designed within the “Common strategy to prevent the Danube’s pollution technological risks with oil and oil products” – CELANDANUBE starting from a set of data determined experimentally or analytically.

   This equipment is basically the “key” to a new strategy proposed by the partners: INCDTurbomotoare COMOTI and Anghel Kancev University form Russe, based on it the application and integration options in an intervention unit can be developed. By using special software, both Bulgarian and Romanian partners have performed multiple simulations to verify the correctness of proposed technological parameters and entire design work starting around the parts, sub-assemblies and assemblies to all equipment. These simulations have clearly shown that solution is viable, effective and feasible. We consider this proposal as a major step forward in terms of looking at the phenomenon of Danube water pollution with petroleum products, adoption of this proposal will demonstrate that “approach and total solution” is possible by a single processing of a very important issue. Advantages are exceptional, we mention the most important:

- The possibility of immediate intervention in case of accidents, pollution prevention and removal in a situation with no current solution.
- Shorter processing time and costs required – polluted waste water from cleaning petroleum tanks and vessels tanks.
- Ability to easily access areas with polluted water.
- Obtaining by means of one single operation of three products, petroleum, solid waters, with properties that fall into specific quality standards that can be restored right into environment (water and solids) or industrial processes (petroleum).

- The elimination of the collateral soil and ground water pollution process through storage space available at this time.

C. The third principle promoted by the newly developed strategy illustrates the new position of European and international society on pollution. Scientists have repeatedly sounded the alarm in recent times on the disastrous influence of pollution on the environment that resulted lately in sharp deterioration in public health, the extinction of many species of fauna and flora, advanced altering of the atmosphere. Under these conditions, as the existence of the planet is threatened and the forecasts are more and more dire, the principle of “polluter pays” loses its primacy.

Today’s society is more interested in prevention and removal of pollution than the fact that the polluter pays for damages.

Firstly, the effects of pollution cannot be estimated, who can say how much the disappearance of a fish species can cost us? Or a bird species? Or flora and fauna of a river? It should be mentioned that effects on human health can be disastrous, regardless of the safety procedures followed as well as the fact that future generations will be deprived of many things that improve the quality of life.

Secondly, collecting the fees agreed as pollution penalties from the polluters has been proven to be extremely difficult, procedures are very complicated and lengthy insomuch that they are often not concluded. The required fees can be so high as to lead to the cessation of economical activities for some economic agents with undesirable social effects (general lay – offs) or can be paid by large economic agents who can recover the amounts via appropriate pricing politics, all from the general population.

In this context, the company responded immediately requesting prevention and immediate elimination of pollution and its effects, as a result, the E.U. introduced, amongst its programs, new directions providing special training to prevent pollution in emergency situations (see P.O.R)

In conclusion, environmental protection is very important and because no effort is too great, immediate and effective must be taken, money is no longer that important and payment is not enough.

The fourth principle promoted by the new strategy developed by the partners is underlying the proposed solution implementation for achieving the strategy goals. The proposed solution consists in creating a complex equipment consisting of, regarding the following scheme:

- The buoyand parcel of polluted water
- The filtering and suction system
- Separation centrifugal separation
- Accumulator system for separated oil products
- Command and control system
- The polluted water collection fleet system
- The filtering and suction system
- Centrifugal separation equipment

- Collection system for separated oil products
- Comand and control system

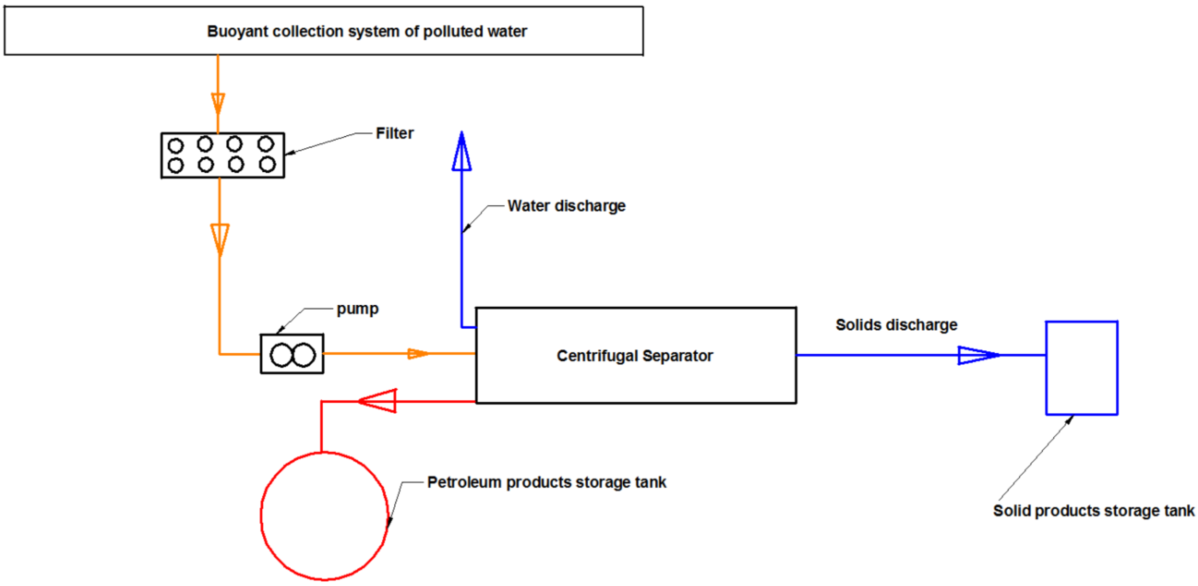


Fig. 1 General scheme for waste oil separation system

The centerpiece of this ensemble is “the single – step centrifugation separation equipment for waters polluted with petroleum and derived products: petroleum, water and solid components”.

The applicability of the promoted solution is extremely important, it practically dictates the viability of the entire strategy developed during the project; special efforts were made to conduct activities that clearly demonstrate this fact. Basically, such equipment was designed, based on data and parameters corresponding to reality. Creating sub-assemblies, assemblies and 3D surface modeling in very complex surface pieces that have come to fruition using Solid Edge software acquired in the project. To clearly show complete separation in three parts with ecological properties complex simulations were performed by the Romanian partner as well by the Bulgarian partner using special software.

We believe that all technical documents presented in the project shows clearly that the proposed solution is viable, the separation of petroleum, water and solids is rendered at quality allowing restoration of water and solids to the environment and reintegration of petroleum in the technological circuit.

Numerical simulations regarding centrifugal separator were conducted in tandem by the Romanian and Bulgarian partner. Each of the them used a different solver, respectively Romanian partner – CFX and the Bulgarian partner – FLUENT.

These numerical simulations were made to study the separation water of oil and of solid particles and to understand the separation process by centrifugation.

Numerical simulation process had several steps.

First step was the achievement of the computing grid, a complicated process due to complex geometry of the separator.

The hydrodynamic computing has some real changes due to the real model and in principle what keeps this work channel. Figure 2 shows the calculations geometry. Figure 3 shows the entrance and the exits and also the helical device that trains, together with carcass, the working fluid.

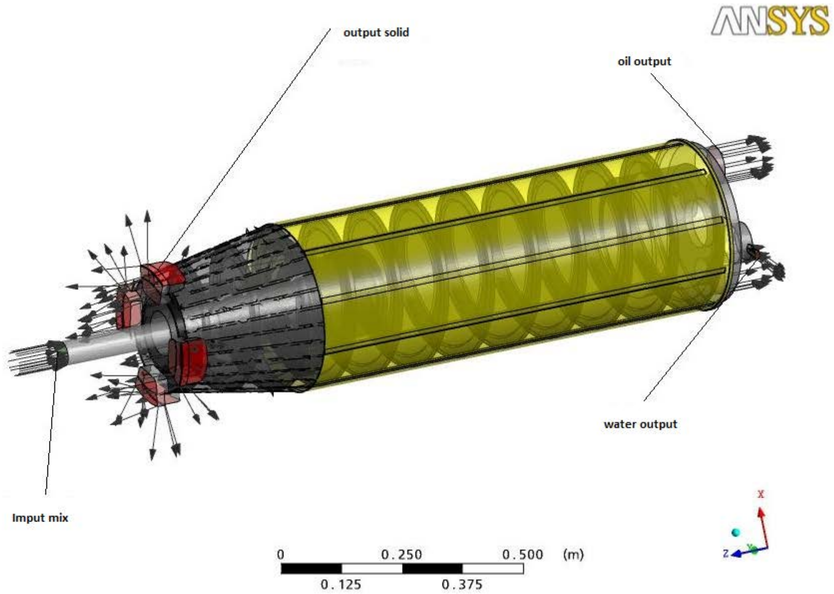


Fig. 2 Calculation Geometry

The second stage meant the imposing boundary conditions, conditions that were chosen in accordance with operating conditions of the separator in real working environment and working nominal regime.

Should mention that the Bulgarian partner made the hydrodynamic analysis of an mixture that did not includes solid particles.

The initial conditions are:

Mixting flow: 20 m3/h

Admission:

Mixture: water + hydrocarbons (C16H34) in liquid phase

Temperature: 293 K

Absolute pressure: 5 bar

Turbulence intensity: 5%

Volume fraction of C16H34: 0.7116

Volume fraction of water: 0.2884

Solid particles conditions: Asphalt

Imput speed: 10m/s

Flow: 68 g/s

Minimum particle diameter: 20 microns

Maximum particle diameter: 60 microns

Discharge:

Flow: 20 m3/h

Carcass: rotation speed: 4000 r/min

Helical device: rotational speed: 3960 rot / min

The third step was the obtaining of results and their interpretation. Thus it can observe that after the analysis the oil gathers around the helical body while the water gathers on the carcass wall (Fig 3). Also at the outputs it could clearly observe the oil – water separation and solids particles.

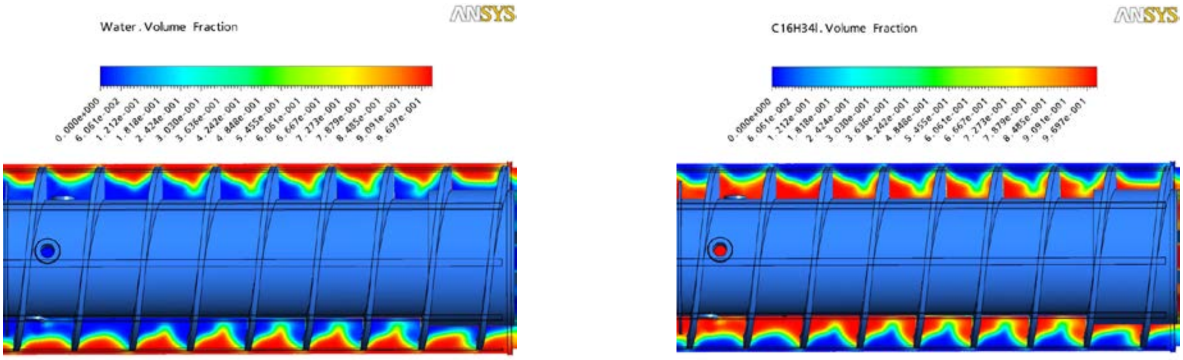


Fig. 3. Water and C16H34 distribution in helical device

In conclusion, these numerical simulations have shown that the chosen solution for situations such is very good and efficient.

The Romanian partner performed simulation using CFX software only for centrifugal equipment, Bulgarian partner performed simulations using FLUENT software for entire equipment, introducing the centrifuge to check if there is any equipment component which can disrupt the centrifuge, an extremely unfavorable case as component separation would not be complete, their quality dropping below environmental standards.

Proposed solution primarily addresses emergencies when, due to errors, sinking or beaching ships that are transporting petroleum. In this case petroleum slicks in Danube waters are uncontrollable by conventional methods, the only viable solution that we consider is applying the new strategy.

Thus, as a result of processing, the water can be restored to the Danube, solids as well, or, considering the small quantity in which they are stored aboard the intervention ship and the recovered petroleum (possible up to 96%) found storaged in the intervention ship’s special tanks.

According to the elaborated strategy in an emergency case, a common and independent Romanian- Bulgarian unit is made, acting immediately no matter what the emergency is, according to a joint work plan, based on existing operational criteria, eliminating any delay intervention formality and does not affect safety.

In this way Danube water pollution can be prevented and a larger quantity of petroleum can be extracted.

Recovered petroleum can be capitalized (because it has the required quality, even better) and the obtained amounts will take part on the intervention costs recovery.

Thus it is possible to diminish dramatically the amounts that the polluter has to pay and so this should be more easily paid overcoming easier the situation.

By the advantages of the proposed solution, it can be applied successfully and very effective economically in processing contaminated water with petroleum products coming from washing tanks, transport tanks, etc. And in this case, we can recover almost all existing petroleum, which cannot be negligible, although in this case, the percentage of solids increases in the mixture, so economically speaking the large amounts necessary for processing will be lower.

In conclusion the proposed solution by the new strategy, a Romanian – Bulgarian common independent unit has a high degree of sustainability, practically it can actually support herself to a great extent by exploiting the collected petroleum.

Another part of the expenses will be covered by the “polluter” or economic agents what requires intervention. If is necessary to cover total expenses both concerned states are required to intervene accessing environmental funds at their disposal.

In this chapter we presented the objectives and principles of the Romanian – Bulgarian joint strategy, developed by partners like INCDTurbomotoare COMOTI and “Anghe Kancev” University from Russe from the “Common strategy to prevent the Danube’s pollution technological risks with oil and oil products” CLEANDANUBE project.

We tried to detail and support, with the knowledge we possess at this time, the principles which we think that makes the strategy a step further, a new way of approach to prevent Danube pollution with petroleum and derived products.

Chapter 2

The European and national legislation demands
Relationship with other strategies, national law and plans:

1. E.U. strategy for Danube’s region.

On Decemeber 8th 2010, European Commission approved and published the **E.U. Strategy for Danube’s region**, materialized in a **Communication** and in an **Action Plan**. The discussed and agreed at community level documents and which forms the core of regional cooperation on the Danube, represent the a development concentrated effort of the frontager states who, with European Commission had analyzed and assessed the real needs of the Danube’s region and they proposed an agreed document, both politically and technically. So European Union whereupon also the frontager third countries are invited to participate.

“Danube Strategy”, a Romanian – Austrian initiative launched in 2008, represent an innovative model of macro-regional cooperation and it implements the new concept of territorial cohesion in the Treaty of Lisbon. It is intended to be a sustainable strategy, a green one, and based on new technologies, on innovation and that leads to the improvement of the European citizens.

Cohesion Policy 2007-2013 of European Union aims to strenghthen economic and social cohesion in the enlarged European Union, in order to encourage the harmonious Community development, balanced and sustainable, as the reduction of economic and social territorial inequalities that have arisen in underdeveloped states and regions, as well their accelerate economic and social restructuring.

The New Cohesion Policy 2007 – 2013 recognizes the importance of trans-border cooperation, transnational and interregional, which is a key objective in an enlarged Europe.

The European Territorial Cooperation objective financed by FEDR aims to strengthen both the transborder cooperation through joint local and regional initiatives and also the transnational and interregional cooperation. This will support favorable actions to integrated territorial development, harmonized with Community priorities, strengthening interregional cooperation and exchange experience promotion between appropriate territorial levels. Main objective of the trans-border in Europe is to integrate areas divided by national borders that face common problems requiring common solutions.

European Territorial Cooperation is designed to bring a significantly contribution to the Revised strategy from Lisbon.

Assistance will focus on main priorities to support sustainable growth and creating jobs.

Settlements regarding the programs that implements in the European Territorial Cooperation Objective are set out in the neq regulations, with a direct and immediate applicability in Romania and Bulgaria after European Union accession, namely January 1st 2007.

Internally, Romania contribution to the strategy elaboration is a result of cooperation of the following government institutions: Ministry of Foreign Affairs, Ministry of Transports and Infrastructure, Ministry of Regional Development and Tourism, Ministry of Environment and Forests, Ministry of Economy, Trade and Business Environment, Ministry of Public Finance, Ministry of Agriculture and Rural Development, Ministry of Administration and Interior, Ministry of Culture and National Heritage, Ministry of Education, Youth and Sports, Department for European Affairs.

Ministry of Foreign Affairs provides inter-institutional coordination as well external representation of Romania on this subject.

On the after July 2011, the responsible central authorities ensures the sectoral coordination of some priority domains of Danube's Strategy, at macro-regional level and jointly with partners from fronyager states.

However, under the bottom-up approach (the governance of the strategy starting from the administrative pyramid base through its top), all interested stakeholders contribute to establish action from Danube's Strategy, by attending to public events and to its debate forums.

Major benefits for Romania brought by the Danube's Strategy:

- Developing the life quality by increasing competitiveness and cities and Danube's villages attractiveness.
- Obtaining economical advantages through closing business partnerships and "cross" cooperation between the public and the private sector
- The organization of annual economic forums;

Investment attracting in strategic domain same as transport, environment and energy infrastructures.

2. The New Strategy for European Union Sustainable Development (SSD)

The European Union New (SSD) adopted by the European Council on 15th/16th June 2006, sets a unique strategy and coherent regarding the mode how European Union will rise to the long-term commitments level.

The main objectives and SSD's challenges have been taken into consideration at program organization. Thus, the strategic objective of the program indicates the commitment related to promotion using "human, natural and environmental resources in a sustainable way".

The environmental protection is directly targeted through Priority Axis No 2 (Environment), but it also represents a horizontal principle of program's implementation.

Social equity and social cohesion are taken into account in two ways: firstly a horizontal aspects, through the principle of equal opportunities followed in all program activities, but also in terms of financing social domain projects. Economic prosperity objective is supported by the program through projects funding in economic development domain, offering support for business organizations.

Moreover, the program will ensure that European Union funding is used and channeled in the best way regarding to promote sustainable development, as set out in section 25 of SSD.

The Intervention Structural Funding in the context of both Romanian and Bulgarian National Strategic Reference Framework for 2007-2013 and the sectoral and regional operational programs.

The program will bring an important contribution to Romania and Bulgaria strategic objectives achieviement established by the new E.U. cohesion policy, such as speeding up the Member States convergence and less developed regions by improving condition for develop and employment work through thrans-border cooperation. In this sens, the synergies of the Romanian-Bulgarian National Strategic Reference Framework Program for 2007-2013 (NSRF) and other OP’s in this NSRF that contributes to reducing isolation through improving network and transport services access, information and communications, by improving environmental management as well to prevent natural and technological risks, through improving infrastructure, particulary in sectors such as tourism, education, innovation and knowledge society, promoting entrepreneurship, taking into account economic and social changes.

3. Lisbon Strategy

It was adopted by the European Council at Lisbon in March 2000 for 10 years period.

The main purpose - to make the European Union the most dynamic and competitive economy of the world.

Romania has adopted this strategy under way – 2007 with the E.U. accession.

4. **National Action Plan for Environmental Protection** is a tool for the relevant policies implementation, by promoting, supporting and achieving the most important projects with significant environmental impact in the implementation and enforcement of national rules and E.U. directives. The plan includes a special chapter dedicated to the treatment and collection system of waste generated by the ships and pollution prevention in the Danube’s Romanian sector.

National Action Plan for Environmental Protection

It promotes the establish support of most important projects, having as final purpose the progressive improvement of the environmental factors quality in Romania.

The document provides a unitary view on the environmental investments made in Romania and only for large regional projects, national or the projects which presents a significant impact regarding the problem size on which we referred to.

The National Action Plan for Environmental Protection, updated in 2007 – 2008, was approved by the Interministerial Committee for coordinating the integration of environmental protection domain in sectoral policies and strategys at national level by Decision no 1/7.11.2008.

5. **National Strategy for Sustainable Development of Romania (2008)** is a national document that respects the E.U. sustainable development strategy. The general objective it is the continuous improvement of life quality, the creation of sustainable communities able to manage and use resources effectively and capitalize the environmental and social innovation potential of the economy, regarding the prosperity insurance, environmental protection and social cohesion.
   In addition of the objectives that derives from strategies, national development plans and programs, the Strategy sets the main action directions for applying and attribute the principles of sustainable development in the next period:
   - Rational correlation of the development objectives, including investment programs, in inter-sectoral and regional profile, with potential and sustainable capacity of the natural capital;
   - Accelerated modernization of educational system and professional training and also public health, considering the unfavorable demographic evolutions and their impact on the labor market.

6. **Sustainable Transport Strategy for the period between 2007-2013 and 2020, 2030** contains a special chapter on marime transport and internal inland waterway.
   The main objectives track to promote marime transport and inland water transport, providing viable solutions for environmental protection. WANDA support this objectives by identifying the best methods of treatment, collection and disposal of waste from ships on the Danube. Priorities of water transport for 2007 – 2013 focus on upgrading / development of water transport infrastructure, ensuring the safety of the traffic, while building ports as intermodal logistics centers, which serves as support to the progressive realization of intermodal freight network and to achieve safer shipping services and more environmentally friendly. To achieve these priorities will be considered, among others:

- Stimulation of shipping safety and ambient efficiency
- Development inspection services, safety and rescue, the implementation of IMO provision in the safety navigation domain (systems like: EDI, dGPS, VTS, GMDSS)
- Development of river information services (RoRIS-“Romanian River Information Services”)

Implementing these actions will alow, starting in 2014, revival of the shipment and progressive strengthening of intermodal transport services.

Development of the network of waterways should be an essential part of developing an intermodal transport system on intra-european plan.

The necessitys, in terms of infrastructure and regulations, must be added also the support for achieving proposed projects by the operators, for the implementation and consolidation of new services: legal support to finance shipbuilding, establishing lines, coordination with rail and road transport services, tax policies, etc. This support can come from European programs or national programs with national nature to intermodality promotion, made and applied so as to avoid distortions in competition condition. The establishment of adequate frame of financial support (fiscal policy) that makes the development of river transport enable with quality guarantee, security, territorial integrity and territorial integrity and the respecting of free competition principle will be essential to facility the river transport in intermodal transport chains, encouraging the reation of new competitive service lines and improving the existing one. It is also considering the developing of a plan concerning economic and financial sector support measures that must have the fundamental objective the facility of river fleet modernization under Romanian flag. This action plan will be in the benefit of improving service’s safety and quality offered by the river fleet.

7. Romania – Bulgaria Trans-border Cooperation Program 2007 – 2013

The basic element of the program strategy is to approach the trans-border communities as a first step towards sustainable and to promote joint action for overcoming physical and social-cultural barriers and to a better exploitesion offered by developing trans-border region growth in the medium – long term. Cooperation strategy focuses on issues and opportunities for which the border is an important factor for trans-border action is a key requirement. It is degined to be a coherent and effective response answer, the obstacle and identified weaknesses points in the trans-border area to be a tool for its sustainable socio-economic development of trans-border. The program notes the limited contract and the low base of trans-border cooperation in long period and recognizes the need to overcome geographical barriers, psychological and language (prerequisite for understanding and trust) for convert the border into a separation line in a communication and cooperation place, designed to promote area potential for integrated development and to integrate trans-border region between two countries, new E.U. member states. Cohesion Policy 2007-2013 of E.U. aims to strengthen economic and social cohesion of Community in E.U. enlarged frame, with order to encourage the harmonious, balanced and sustainable development of Community, as the reduction of regional economic and social inequalities that have emerged in underdeveloped countries and regions, as well the acceleration if of economic and social restructuring. The new Cohesion Policy 2007 – 2013 recognizes the importance of trans-border, transnational and interregional cooperation, which is a key objective in an enlarged Europe. European Territorial Cooperation Objective financed by FEDR aims to strengthen the trans-border cooperation through joint local and regional initiatives also the transnational and inter-regional cooperation. He will support favorable to integrated territorial development actions, harmonized with the Community priorities, strengthening inter-regional cooperation and promotion of exchange of experience between territorial levels appropriate. Main purpose of trans-border cooperation in Europe is to integrate divided areas by national borders that confronts with common problems, requiring common solutions.

The program will promote a sustainable integrated cooperation in the trans-border region, focusing on the strategic dimension of European territorial trans-border development involving and from which local communities benefits. This will be achieved by joining communities from programs eligible area and their involvement in economic, social and environmental activities. The concern of risk prevention measures through improved management of natural resources, through specialized research and through innovative public management policies, will place a premium importance. Along the Danube,it still persists serious environmental problems. These are in particular those relating to water pollution and industrial pollution. The proportion of localities connected to public water network is low and in the most villages this system is missing. The navigation exert a higher pressure upon Danube, this affects the riverbed morphology and presents risks of accidental pollution. Between 1983 and 2003, 455 ships accidents occurred on the Danube, 30 of them having as result serious water pollution.

Black Sea water quality depends considerably on the Danube water quality. Considering all sources of pollution (Danube and other banks with pollution sources) most of the pollutants are brought by the Danube: 99.5% of nutrients, 99% of N, and 91.8% of P-PO4. The N-S dominant flow of the marine currents favoring the pollutants spread fro Danube in coastal waters of programs area. Great variety and richness of the ecosystem of the programs area creates opportunities for future development. Cooperation between the institutional structure of the border area (eg: environmental agencies, administrations of protected areas), establishment of protected common areas, as the development of joint management plans in order to protect biodiversity will contribute to strategin development and on long term of programme area. Environmental issues will be among the priorities of tourism development in the region. Perhaps the most important role that environmental quality from border area will take in the next decade is to shape the region’s image as a favourable place to live, to work and tourism.

The environment is a valuable element to increase regional identity, which should be used to attract local and external investments, and to support forming an attractive business environment.

The outstanding specific natural heritage of programs area must be analyzed from two points of view. Must be protected and maintained, exploited and further, the improving , as a living sustainable environment and at the same time, must be regarded as a favorable factor for business from the area.

In order to preserv unique ability of the environment, long-terms environmental joint strategy must be launched, the strategies which aimes conservation and natural resources, prevention of natural and technological disaster as the adapting to climate change.

In an area with such outstanding natural resouces, the care for environmental protection will be inevitably a priority in future relations regarding trans-border cooperation. Industrial pollution has already made its mark on water quality, and other measures to improve local infrastructure must take into consideration the long-term effects on the environment.

There are tremendous opportunities to conduct joint monitoring activities throughout the hole area to ensure protection and sustainable of the environment and ecosystems.

This monitoring is necessary because the construction of the new infrastructure and modernization of the existing one, will inevitably affect the environment. The ecosystems variety in the region offers the opportunities for future development. Environment will be among the most important factors in the region.

National Legislations:

1. **Romanian legislation on environmental protection domain in the water domain**

Recent course, included also in the European Union of the Water’s Directive Cadre is to combine the two types of approaches, which consists in quality control of the emitted pollutants into the aquatic environment concomitant with the improving of the reception aquatic environment quality. Generally this needs using, in greater extent, the precautionary principle: avoid pollution, instead of trying to limit pollution.

To implement this new combined approach, is recommended using of an efficiently polluter pays principle, and a greater integration, taking into account the potential pollution effects caused by territorial planning.

In Romania, in recent years, it was adopted a series of laws and new normative acts, aiming legislation and national standards aligning to the European Union. Among this acts counts:

- H.G. Nr. 188/28.02.2002 (M.O. Nr. 187, Part I, 20.03.2002), for approving of standard specification concerning the discharge conditions of wastewater in aquatic environment. H.G. contains as an integral part, the following standard specifications.
    - NTPA – 011 in which are regulates conditions concerning collection, treatment and disposal of town wastewater and conditions for purging and evacuate industrial wastewater. (Annex 1 from H.G. The normative includes an Axis wherethrough is adopting Action Plan for collection, purge and disposal of town wastewater.
    - NTPA – 002/2002 – concerning the regulated requirements to be met by wastewater discharged into the local sewerage networks and directly into purge stations (Annex 2 of H.G.)
    - NTPA – 001/2002 – concerning the set loading limits with pollutants of industrial and urban wastewater in natural receivers. (Annex 3 of H.G.)
- H.G. Nr. 100.07.02.2002 (M.O. Part 1, no. 130, 02.19.2002) for approving quality standard that needs to meet surface water use for drinking and normative regarding measurement methods and frequency of sampling and samples analysis from surface water meant to produce drinking water. From H.G. sits on integral part the following rules:
    - NTPA – 013/2002 – wherethrough the quality norm that must met by surface water used for drinking are regulated
    - NTPA – 014/2002 – wherethrough the measurement methods and the frequency of the sampling and analysis of surface water forthcoming drinking water production are regulated
- Law no. 458/2002 on drinking water quality, (M.O. No. 552 Part I / 07.29.2002) active since 08.29.2002. Law contains the following:

    - Drinking water quality parameters (microbiological, chemical, and indicators), which are provided by CMA, together with analysis method)
    - Requirements for control and audit monitoring.
      Control monitoring regular provides information concerning organoleptic and microbiological quality of drinking water, concerning the effectiveness of treatment technologies to determine if drinking water coincide or not with the term of the quality parameters values established by law.
      Audit monitoring provides the necessary information to establish whether the values conform or not for all quality parameters established by law
    - Specifications for parameters analysis.
- HG No. 201 (M.O. No. 196/22.03.2002) for approving technical standards concerning water quality of shellfish. H.G. contains two appendices:
    - Annex 1 – through in which the water quality for shellfish, methods and frequency of sampling are established
    - Annex 2 – that specifies particular issues regarding limit values for certain indicators.
- HG no 459 (M.O. no 350/27.05.2002) regarding quality standard specifications approval for water coming from natural landscaped areas for bathing (M.O. No 350/27.05.2002)

2. Bulgarian legislation on environmental protection domain in the water domain

The Bulgarian institution responsible for the protection of the marine environment and the Danube River from pollution from ships is the Maritime Administration Executive Agency. It is the national competent authority for Flag State Control and Implementation.

The Agency organises and coordinates the activities related to the safety of shipping in the sea spaces and inland waterways of the Republic of Bulgaria. The Agency ensures the actual liaison between the government and ships flying the Bulgarian flag. It exercises control on:

- observation of shipping safety requirements by Bulgarian and foreign ships;
- observation of the working and living conditions of seafarers;
- provision of services for traffic management and information of shipping maritime spaces, inland waterways, canals, ports in Bulgaria and other duly defined regions;
- compliance with the quality requirements for marine fuels;

The Agency organises and coordinates the search for and rescue of people, vessels and aircraft in distress.

There exist various normative documents relating in a certain aspect to the water pollution of the Danube River.

The Bulgarian Laws that govern the prevention of the pollution of the Danube with oil products and the wastes in general are the Law on the Sea Areas, Internal Waterways and Ports of the Republic of Bulgaria and the Law on Waste Management. Two by-laws have been issued by the Minister of Transport, Information Technologies and Communication, namely Ordinance No. 9 of 29.07.2005 on the Requirements for Port Operational Capacity and Ordinance No. 15 of 28.09.2004 on the delivery and reception of ship-generated wastes and cargo residues. These documents, along with other international conventions and recommendations, under which the Republic of Bulgaria is a party, have been described below.

In Bulgaria national legislation is aligned with the European Union. These laws include:

- CELEX No 32009L0090 Commission Directive 2009/90/EC of 31 July 2009 laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status (Text with EEA relevance)
- CELEX No 32008L0105 Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council
- CELEX No 32008L0032 `Directive 2008/32/EC of the European Parliament and of the Council of 11 March 2008 amending Directive 2000/60/EC establishing a framework for Community action in the field of water policy, as regards the implementing powers conferred on the Commission
- CELEX No 32007L0060 Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (Text with EEA relevance)
- CELEX No 32006L0113 Directive 2006/113/EC of the European Parliament and of the Council of 12 December 2006 on the quality required of shellfish waters (codified version)
- CELEX No 32006L0118 Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration
- CELEX No 32006L0044 Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life (Text with EEA relevance)
- CELEX No 32006L0011 Directive 2006/11/EC of the European Parliament and of the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Codified version) (Text with EEA relevance)

- CELEX No 32006L0007 Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC
- CELEX No 32011D0127 2011/127/EU: Commission Decision of 24 February 2011 amending Decision 2007/697/EC granting a derogation requested by Ireland pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (notified under document C(2011) 1032)
- CELEX No 32000L0060 Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy
- Directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water, amended by Directive 79/869/EEC concerning the methods of measurement and frequencies of sampling and analysis of surface water intended for the abstraction of drinking water and Directive 91/692/EEC standardizing and rationalizing reports on the implementation of certain Directives relating to the environment, repealed by Directive 2000/60/EC with effect from 22.12.2007
- Directive 2006/44/EC of the European Parliament and of the Council of 6 September

- Directive 91/271/EEC concerning urban waste-water treatment, emanded by Directive 98/15/EC with respect to certain requirements established in Annex I

Chapter 3

The situation analysis and the monitoring Danube’s water.

Danube’s water are in both Romanian and Bulgarian attention of government agencies, being monitored in accordance with active laws with each state norms and regulations

Decrease of economic activities in Danube’s area led to reduced pollution but the indiscipline manifested in all domains reached alarming heights, thats way Danube’s water, although it fits in the afferent regulation, yet remains highly polluted. However, experience had shown us that the samples that were taken according to pre-established plans fits almost always in prescriptions. The accidental pollution can be cotrolled less and less, because of the technological risks, which is monotored only in exceptional cases, when due its gravity, it can not be hidden. This kind of pollution has important consequences on the environment, primarily because is more severe on small areas and secondly because it is hidden.

In the project, Danube’s water characteristics was studied in the trans-border area covered by the Program. The taken samples followed a plan, with qualitative – quantitative – positioning components, so that the main situatian should be covered, which we will meet frequently.

This complex analysis, taken into INCDTurbomotoare COMOTI and Angel Kancev University from Russe laboratories were absolutely necessary in designing of centrifuge equipment in choosing the best materials. The proposed strategy in the draft project does not address to the decontamination of Danube basic water but only to the heavily polluted with petroleum, accidentally or deliberately water from some areas.

As we said, the ““Common strategy to prevent the Danube’s pollution technological risks with oil and oil products” – CLEANDANUBE project studied the severe pollution with petroleum and derived products phenomenon of the Danube’s water in case of emergencies, diving, wreck or ship failure of the carrying petroleum ships, ships with large tanks or in case of water discharges from washing oil tankers, holds and container.

These are two main cases, recognized, required to be taken into account. Of course there are discharges of petroleum waste, containing water more or less, difficult to assess so unrecognized by the pollutants. Should be noted that disasters due to pollution, especially with petroleum derived products, is due to being hidden, unreported or unrecognized in manner time.

Apart from cases involving sinking – ship failure – ship damaging that can not be located, in principle they can occur anywhere, other cases occur in port cities on both sides of Danube’s strand, in industrialized areas bordering on the Danube.

The proposed strategy is based on an innovative viable and effective technical solution, however based, in part to prevent pollution, due a collaboration between potential polluter and action unit (decontamination)

The state of water quality on the lower Danube Delta is influenced by the significant pressures are:

- pressure from pollution sources upstream of Bazias Danube basin. Thus, the total load of nitrogen and phosphorus is found in section Reni Danube water, 82% nitrogen and 70% of phosphorus from upstream Bazias;
- pressures Danube tributaries downstream of Bazias especially rivers: Jantra, Lom, Arges and Prut;
- point sources of pollution located on the Danube.

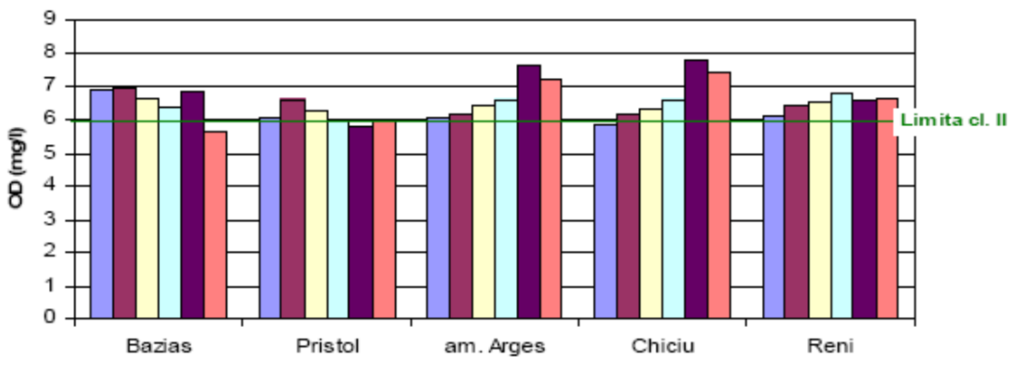
Quality of water resources is influenced to a great extent and accidental pollution. Information on accidental pollution with transboundary impacts are transmitted through "System alarm pollution prevention and accident" (Accident Emergency Warning System - AEWS). The ICPDR was developed AEWS system according to the requirements of Article 16 of the Convention on Cooperation for the Protection and Sustainable Use of the Danube River.

To assess human impact on the Danube River were used data from the Transnational Monitoring Network, National Monitoring networks and data expeditionary campaigns (eg Joint Danube Survey 2002).

In terms of time, water status and impact evaluation was performed on a 6-year period (1996-2001) for physico-chemical parameters and four years from 1997 to 2000 (for biological parameters).

Water quality assessment was based on Norm 1146/2002 and based on water quality classification scheme of biologically in the basin. Target quality objectives are the amounts of Class II Norms of Quality 1146/2002 and the classification scheme.

Results of analyzes for organic substances, as can be seen in Figure 4 showed that dissolved oxygen values ranged Danube organic matter generally to class II for most sectiunileor monitoring, except for some sections for some years in class-III of quality. To assess the impact of pollution with organic substances using saprobic index of phytoplankton.



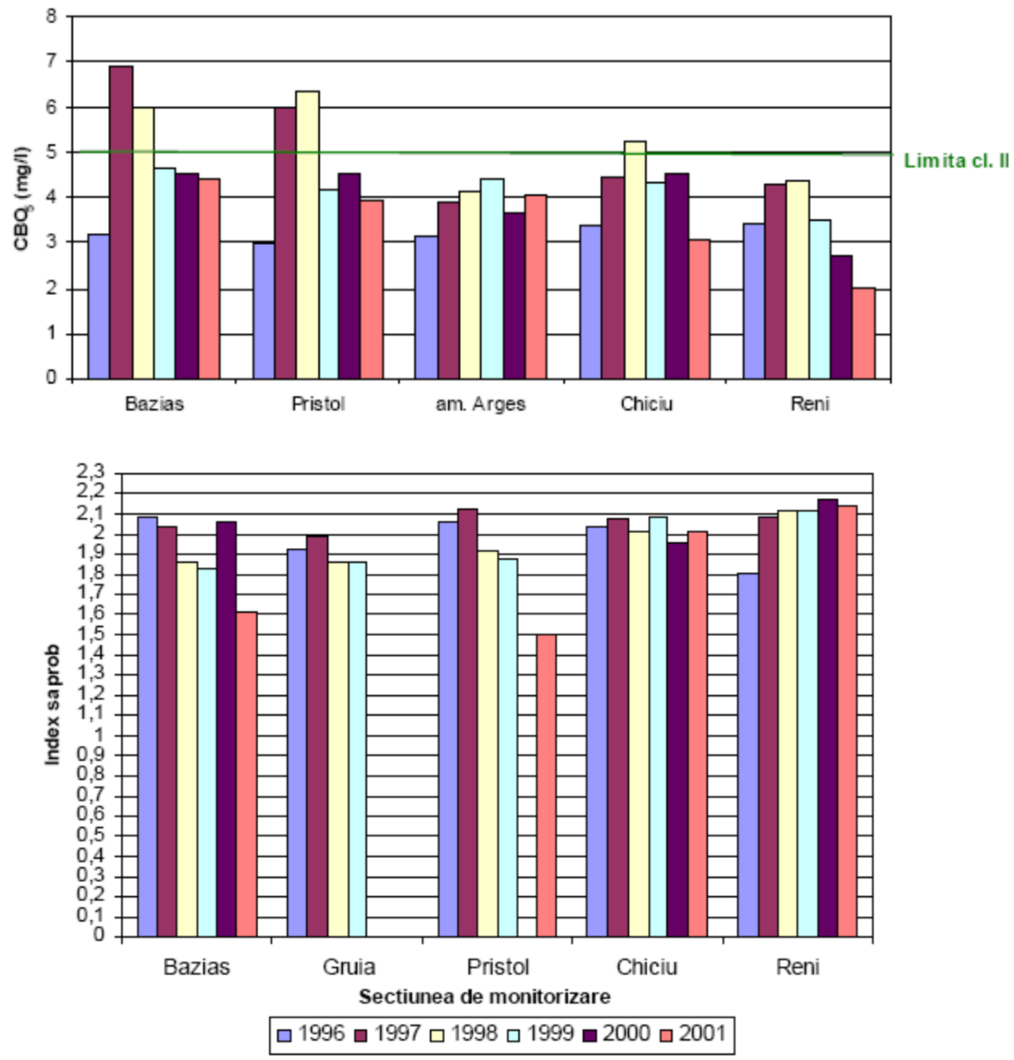
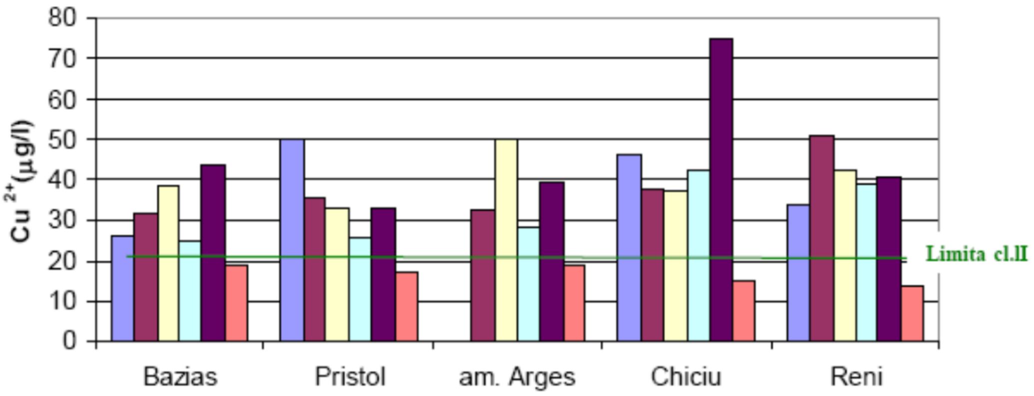


Fig. 4 Evolution of spatial concentrations of oxygen (O_2) organic matter (CBO_5) and saprobic index Danube River during 1996 to 2001



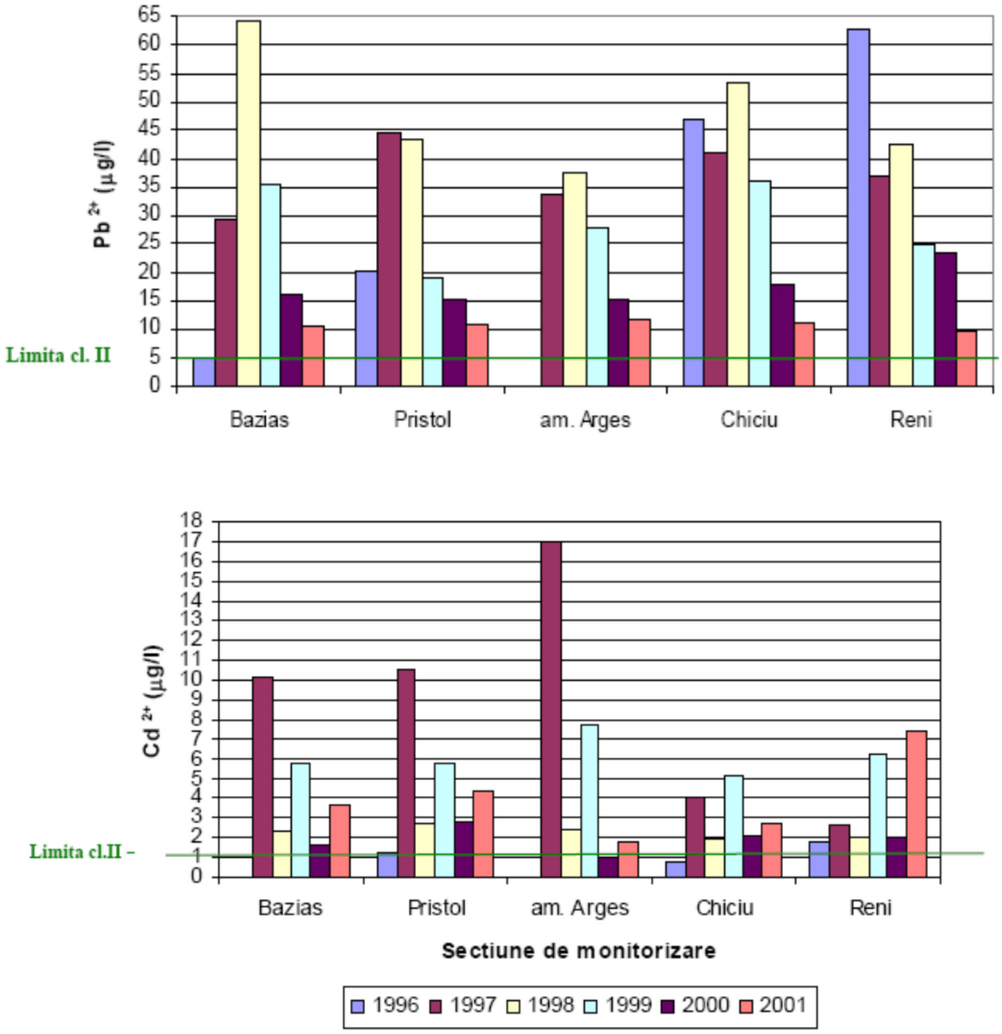
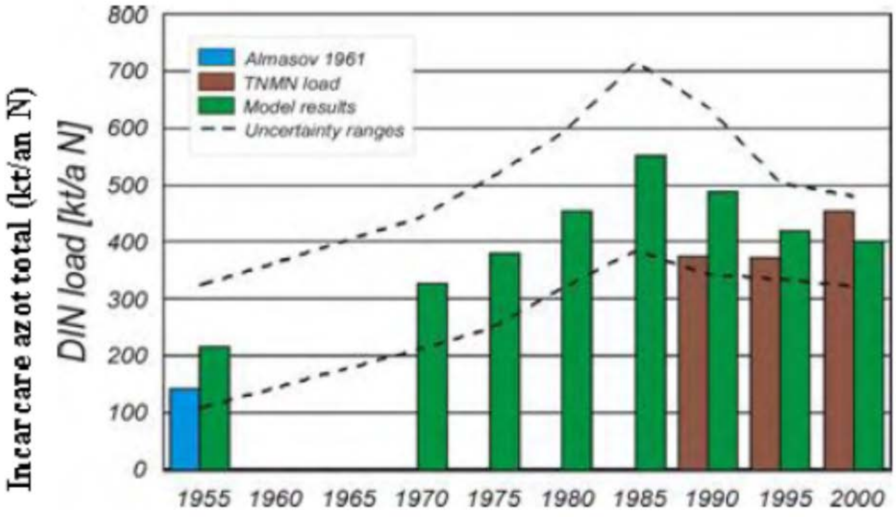


Fig. 5 Evolution of heavy metal concentrations in the Danube River during 1996 to 2001

Changes in concentrations of nitrogen and phosphorus on the Danube shows an increase during 1980 - 1989 due to the development of economic activities in the Danube basin, then their is a decrease due mainly to reduce economic activities in central and eastern European countries.

The most pronounced decrease was observed when phosphorus load due to accumulation detention Iron Gates I (Portile de Fier) and II to about 32% of the phosphorus in lake tributaries Iron Gates I.



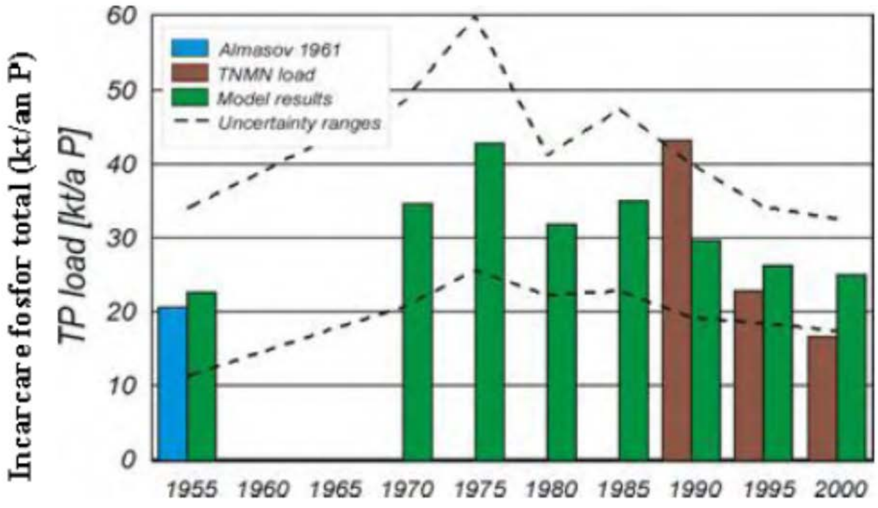


Fig. 6 Variation of nitrogen and phosphorus loads on the Danube in Isaccea section during 1955 to 2000

These results lead to the conclusion that the Danube on the Romanian sector shows significant loads of nutrients (nitrogen and phosphorus forms), heavy metals (copper, cadmium and lead) and organochlorine pesticides (DDT and lindane). This is because both diffuse agricultural sources, in particular, the use of chemical fertilizers in the upper basin of the Danube countries, and improper operation of wastewater treatment plants in central and eastern Europe, including Romania. Although state Danube water quality improved after 1990, it is lower reference state in the 50s and lower water quality is also other European rivers: the Thames, Rhine, etc. ..

Significant pressure on the Danube is the navigation that bed morphology change and cause accidental pollution of water. Thus, during 1983 - 2003, on the

Danube, between km 655 - 1075 there were 453 shipping accidents, of which 30 produced significant water pollution especially oil products (Fig. 7)

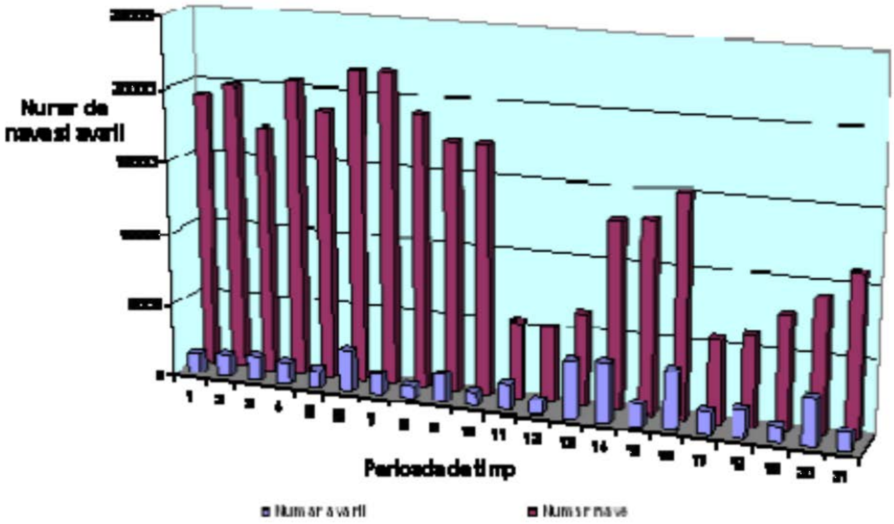


Fig. 7
Comparison Chart of traffic volume and total number of ships wrecks on the Danube between 1075 - 655 km in period 1983 - 2003

Chapter 4

Steps that must be taken to objectives achieving

The key element of the strategy is to bring together trans-border communities as a first step to a sustainable cooperation and promoting joint actions in order to overcome pshysical and socio-cultural barriers, and towards to exploit opportunities offered by the development of trans-border area for sustainable growth on long and medium term.

Cooperation strategy focuses on issues and opportunities that arised there where the border is an important factor and the trasn-border action is a key requirement. This is intended to be the promoter of the socio-economic trans-border sustainable development, as a coherent and effective response to the identified needs of the area.

The strategy takes into consideration the following strategic considerations :

- Establish common business interests that leads to improving economical cooperation level and to prevent the economical divergence of the border regions of the two countries.
- Area’s natural characteristics are important values that can be maintained only through joint interventions.
- Mutal knowledge is the basic requirement for economical and social connections, which will be reflected in the priority given to the social and cultural bounds.

There are of course limitations regarding on what can the Program do, concerning to trans-border area multiple problems solving, given its size and assigned financial resources. While the strategy trys to use available resouces efficiently as possible, it is recognized also the importance of extensive activities stimulation to overcome the inherent weak points of the area.

Basic strategy aims to overcome the physical and socio-cultural barriers what are still present and to promote territorial development which respects environmental issues and the need for sustainable growth in the medium and long term through joint initiative in trans-border area.

Given this issues, the main elements of joint development strategy is based on establishing common frameworks of cooperation development between the main factors that can be developed as well as identifying subjects where common interests can be established and developed, and regional identification of the trans-border area can be strengthened. To achieve the strategy must be carried out several activities, steps that must be taken to establish a responsible and effective management of emergency situations, the technological risks of contamination of the Danube’s water with oil and oil products. In the following we try to define, regarding our knowledge level at this date, generally, the main steps that must be followed:

- Creating a Romanian-Bulgarian jointly working group, at national level that must analyze the proposed strategy in the project, to decide its adoption or not, and the moment of commencement of application activities, as well the designation of operational teams.
- The analysis of the situation from all points of view since the integral or partial moment starts the application of the proposed strategy
- Completion, given the current situation, the philosophy and visions for the future of the new promoted strategy
- Identifying problems and causes that generate them, updating them to the applicability moment of the strategy by the operative team.
- Identify community resources
- Completing the new strategy objectives by the operative team, given the updated situation and gained information in the las period.
- Establishing priorities
- Initiating the action plan- creating sequential programs.
- Action plan implementation and monitoring
- Plan evaluation

Chapter 5

Implementation of new technical solutions for proccessing contaminated waters

Sedimentation in centrifugal field

The phenomenon is the result of different densities of heterogeneous mixture phases. The emulsions or suspensions that are difficult filterable are due to be separated in components phases (decanted).

The centrifuges that are doing the sedimentation are commonly called centrifugal decanters. A measure of the velocity of the particle displacement in the centrifugal fiel dis given by the Stockes law in which the gravitational acceleration is relaced with the acceleration given by (1).

The recourse to Stockes law is justified by the domain in which currently it is applying to the centrifugation (very fine particles, sedimentation characterized by the value of the Re criterion, reported to the particle, the lower of 1).

The value of this sedimentation velocity in the centrifugal field varies with R distance from the rotation axis. An average speed is estimated folowing for R radius the value of a logarithmic average (see Table 2).

The sedimentation velocity in centrifugal fiel dis as in the gravitational field, a limit. It results from a balance between weight of the particle that is submitted (or centrifugal forces acting on it) and resistance forces opposite by the field through which the particle moves.

Theoretically, this balance is achieved in an infinitely long time.

The real sedimentation speeds will be fractions of these limits and they will approach asymptotically to them.

For example, particles of micron order reach approx. 90% of the calculated sedimentation speed in time of microseconds order, larger particles (about 100 microns) reach the same limit fraction in miliseconds.

It considers the period of 0.1 seconds to be sufficient to all dispersed particles in order to practicaly reach sedimentation speed limit, although this limit varies in centrifugal field, as shown.

Stationary time of heterogeneous mixture in continuous centrifuges that can be calculated from this observations.

Various constructions of centrifugal decanters are listed in Table 3, together with indications regarding the usage field.

Various interior improvement of the centrifuges aimed at :

1) reduction traveled trajectory on particles to sedimentation. The mass stand to centrifugation is divided by means of dics, traps, inclinde in the direction of centrifugal forces. In the same purpose are achieved centrifuges with large proportions reel's depth / diameter.

2) Turbulence attenuation that prejudices the sedimentation, especially of fine particles. It is assembled baffle, downcomer logjam, stablizing surfaces, alimentation connecting pipe are installed even in the phase separation area.
3) Sediment removal. A particular use of decanter centrifuge is the sorting of graining polidispersed materials. Properly adjusting the speed and the time in which the suspension is centrifuged. It can be controled the diameter of deposited particles. It will remove with the fluid phase the fraction of inferior particle dimension. The technique can be imporveed by inserting cages in suspension mass. In Table 2 are summarized the main elements of technological calculation of the decanter centrifuges.

Calculating relations for sedimentation in centrifugal’s field. *Tabel 2.*

Serial number	Denomination	Relations	Observation
1	Sedimentation speed	$\overline{w}_{0,c} = \frac{1}{18} d^2 \frac{\rho_1 - \rho_2}{\eta} \omega^2 R$ $\overline{w}_{0,c} = \omega_{0,g} \cdot \overline{Z}$	It is deduced from the Stokes (v. sedimentation $\overline{R} = \frac{R_2 - R_1}{\ln \frac{R_2}{R_1}}$ $\overline{Z} = \omega^2 \overline{R}$
2	Minimum diameter of the particles that deposit	$d_m = 3\left[\frac{2\eta \ln(R_2/R_1)}{\omega^2 \tau(\rho_1 - \rho_2)}\right]^{1/2}$	For discontinuous, tubular centrifuges
		$d_m = 3\left[\frac{2\eta \ln(R_2/R_1)}{\omega^2 \tau(\rho_1 - \rho_2)}\right]^{1/2}$	For continuous, tubular centrifuges.
3	Σ index	$\Sigma = \frac{\omega^2 R_2 V}{g \cdot s} = z \cdot \frac{V}{s}$	For continuous, tubular centrifuges.

Instructions for choosing decanter centrifuges. *Tabel 3*

Alimentation	**The system subdued to separation**	**Modul de evacuare a fazelor**	**Tipuri de centrifuge recomandate**
Continuous	Liquid- Liquid systems with possible low concentrations of solid phase Suspensions with medium concentrations of solid phase Concentrate suspension, sludges, crystaline masses	Continuous evacuation of fluid phases. Continuous evacuation of the liquid and discontinous of the sediment Continuous Continuous for fluid Discontinuous for sediment Continuous	Trap separator Reel centrifuge Supercentrifuge Ultracentrifuge Trap separators Centrifuges with helical carrier Centrifuges with trap and talere şi valve Trap separators
Discontinuous	Medium concentration suspensions Concentrated suspension	Discontinuous, manual Discontinuous, manual sau automatic	Centrifuge with helical transporter Chamber centrifuge Centrifuge wiht filled barrel

In a continuous decanter tubular centrifuge, the fluid debit through centrifuge, understood as the liwuid volume that passes through a flow perpendicular section on the flow direction per unit time is:

$$Q = \left(\frac{d^2 g(\rho_1 - \rho_2)}{\rho \cdot \eta}\right) \cdot \left(\frac{\omega^2 R_2 V}{gs}\right) \quad (3)$$

The first parenthetical groups the sizes that are referring only to suspension. The factors from the second parenthetical defines the (4) coefficient:

$$\sum = \frac{\omega^2 R_2 V}{g \cdot s} = z \cdot \frac{V}{s} \quad (4)$$

and refers only to the centrifuge characteristics (gravitational acceleration “g” being an universal constant)

Performance of the decanter centrifuge *Tabel 4*

Characteristic	Type of centrifuge			
	With reel	With trap	With trap and lateral socket	Supercentrifuge

The minimum diameter of the particles that can be separated µm Solid phase concentration % mass Separate solid flow, kg/h Discharged liquid flow, m^3/h Sediment	2 2 – 60 50 – 50000 0,2 –130 Paste or granules	0,25 1 0,5 – 50 0,2 –130 Paste or granules	0,25 2 – 20 5 – 1500 0,2 – 200 Thin mud	0,1 0,1 0,4 – 2 0,05 – 5 Paste or granules

Results for the same suspension liege to settlement in different decanter centrifugal:

$$\frac{Q_1}{\Sigma_1} = \frac{Q_2}{\Sigma_2} = ... = 2\omega_{0,g} = \text{const} \quad (5)$$

The (5) relation allows comparison and transposition of centrifuges scale. The Σ coefficient has a surfaces dimensions and it is the horizontal area of an used recipient for sedimentation of the same suspension in gravitational field, recipient which performs the same separation as in the centrifuge. The applying of the Σ coefficient for pransposition at scale it is still limited by assumptions used for deduction of its expression, namely:

1) Conditions relating to solid dispersed phase: spherical grains of equal size, the absence of coalescence or dissolution of the particles (sases where sedimentation speed is not the same as for parcles that settles individualy), uniformly distributed solid in fluid, application conditions of Stockes law.

2) Assuptions regarding the flow through centrifuge: radial diverging streamline, operated fluid is instantaneously distributed throughtout the mass of fluid existing in centrifuge, neglecting centrifuge mass heterogeneity and transitional flow regimen, rotational speed of the fluid is the same with the centrifuge wall, is not taken into consideration the mixing effects and redispersal of the solid phase from the liquid. The flow is not altered in the vicinity of the sediment mass.

To enable using extrapolation of the Σ coefficient in design calculations, equation (5) was modified (6):

$$\frac{Q_1}{e_1 \Sigma_1} = \frac{Q_2}{e_2 \Sigma_2} = ... = \text{const} \quad (6)$$

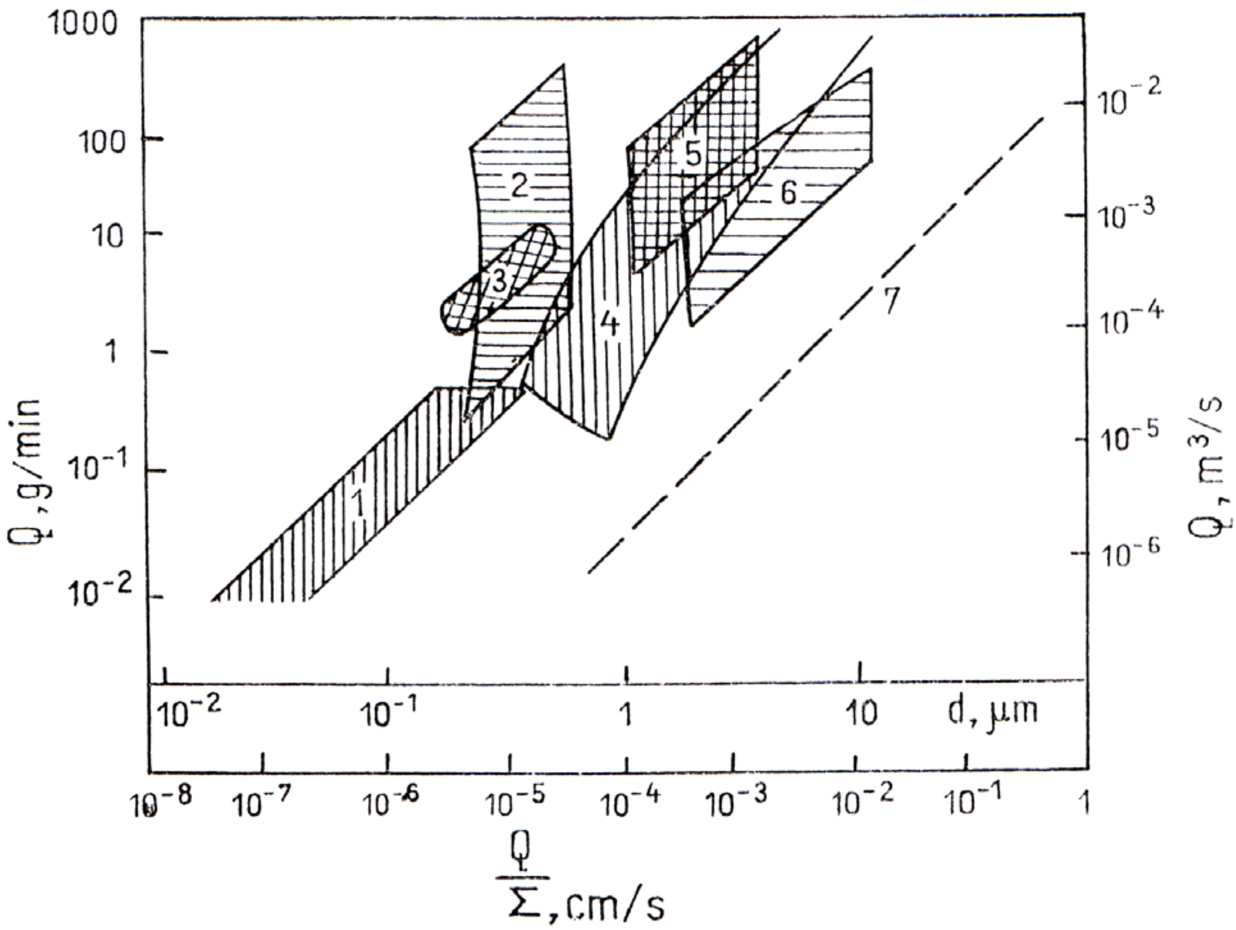


Fig.2 Diagram for preliminary calculation of decanter centrifuge

The centrifuge separates the same suspencion, in the same matter. The factor defines an efficiency that includes all neglected effects of Σ coefficient, the effects enumerated above. Experimental studies, in-depth on a particular type of centrifuge, leads to values that can be used to calculate a new device, of the same type. Note that, although the deduction of Σ coefficient have resorted to the example of a tubular centrifuge, the drawn conclusions are applicable to other centrifugal decanters construction. A more rigorous transposing will include, besides an analysis of Σ coefficient and efficiency factor is (equation (6)) and the stationary duration of the centrifuge phase, the maximum amount of solid phase that can be accumulated in the equipment, etc..

The figure 2 allows the selection and preliminary calculation of centrifuge. The graphics are valid on a density difference between phases 1g /cm3 and a liquid viscosity of 1 cP. The diameter scale of the particles refers to the 50% depose of particles of a certain size. For other values of the specified parameters, the scales (d) and (Q / Σ) are adjusted so that the point of 1 μm from scale (d) should correspond to the corrected value:

$$Q/\Sigma = 1{,}09 \times 10^{-7} (\rho_1 - \rho_2) / \eta \qquad (7)$$

With density measured in g/cm3 and viscosity in Pa·s. according to the particle side that must be separated in a 50% proportion in centrifuge and the suspension flow for processing, is defined in the field of the figure a point that fits within one of the domains marked with numbers from 1 and 6. In this way is choosen the convenient device type for operation and simultaneously, on adjusted (Q / Σ) scale it is read the value of this ratio. It results Σ, the Q flow being imposed by the material balance of the installation of which the centrifuge is part of. From the definition of Σ coefficient ((4) equation) it can be obtained the operating parameters of constructional dimensions.

Operation general principle:

The separator with different densities components in principle works only through sedimentation, a process which produces the separation of liquids and solids in suspension due to the density difference. If the density difference is large, then the gravity can provide enough force to occur separation within a reasonable time – as in the case with large tanks or inclined ribbed separator or inclined plate separator. If the density difference is small, then the gravitational separation would take too long and the separation force must be increased by addition of centrifugal forces several times higher than that of gravity. The centrifugal force can be created either by flowing mixture as a hydrocyclone or mechanically driven rotation, as in sedimentation centrifuges. The main beneficial characteristics of the separator in this equipment range its ability to separate the phases in continuous system.

The separator with centrifuge can be used for most types of liquid / solid separation, given its ability to handle a variety of different mixtures and different concentrations. The separator can be used for three-phase separation in which the liquid is composed of water and oil. It can be operated so as to give a high degree of separation. Multiphase mixture enters through a pipe inside the centrifugal separator through annular arbor to the feed trunk and accelerator level, parts located in transporter assembly that together carries out the mixture acceleration and its radial leading through alimentation bean made of a hard ceramic material, into annular compartment bounded by the cylinder and transporter assembly. Thus, solid particles are firstly designed, before the liquid phase, on the inner wall of the cylinder which has a rotation motion about 3850 rot/min, through exhaust bean. The second round of centrifugal separation founds the three mixture components layered disposed as follows: the solid component towards the cylinder wall, and then also water towards the inside of oil layer.

The evacuation of the three components resunted from the centrifugation process is made as follows: because the transporter is provided with a snail made of sealed plate meaning reverse wrapping than rotation direction, producing displacement if the two fluid layers to the one form the separator terminal. Here liquids meets four baffle diaphragms, two for water and two for oil, diametrically disposed and under different radius, so that water collection is possible on its deposit layers level. On the other hand, on the cylinder body are sealed through longitudinal narrowed strips of certain depth, which carries a radial clearance with cylinder coil and formed between spaces. As the solid layer thickness increases, the part that As the solid layer thickens, the part exceeding the helix' (3d; daca e 2d "spiral's") towards the inside is dragged along by the hob together with the water and petroleum, while always being in contact with the cylinder until its thickness reaches the radial clearance level at which moment the hob's coil is left with nothing to carry (thus, there is a return point at which the axial component of a sediment particle's velocity is zero), initiating the motion in the opposite sense in the sediment layer at the cylinder wall, by means of gaps created by platbands welded due to lower hydraulic resistance.

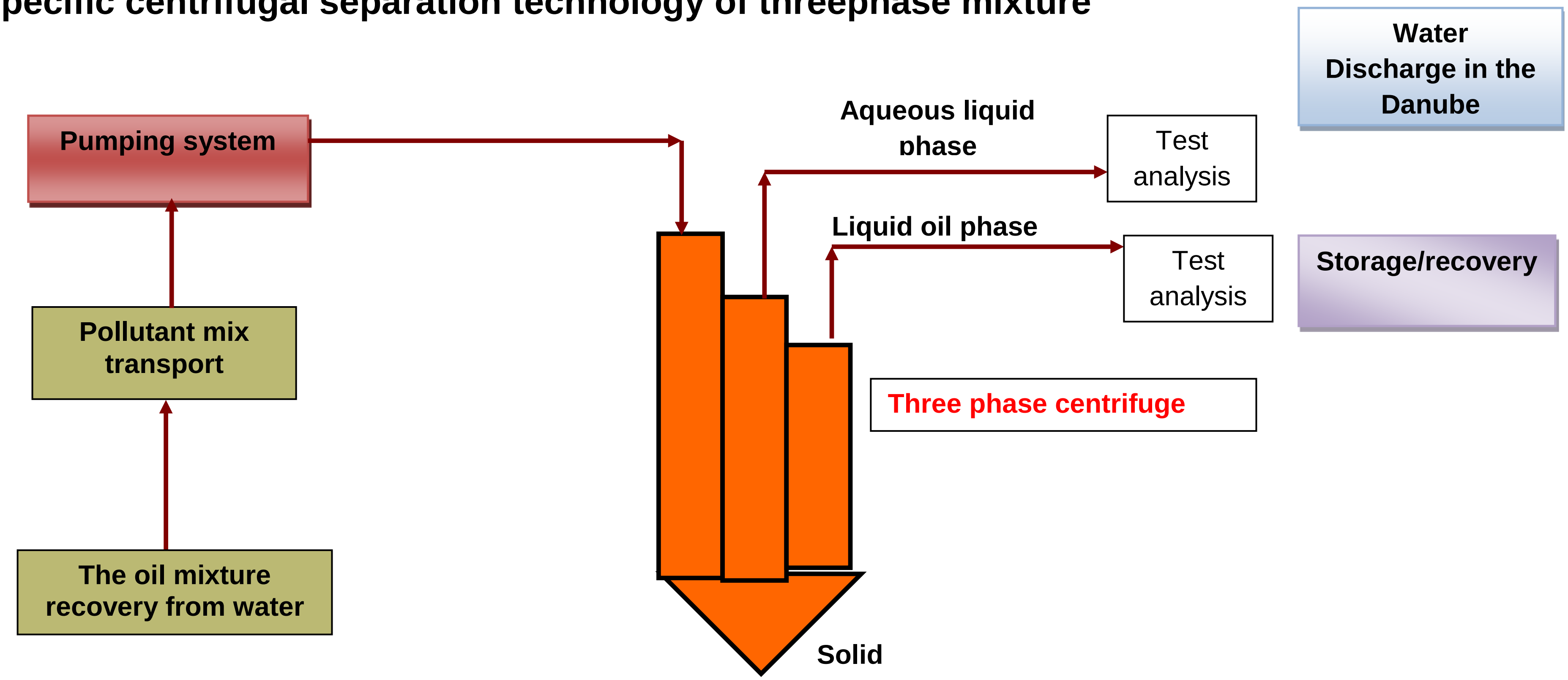
Therefore, solids execute two rotor-translation motions: the first one is executed by the layer exceeding the blade's tip towards the inside, in the sense of the transportation of water and oil to the return point; the second motion, of opposite sense to the first, executed by the layer of solids situated near the cylinder's wall in the gaps created, which evacuates the solid component. Henceforth, the sediment's path reaches the confuzor which through its convergent profile decreases the sediment centrifuging force at the evacuation slits. Also, to allow the axial displacement of the sediment the confuzors body is provided with longitudinal channels.

The difference in rotation velocities between the cylinder and the carrier assembly is what gives the degree of dehydration of the sediment. The greater it is, the longer the sediment stagnation period, therefore making it drier, but increasing the resistant moments and decreasing the mechanical efficiency of the machine.

The smaller the velocities difference, the shorter the sediment stagnation period and so, it is wetter and the resistant moments are smaller, giving better mechanical efficiency. On the other hand, certain parameters with respect to the petroleum percentage in the mixture, which must not exceed a certain greening degree, are imposed.

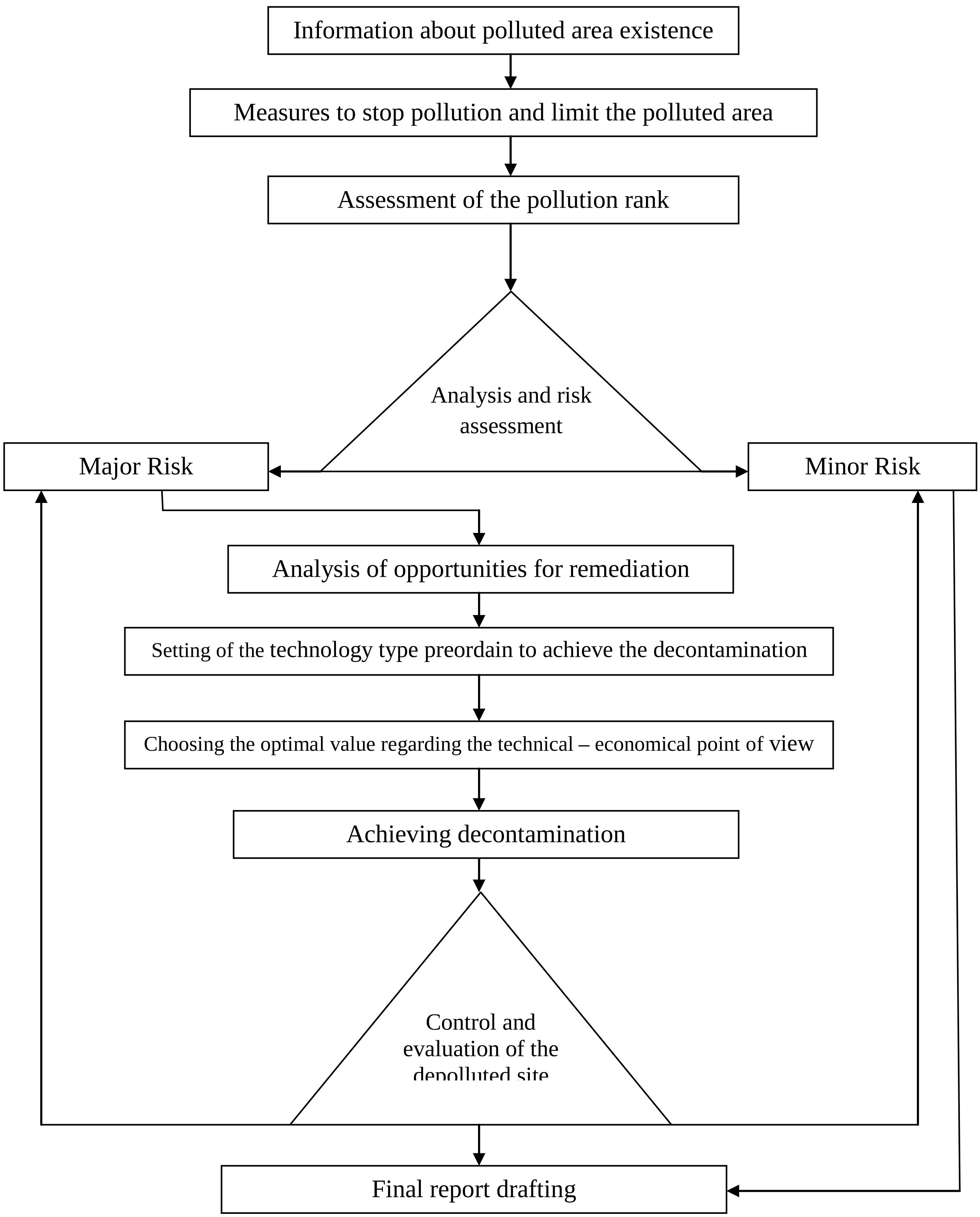
Hence, there is an optimum value of the differential velocity, for each petroleum products mixture composition, which is established only experimentally, during exploitation.

Specific centrifugal separation technology of threephase mixture



Schematic diagram of the technological green steps of polluted water with oil products

The analys and Risk management



In principle, the technological flow for treating water contaminated with petroleum products in marine accidents include the following operations:

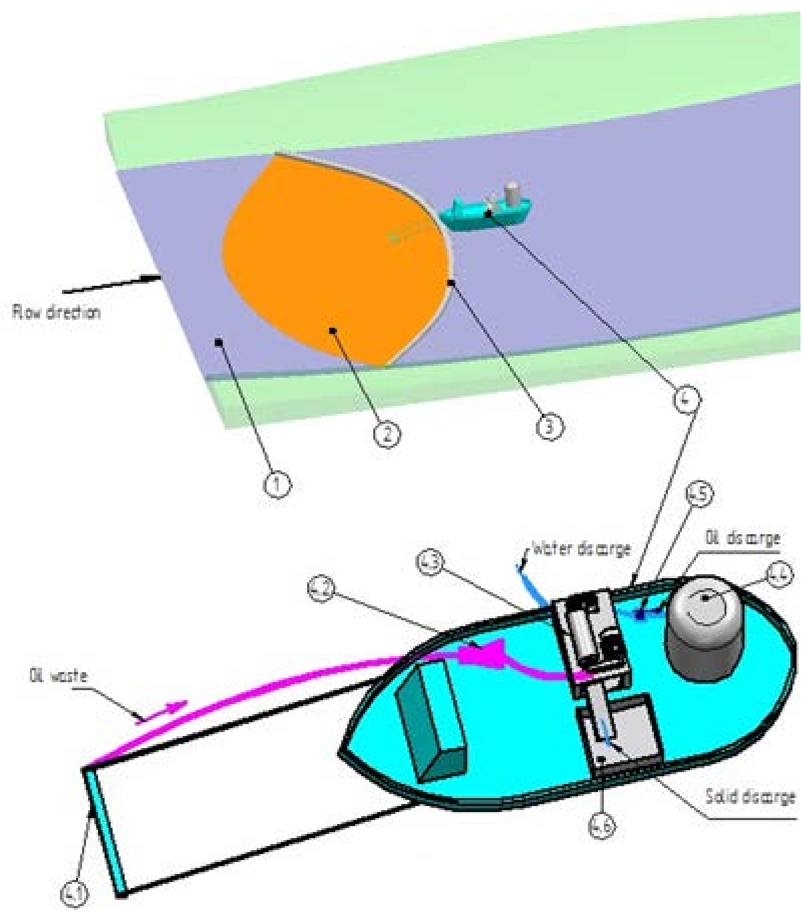
1. Information, Warning
2. Measures to stop pollution and limit the polluted area
3. Monitoring is done throughout the works of removing pollutants. The initial phase of monitoring is to determine pollutants by analysis of samples, analyzes that will be resumed in the terminal phase to confirm the completion of remediation and the possibility of recovering the water and the solid part without the oil component, which is stored separately.

Depending on the appearance and color of the oil slick on the water surface, we can determine the thickness (volume) of the pollutant.

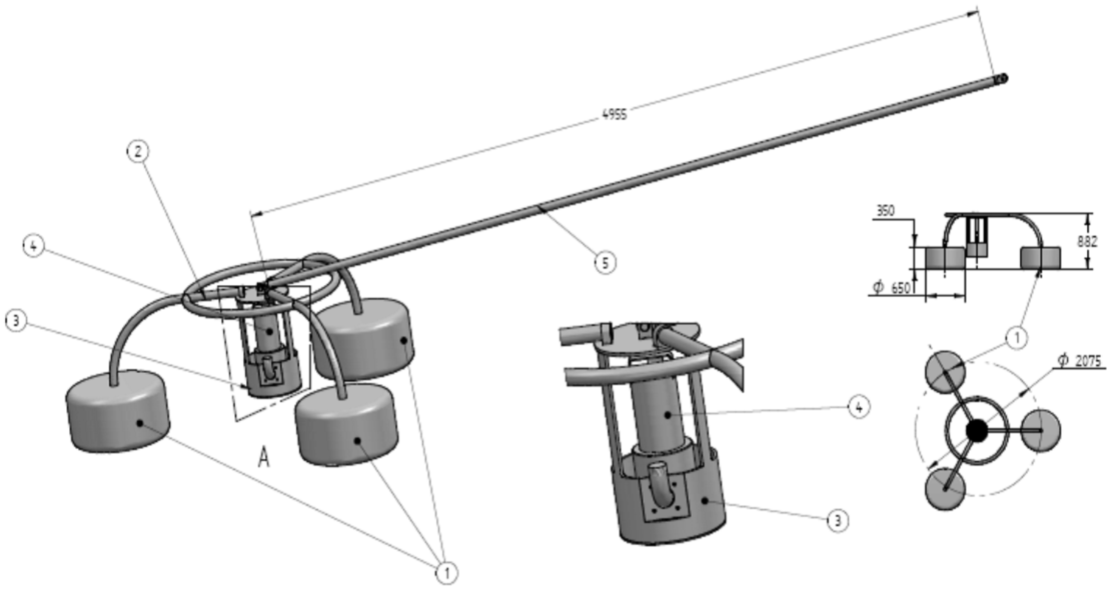
Surveillance of the area will continue after the completion of works by checking for anything that may have been overlooked.

According to the initial observations a method of intervention is defined in order to be applied. (minor or major intervention)

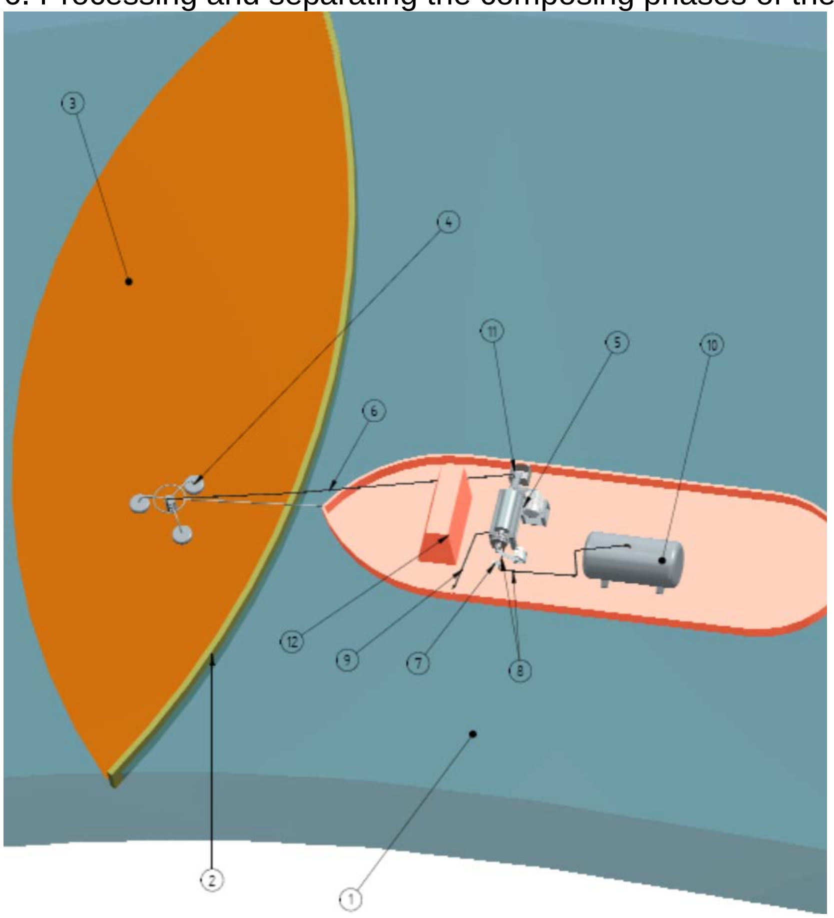
4. Isolating the contaminated area

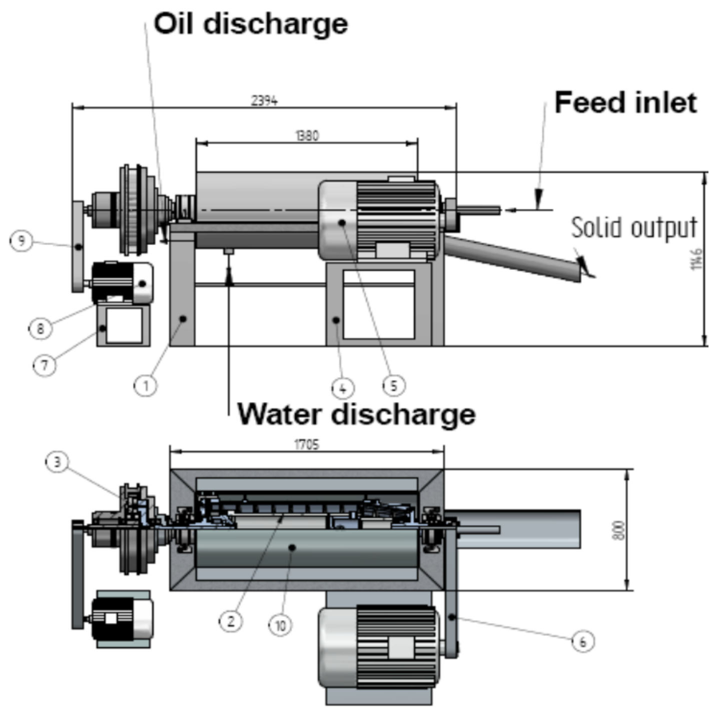


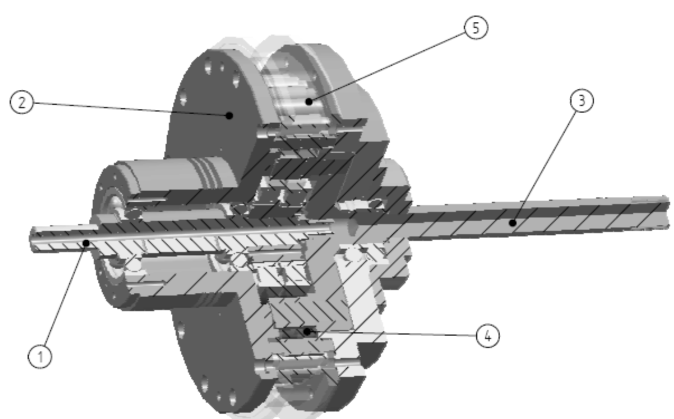
5. Recovering the water polluted with oil products



6. Processing and separating the composing phases of the polluting mixture







7. Controlling and appreciating the decontamination. Verification and analysis of separate.

The quality of the water can be defined as a conventional set of physical, chemical, biological and bacteriological characteristics, allowing the sample to come under a certain category, therefore coming to serve a purpose

To determine the quality of the water, out of the multitude of physical, chemical, biological and bacteriological characteristics to be established through laboratory analysis, only a small number, considered to be more significant, are used. The world environment supervision system makes provisions for water quality management by means of the following three categories of parameters:

- Basic parameters temperature, ph, conductivity, dissolved oxygen, bacillus coli
- Indicators parameters of persistent pollution: cadmium, mercury, organo-halogenated and mineral oils
- Optional parameters: total organic carbon (TOC), biochemical oxygen demand (BOD), anionic detergents, heavy metals, arsenic, boron, sodium, cyanide, total oils, streptococcus. Under E.U. law in force, implemented in legislation of both countries, to characterize the quality and pollution rank of water that uses the quality indicators, which are several categories:

Organoleptic indicators

Indicators	**Allowed values**	**Exceptional allowed values**
Odor, degrees	2	2
Taste, degrees	2	2

Physical indicators

Indicators	**Allowed values**	**Exceptional allowed values**
Ion hydrogen concentration (pH), pH units	6,5 ... 7,4	max. 8,5
Electrical conductivity, μs/cm	1000	3000
Color, degrees	15	30
Turbidity, degrees or formasine turbidity units	5	10

General chemical indicator

Indicators	**Allowed values**	**Exceptional allowed values**
Aluminum, mg/dm^3	0,05	0,2
Ammonia, mg/dm^3	0	0,5
nitrite, mg/dm^3	0	0,3
Calcium, mg/dm^3	100	180
Residual chlorine in water, mg/dm^3		
- To consumer		
- Free residual chlorine	0,10 ..0,25	
- Total residual chlorine	0,10 ..0,28	
- On entering the network		
- Free residual chlorine	0,5	
- Total residual chlorine	0,55	
Chlorides, mg/dm^3	250	400
Distillate phenols compounds, mg/dm^3	0,001	0,002
Copper, mg/dm^3 max	0,05	0,1
Synthetic anionic detergents, mg/dm^3	0,2	0,5
Total hardness, german degrees	20	30
Iron, mg/dm^3	0,1	0,3
Phosphates, mg/dm^3	0,1	0,5
Magnesium, mg/dm^3	50	80
Manganese, mg/dm^3	0,05	0,3
Dissolved oxygen, mg/dm^3	6	6
Fixed residue, mg/dm^3 min max	100 800	30 1200
Oxidizable organic substances, mg/dm^3 - Through method with $KMnO_4$ expressed in: - $CCO_{Mn}(O_2)$ - $KMnO_4$ - Through method with $K_2Cr_2O_7$ - $CCO_{Cr}(O_2)$	 2,5 10 3	 3 12 5
Sulfates, mg/dm^3	200	400
Sulfur and sulfide hydrogen, mg/dm^3	0	0,1
Zinc, mg/dm^3	5	7

Toxic chemical indicators

Indicators	Allowed values
Aromatic amines, mg/dm^3	0
Arsenic(As^{3+}), mg/dm^3	0.05
Nitrogen(NO_3^-), mg/dm^3	45
Cadmium(Cd^{2+}), mg/dm^3	0.005
Free cyanide (CN^-) mg/dm^3	0.01
Chronmium (Cr^{6+}) mg/dm^3	0.05
Fluorine (F^-), mg/dm^3	1.2
Polycyclic aromatic hydrocarbons, $\mu g/dm^3$	0.01
Mercury (Hg^{2+}), mg/dm^3	0.001
Nickel (Ni^{2+}), mg/dm^3	0.1
Pesticides (insecticides, herbicides) $\mu g/dm^3$ - each component - sum of all components	 0.1 0.5
Plumbum (Pb^{2+}), mg/dm^3	0.05
Selenium, mg/dm^3	0.01
Trihalomethanes mg/dm^3 -total - cloroform ($CHCl_3$)	 0.1 0.03
Natural uranium, mg/dm^3	0.021

Radioactive indicators

Global activity, max.	Allowed values	Exceptional allowed values
	Bq/dm^3	
alpha	0.1	2.3
-beta	0	50

Biological indicators

Indicators	Allowed values
Seston volume obtained by filtration through plakton netting ,cm^3/m^3:	1-10
Animal organisms, plant and particles visible to the naked eye	absence
Microscopic animal organisms, number/dm^3	20
Organisms by multiplying the mass, changes the organoleptic or physical properties of water / 100 dm^3	absence: are allowed the isolated exemplars according to the species
Indicator organisms of pollution	absence
Harmful organisms: geo-helminth eggs, cysts of Giardia, pathogenic intestinal protozoa	absence

Values are tabulated according to in force regulations, chemical and physical indicators, that are detailed on the 5 quality classes:

- First Class - limits to natural reference conditions(for potable water feeding, industrial processes, live-stock breeding, food industry feeding, irrigation of crops, salmonidae breeding, swimming pools)
- Second Class – limits adequate to water utilized for protection of aquatic ecosystems, for stock pond feeding, except for those with salmon, breeding and development of plain fishing stock . feeding of industrial processes and for urban recreation purposes
- 3rd , 4th, and 5th Class – limits adequate to 2 to 5 times larger than reference objectives, feeding of irrigation systems, feeding of various industries and other uses not mentioned in classes I and II

Values on classes limits of the main physico-chemical indicators

Physico-chemical indicators		**UM**	**Limit values on class**				
			I	**II**	**III**	**IV**	**V**
Phisics	Temperature	Celsius degrees	It is not regulationg				
	pH	-	6,5 – 8,5				
Oxygen regime	Dissolved oxygen	mg/l O_2	7	6	6	4	<4
	CBO_5	mg/l O_2	3	5	10	25	>25
	CCO-Mn	mg/l O_2	5	10	20	50	<50
	CCO-Cr	mg/l O_2	10	25	50	125	>125
Nutrients	Ammonium $N\text{-}NH_4$	mgN/l	0,2	0,3	0,6	>1,5	
	Nitrite N-NO	mgN/l	0,01	0,06	0,12	0,3	>0,3
	Nitrogen $N\text{-}NO_3$	mgN/l	1	3	6	15	>15
	Total nitrate N	mgN/l	1,5	4	8	20	>20
	Orthophosphate $P\text{-}PO_4$	mgP/l	0,05	0,1	0,2	0,5	>0,5
	Total phosphate P	mgP/l	0,1	0,2	0,4	1	>1
	Chlorophyll a	>µg/l	0,05	0,1	0,2	0,5	>0,5
General ions, salinity	Filterable residue	mg/l	fond	500	1000	1300	>1300
	Sodium Na^+	mg/l	fond	50	100	200	>300
	Calcium Ca^{2+}	mg/l	75	150	200	300	>300
	Magnesium Mg^{2+}	mg/l	fond	25	50	100	>100
	Total iron	mg/l	fond	0,1	0,3	1,0	>1,0
	Total manganese	mg/l	fond	0,005	0,1	0,3	>0,3
	Chlorides Cl^-	mg/l	fond	100	250	300	>300
	Sulfates SO_4^{2-}	mg/l	80	150	250	300	>300
Metals -dissolved fraction	Zinc Zn^{2+}	µg/l	fond	5	10	25	>25
	$Copper^{2+}$	µg/l	fond	2	4	8	>8
	Total chromium	µg/l	fond	2	4	10	>10
	Plumb Pb^{2+}	µg/l	fond	1	2	5	>10
	Cadmium Cd^{2+}	µg/l	fond	0,1	0,2	0,5	>0,5
	Mercury Hg^{2+}	µg/l	fond	0,1	0,15	0,3	>0,3
	Nickel Ni^{2+}	µg/l	fond	1,0	2,0	5,0	>5,0
	Arsenic As^{2+}	µg/l	fond	1,0	2,0	5,0	>5,0
-total concentration	Zinc Zn^{2+}	µg/l	fond	100	200	500	>500
	$Copper^{2+}$	µg/l	fond	20	40	100	>100
	Total chromium	µg/l	fond	50	100	250	>250

	Plumb Pb^{2+}	μg/l	fond	5	10	25	>25
	Cadmium Cd^{2+}	μg/l	fond	1	2	5	>5
	Mercury Hg^{2+}	μg/l	fond	0,1	0,2	0,5	>0,5
	Nickel Ni^{2+}	μg/l	fond	50	100	250	>250
	Arsenic As^{2+}	μg/l	fond	5	10	25	>25
Toxic organic substance	Phenols	μg/l	fond	1	20	50	>50
	Active anionic detergents	μg/l	fond	500	750	1000	>1000
	Petroleum hydrocarbons	μg/l	fond	100	200	500	>500
	PAHs	μg/l	-	-	-	-	-
	PCBs	μg/l	-	-	-	-	-
	lindane	μg/l	0,005	0,1	0,2	0,5	>0,5
	Pp DDT	μg/l	0,001	0,01	0,02	0,05	>0,05
	Atrazine	μg/l	0,002	0,1	0,2	0,5	>0,5
	Trichloromethane	μg/l	0,02	0,6	1,2	1,8	>1,8
	Tetrachloromethane	μg/l	0,02	1	2	5	>5
	Trichloroethane	μg/l	0,02	1	2	5	>5
	Tetrachloroethane	μg/l	0,02	1	2	5	>5
	AOX	μg/l	10	50	100	250	>250

Physical-chemical sediment determination		
Components	**UM**	**Concentration limit**
Arsenic	mg/kg	17
Cadmium	mg/kg	3,5
Chromium	mg/kg	90
Copper	mg/kg	200
Plumb	mg/kg	90
Mercur	mg/kg	0,5
Zinc	mg/kg	300
Benzpirene	mg/kg	750
Lindane	mg/kg	1,4
PCBs	mg/kg	280

Biological indicators					
Indicator	Class values				
	I	II	III	IV	V
Index saprobic MXB	<1,8	1,8 -2,3	2,31 - 2,7	2,71 - 3,2	>3,2

Microbiological indicators					
Indicator	Class values				
	I	II	III	IV	V
Total coliforms	500	10000	-	-	-
Fecal coliform	100	2000	-	-	-

According to Art. 13 of Water Frame Directive, member states develop a management plan for each hydrographic district, and if localized in an international district must ensure coordination for production of a singular management plan. Romania, like Bulgaria, situated in the Danube's basin, contributes to the elaboration of the Danube's Hydrographic District Management Plan

The water and solids restored in the environment; petroleum stored for transport. According to oil waste centrifuging systems, three steady phases result that must be verified and enclosed within legal limits of use restoration or source discharge.

WATER resulted from centrifuging must be verified to abide legal requirements for used water discharge by means of quality indicators for waster water provided by HG 352/2005(NTPA 002/2005) according to the following table:

Table 7.3

	Water category WASTEWATER NTPA-002:2005	Quality indicators	Maximum permissible concentrations [mg/l]	Maximum concentrations MEASURED [mg/l]
		pH	6,5-8,5	7,6-8,9
		Suspensions	350	160-320
		CCOCr	500	300-700
		Detergents	25	30-60
		Phenols	30	10-20
		Extractable substances	30	10-75
		Sulfur and sulfide hydrogen	1	10-35

Chapter 6

Intervention methods in case of hydrocarbons pollution

Essential elements underlying intervention in case of hydrocarbons pollution, is materialized by:

- The existence of coordination legal national organism and operations organization
- The existence of specialized and trained personnel
- The existence of specialized and reliable equipment

The main objectives of intervention are:

- Border protection and sensitive areas pollution limitation (economic, touristic and reservations)
- The pollutant recover as possible
- The polluted area rehabilitation as possible for restoring the initial ecological situation

Intervention methods appliance is conditioned by several factors that concur in different proportions to the intervention operations success:

- Hydrometeorological conditions at the intervention moment (wind, strong waves, floods, temperature, etc.)
- The acting processes on the discharged pollutant
- Type and amount of the pollutant
- The impact type and polluted area type
- Human and material resources available at the intervention time

Regarding to the pollutant impact type, this can be:

- Economical
- Ecological
- Social
- Political

Economical impact refers to the negative effects induced to economical activities, whether industrial, touristic, industrial and sportive fishing and not least shipping itself.

If we talk about ecological impact, pollution effects depends on several factors such as spill volume, pollutant type and characteristics, hydrometeorological conditions and the season in which occurs accidental / incidental border and area topography, of the bottom water, relationship between pollutant – sediment, their degree of mixing, etc.

In the end the most severe repercussions are on the high water toxicity level , mainly due to the toxicity of soluble fractions from the water: alkenes, benzene and naphthalene, the lethal dose to 96 hours from the exposure (DL50) being between 0.5 and 10 mg/l.

The presence of sulfide hydrogen is the main cause what can generate immediate lethal effects: from 0.0001% (concentration that is detectable by smell and irritate the respiratory tract) to only 0.1%, concentration that causes immediate loss of consciousness and brain damage, death occurring in about 3 to 5 minutes of continuous exposure, (thus are exposed also aquatic birds, fish). The negative effects can occur also on human body, on health of local population and even to the respective community image.

Nu trebuie neglijate in final nici efectele politice ale fenomenelor de poluare, in cazul in care aceasta depaseste granitele tarii putand aparea pagube, reclamatii si despagubiri intre cele 2 sau mai multe state implicate. Impactul politic este mai accentuat in cazul in care tarile respective nu sunt membre ale organizatiilor si conventiilor internationale care sa le acorde asistenta si protectie in caz de poluare.

Of all forms of pollution, the most severe impact on water it has the hydrocarbons pollution during transport, although this represents only 24% of the causes of pollution.

50% of all cases is the border operations (leaking rainwater, wastewater discharges, hydrocarbons processing, refining or port activities and shipyards activity), 2% of freight transport operations, 4 % due natural causes (eruptions), and 13% cases from the atmosphere (after combustion air)

The existing strategies to prevent / control pollution in trans-border areas are targeting three large action categories: awareness, promotion and technical solutions.

They are:

- Improvement of the international cooperation that allows to elaborate a collection system and exchange of information regarding the trans-border water quality trend, due to determine the lowest cost of pollution control measures.
- Promotion of economical market instruments which has to take into account the environmental issues.
- Taxes applications for pollutants that are discarged into water, air and ground water
- Reductions or exempt taxis for the use of technologies with low environmental impact
- Facilitation obtaining sources of funding for environmental activities
- Providing technical and logistical means of operative intervention in case of contaminations of river and stream

- Implementation of national and regional environmental programs with international assistance, a national environmental protection program of the Danube’s basin environment.
- Develop the ability to control ecological guards
- Realization of water purge installation of trans-border area for industrial wastewater and domestic wastewater
- Development of safe waste disposal systems
- Expanding and modernizing the national network of water quality monitoring
- Establishment of training and education programs to increase the capacity of making decisions about environmental protection
- Making advertising effective action to combat pollution

Chapter 7: Methods to apply the “polluter pays” principle.

Oil pollution prevention and waste reduction

Pollution prevention principle also derives from general obligation to avoid environmental damage.

The current focus on prevention pollution, manifested by both industry and policy makers, reflects a growing recognition of reality that the avoidance or reduce pollution is almost always less expensive than trying to fix or restore a contaminated area.

In general terms, the principle of pollution prevention was adopted by Stockholm Declaration **The Stockholm Declaration, 6th Principle**

The discharges of toxic substances must be stopped or of other substances, and the heat releases in such quantities or concentrations, which can overcome the environmental capacity to make them harmless, to ensure that ecosystems are not submissive to severe irreversible damage.

The precautionary principle is one of the general principles of environmental protection, aimed to avoid environmental damage and achieving sustainable development:

The Rio Declaration, 15th Principle

In cases where there is danger of severe or irreversible damage, the lack of full scientific certainty should not be used as an argument for delaying the implementation of cost-effective measures to prevent the environmental degradation.

Precautionary approach is the basis for many international legal instruments and it is also applied in various fields, from protecting endangered species, to prevent pollution.

The precautionary principle has evolved as a result of growing recognition fact that many times, scientific certainties appear too late to allow taking functional actions for counteracting possible damage to the environment.

The precautionary principle can have extended implications. For example, the implementation of the precautionary principle in the context of pollution prevention led to the express request formulation by the Governing Council UNEP addressed the states to adopt “Cleaner Production alternative methods” which would include raw materials selection, product replacements, technologies and clean production processes, as implementation measures of precautionary principle to promote production systems that can reduce or eliminate dangerous waste generation.

The duty to compensate damage

State responsibility

The basic rule of state responsibility in environmentally context can be synthesized as follows: states are responsible for environmental damage from other states or the global environment, resulting through violation of international rules or a generally accepted international standard. State responsibility is confirmed by the Stockholm Declaration:

The Stockholm Declaration, 21th Principle

The states have the responsibility to ensure that activities under their jurisdiction or under their control not causing environmental damage in other states or areas outside the limits of national jurisdiction.

Fundamental constitutional elements to claim states responsibility is considered to be:

- **The environment damage must be the result of a violation of international law.** International environment law is emerging, and many environmental protection treatises are strongly based on the general obligation concerning cooperation. These obligations, along with specific provisions of prohibition, often brings difficult issues to demonstrate and confirm guilt.
- **The state is responsible both for their own activities and the legal entities of individuals activities under its jurisdiction or under its control.** Thus, even if the state is not the directly polluter, he is responsible for his failure in stopping and controlling polluting activities performed by others. Under this rule, states may be responsible because: they did not adopt or impose lows necessary for environmental protection, they have not stopped dangerous activities, or they left unpunished law violations.
- **There should be no justifying circumstances such as the affected state agreement or intermediate cause, such as a divine action.**
- **The damage must be “significant”,** which can put up serious problems for establish evidence and quantify prejudice

In practice, there are few legal action based on state responsibility, most cases of pollution that are international unsolved, but through civil liability international rules, namely directly between involved people. Are also important international claiming commission, which distributes “donated” founds by the generating of prejudice state, direct to the claimed state. Such a procedure allows states to settle clams without admitting legal liability.

There is still no international consensus on the details concerning the payment of compensation moment and method, but only general nature provisions:

The Rio Declaration, 13th Principle

States must develop national law regarding liability and compensation for pollution victims and other environmental damage. Also, the states should cooperate with greater timeliness and determination to develop further international laws regarding liability and compensation for adverse effects caused by damage to the environmental through activities under its jurisdiction or under its own control, in areas outside national jurisdiction.

The “polluter pays” principle

Under the “polluter pays” principle, polluter must bear the costs for implementation of pollution prevention measures or he must pay for damage caused by pollution. Establishment of “polluter pays” principle assures reflection concerning products prices of production costs, including costs associated with pollution, resource degradation and environmental damage.

Environmental costs are reflected or “internalized” in each item price. The result is that, less polluting products will cost less, and the consumers may switch to less polluting products. Major consequences will result in more efficient use of resources and generating less pollution. Originally recommended by the Organization Council for Economic Cooperation and Development (OECD) in May 1972, the “polluter pays” principle had an increased acceptance as an international principle for environmental protection. The principle was explicitly adopted in The Rio Declaration:

The Rio Declaration, 16th Principle

National authorities should make efforts to promote the internalization of environmental costs and use economic instruments, taking into account the approach that, in principle, the polluter should bear the pollution costs with due concern for the public interest and without distorting trade and international investments.

Equal access to administrative and judicial

A central issue of the debate on compensation theme for environmental damage is the current orientation to equal access to administrative and judicial proceeding.

According to the equal access principle, affected parties of a state must be given the same access to remedial and repair, which is provided to affected parties from the states wherein located polluting activities. The principle also extends to issues of legal liability and compensation:

The Helsinki Convention on the Trans-Boundary Effects of Industrial Accidents. 9th Article

Parties shall ensure natural or legal persons who are or may be adversely affected by trans-boundary effects of an accident on the territory of the parties, also ensure access to administrative and judiciary procedures, including opportunities to initiate legal action (lawsuit) and to appeal against a decision that affects their rights, similar to those available to persons (natural or legal) in their jurisdiction.

Chapter 8
Action plan

One of the most important steps that must be made (action group) is “ Initiating action plan – creating sequential programs”. It is premature at this moment to develop an action plan, especially this does not make the object of the project.

The first steps that must be taken to reach the strategy goals will be achieved by applying its legal framework , we assume that this stage will be the most difficult because the strategy proposes new things (Romanian-Bulgarian) unit joint of common action *public – private partnership* new technology

Action that must be made in this direction will be defined and evaluated from all aspects of joint working group and operational team.

In this stage we can defined clearly only pure technical activities being the most important in the practical implementation of pollution prevention or purge polluted water with petroleum and derived products.

Assessment of priorities implies dissemination of areas of prime interest, approximate pollutant quantities and mass flow, we consider technical actions can be undertaken afterwards

Recheck water composition in priority areas

- 10 interviews min. – cost –

Verify the developed project in frame C –

- 5 days - 500€ cost –

Preparing documents for purchase of parts that must be made – launched in manufacturing

- 7 days - 600€ cost –

Preparing documents for purchase of components that can be supplied directly

Conclusions:

The strategy in which the partners in “ Common strategy to prevent the Danube’s pollution technological risks with oil and oil products” – CLEANDANUBE project are aiming to promote, establishes the technique to solve by a Romanian-Bulgarian common unit of environmental issues that arise once with Danube’s water pollution with oil and oil products.

The proposed strategy in the project involves processing, on-site contaminated water with oil products and reintegration into the natural circuit of water and solid components, oil obtained being taken into special tanks, total and immediate problem solving.

This is possible using special centrifugal processing equipment of water polluted with oil in one step and the separation into organic products, solid water and oil. Within the “Common strategy to prevent the Danube’s pollution technological risks with oil and oil products” – CLEANDANUBE project was calculated and designed such device from a set determinated experimentally and analytical. The proposed solution is aiming primarily to emergencies, when due to errors, ships carrying oil sink or fails. In this case the oil spills in Danuve are uncontrollable by conventional methods, the only viable solution that we see is the application of the new strategy. According to the developed strategy, intervention in a emergency case is made by a Romanian-Bulgarian common unit, independent, that acts immediately no matter where the emergency is, according to a joint work plan, on the basis of existing operation criteria, eliminating any delay intervention formality and does not affect safety. This way you can prevent Danube’s pollution and can be removed a larger amount of oil. Recovered oil can be revaluate (because it has the required quality, even a better one) and obtained amounts will participate in the intervention cost recovery. The proposed solution by the advantages that it has can be applied successfully and very effective and economically to contaminated water with oil and oil products process coming from the washing tanks, transport tanks, etc. And in this case it can be recovered almost all existing oil, which is not to be negligible although in this case the solids percentage in the misture increases, so from economical point of view the amounts necessary to the process will be lower.

In conclusion the proposed solution by the new strategy, a Romanian-Bulgarian indetendent and joint unit has a high degree of sustainability; practically it can support herserf by revaluation of collected oil.

By developing this strategy were detailiat and supported, at a knowledge level that we have at this time, the objectives and principles which, we belive, is a new approach way to prevent pollution of the Danube with oil and oil products.

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ANNEX

1. Simulare numerica a curgerii in separatorul centrifugal

Nomenclature

D_I kinematic diffusivity [m^2/s]
h specific thermodynamic enthalpy [J/kg]
k specific turbulent kinetic energy per unit mass [m^2/s^2]
w molecular weight [$kg/kmol$]
p pressure [N/m^2]
R universal gas constant [J/kgK]
S_I is the source term due to chemical reaction rate involving component I
T temperature [K]
u velocity [m]
P_k turbulence production due to viscous forces
t time [s]
R_K elementary reaction rate of progress for reaction k
W_I molar mass [$kg/kmol$]
Y mass fraction [-]
C_{S1} model constant [-]
C_{S2} model constant [-]

Greekcharacters

δ Kronecker delta [-]
ε dissipation rate of the turbulent kinetic energy per unit mass [m^2/s^3]
μ dynamic viscosity [$kg/(ms)$]
ν kinematic viscosity [m^2/s]
ρ density [kg/m^3]
ν_{kI} stoichiometric coefficient for component *I*
τ_{ij} turbulent stress tensor [m^2/s^2]
σ_k model constant [-]
σ_ε model constant [-]
Γ_i diffusion coefficient of component I [m^2/s]

Dimension less numbers

Pr Prandtl number

Statistical quantities

$\bar{\phi}$ time or ensemble average of variable ϕ

ϕ' fluctuating part of variable ϕ

$\tilde{\phi}$ filtered variable ϕ

4.10.1 Introduction

Development of high speed computers has a significant impact on how the principles in fluid mechanics and heat transfer are applied in modern engineering design process. Design issues pertaining to this area can be solved in a short time with current computers, problems that have required years of calculation methods and computing power twenty years ago.

From the progress of methods and computing power have benefited primarily research laboratories and specialized industry where solving the problem in shortest time was a priority. Also the implementation of specialized schools helped form specialists who know how to use new methods before graduation.

In recent years we have seen the development of new methods to solve complex problems in fluid mechanics and heat transfer. This new method has been called CFD (Computational Fluid Dynamics). It is characterized by the fact that the governing flow equations, usually written as partial derivatives are solved numerically.

This method was developed in the past as a third method of design of equipment besides the theoretical and experimental methods, in terms of fluid mechanics and heat transfer.

Although it is very costly the experimental method is still very important especially in complex flows, but the focus begins to be increasingly more on CFD, where solutions are validated using experimental methods. The use of CFD in design a can be explained in two different aspects:

1. Economic aspect (Chapman 1979) - As the years past computing speed increased much more than the cost of computing. As shown in Figure 1 for a specific problem of computing costs have fallen 10 times in the course of eight years.

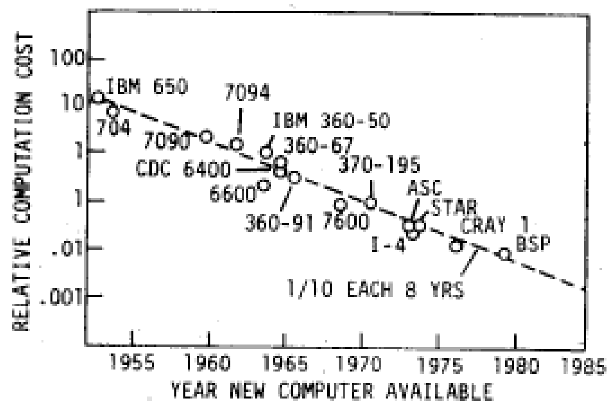


Fig 1 The evolution of the costs account for a certain flow and algorithm (Chapman 1979)

An example is that described by Chapman in 1979 he found that numerical simulation of flow over an airplane wing using Navier Stokes equations, Reynolds averaged, can provide a solution in less than half an hour with about $ 1,000 costs today.

If this calculation had been tried 20 years ago, with the computers (e.g. IBM 704-class) and algorithms known at the time, computing costs would have been approximately $ 10 million and results for this flow were hardly available in about 30 years.

2. Aspect of computing speed - as computers grow their computing speed increases which leads to problem solving in shorter and shorter time.

Method	Advantages	Disadvantages
Experimental	1.The most realistic	1. Specialized equipment 2. Scaling problems 3. Test bench corrections 4. Measuring difficulties 5. Operating costs
Theoretical	1.exact, general information	1.restricted to simple phsical Problems and simple geometries 2. restricted to linear problems
Numerical	1. No restriciton concearnig liniarity 2. Complex roblems can be studied 3. Time dependent solution of the flow	1. Truncation errors 2. Problems with boundary conditions

Table 4.1

As you can see from the table 4.1 and the most viable design and calculation methods remain the experimental and the numerical method. But between them remain some differences that deserve to be mentioned. The experimental method is usually used on smaller scale models due to high costs.

Another feature is the inability to accurately simulate operating conditions of various equipment and data sampling areas and obtain certain results. The main experimental method has several constraints which numerical method does not have but on the other hand this one has other drawbacks like limited data storage space and computing speed.

And another thing worth mentioning to the numerical method is that misunderstanding of certain phenomena and their impossible mathematical transcription. But of all these disadvantages of the numerical method is not insurmountable.

Progress of CFD in the past 50 years is impressive, therefore experimental method in recent years began to play a secondary role, namely to validate the numerical methods in aerodynamic problems.

In this paper we present a fluid dynamics study of three-phase separation applicable to centrifugal separator (tricanter) designed.

Due to the complex geometry flow analysis will be performed in 3D.

4.10.2. Numerical Method

For this study, the flow was assumed compressible, the ecuations that govern the flow, written in Reynolds averaged form, time and mass averaged [4] , being, in the repeated indices summation convention:

<u>The Continuity Equation</u>**:**

$$\frac{\partial \overline{\rho}}{\partial t} + \frac{\partial \overline{\rho} \tilde{u}_j}{\partial x_j} = 0 \tag{1}$$

<u>The Momentum Equations</u>:

$$\frac{\partial \overline{\rho} \tilde{u}_i}{\partial t} + \frac{\partial \overline{\rho} (\tilde{u}_i \tilde{u}_j)}{\partial x_j} = -\frac{\partial \overline{p}}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\overline{\tau_{ij}} - \overline{\rho u_i' u_j'}\right) \tag{2}$$

, where

$$\overline{\tau_{ij}} = \mu\left[\frac{\partial \tilde{u}_i}{\partial x_j} + \frac{\partial \tilde{u}_j}{\partial x_i} - \frac{2}{3}\delta_{ij}\left(\frac{\partial \tilde{u}_k}{\partial x_k}\right)\right]$$

represent the stress tensor.

The Total Energy Equation:

$$\frac{\partial}{\partial t}\left(\overline{\rho}\tilde{h}\right) + \frac{\partial\left(\overline{\rho}\tilde{u}_j\tilde{h}\right)}{\partial x_j} = \frac{\partial \overline{p}}{\partial t} + \frac{\partial}{\partial x_j}\left(\overline{\frac{\mu}{\Pr}\frac{\partial h}{\partial x_j}}\right) + \frac{\partial}{\partial x_j}\left(-\overline{\rho h' u'_j}\right), \qquad (3)$$

where h is the enthalpy.

Ideal Gas Equation of State:

$$\tilde{\rho} = \frac{w\left(\tilde{p} + p_{ref}\right)}{R_0\tilde{T}} \qquad (6)$$

, where w is the molecular weight

To close the correlation type terms that appear in the above equations, the k-ε two-equation turbulence model is employed. The model uses the gradient diffusion hypothesis to relate the Reynolds stresses to the mean velocity gradients and the turbulent viscosity. The turbulent viscosity is modeled as the product of a turbulent velocity and turbulent length scale.

In the two-equation class models, the turbulence velocity scale is computed from the turbulent kinetic energy, which is provided by numerically solving its transport equation along with the governing equations presented earlier. The turbulent length scale is estimated from two properties of the turbulence field, in this case the turbulent kinetic energy, k, and its dissipation rate, ε. The dissipation rate of the turbulent kinetic energy is also provided by numerically solving its transport equation.

$$\frac{\partial(\rho k)}{\partial t} + \nabla(\rho U k) = \nabla\left[\left(\mu + \frac{\mu_t}{\sigma_k}\right)\nabla k\right] + P_k - \rho\varepsilon \qquad (7)$$

$$\frac{\partial(\rho \varepsilon)}{\partial t} + \nabla(\rho U \varepsilon) = \nabla\left[\left(\mu + \frac{\mu_t}{\sigma_\varepsilon}\right)\nabla \varepsilon\right] + \frac{\varepsilon}{k}\left(C_{S_1}P_k - C_{S_2}\rho\varepsilon\right) \qquad (8)$$

Where C_{S1} , C_{S2} , σ_k , σ_ε are model constants, and $P_k$is the turbulence production due to viscous forces which is modeled using the following formula [3]:

$$P_k = \mu_t \nabla U \left(\nabla U + \nabla U^T \right) - \frac{2}{3} \nabla U \left(3\mu_t \nabla U + \rho k \right) \quad (9)$$

These equations are discretized using a second order upwind scheme.

4.10.3. Setup and Boundary conditions of the numerical simulations

Aerodynamic computational model implies certain modifications from the real model. Basically what is kept is the path of the working fluid inside our tricanter centrifuge.(Fig. 2)

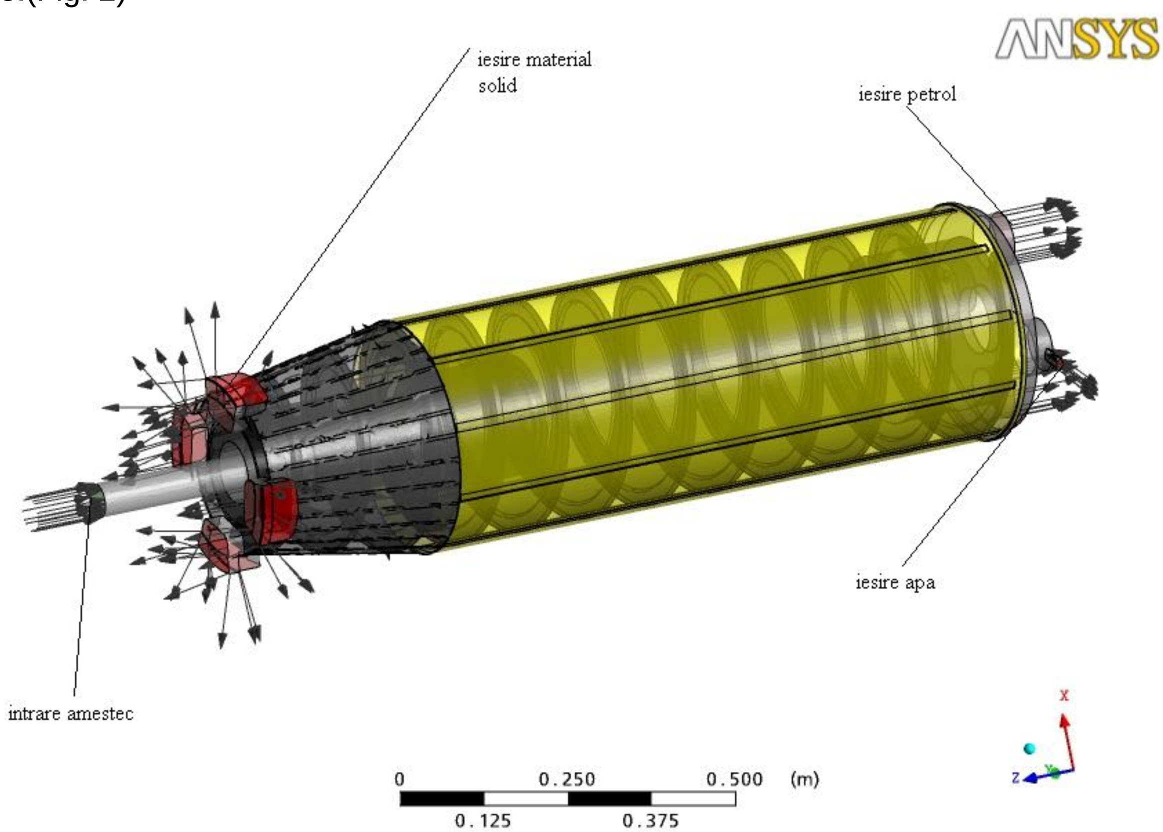


Fig.2 Computational domain

Initial conditions are the following:
Mass flow: 20 m^3/h
Inlet:
mixture: water + oil in liqiud form
Water density: 1000 kg/m^3
Oil density: 795 kg/m^3
Temperature : 288 K
Total pressure: 5 bar
Turbulence intensity: 5 %
Oil volume fraction: 0.7116
Water volume fraction: 0.2884

Solid particles:
Density: 2011 kg/m^3
Inlet speed : 12 m/s
Mass flow : 68 g/s
Particle minimum diameter: 25 de microni
Particle maximum diameter: 55 de microni

Outlet:
Mass flow : 20 m^3/h
Casing:
Speed: 4000 rot/min
Centrifugal rotor:
Speed: 3960 rot/min

The solid walls were considered adiabatic (no heat transfer), impermeable and no-slip (zero velocity at the wall).

For this case an unstructured grid had been used because the complexity of the tricanter makes the problem too computationally expensive for a structured grid. Also, in order to be able to control the total numer of cells, local refinments have been used .

Results

In the follwing we will present to you the results of the aerodynamic analisys of the tricanter centrifuge.

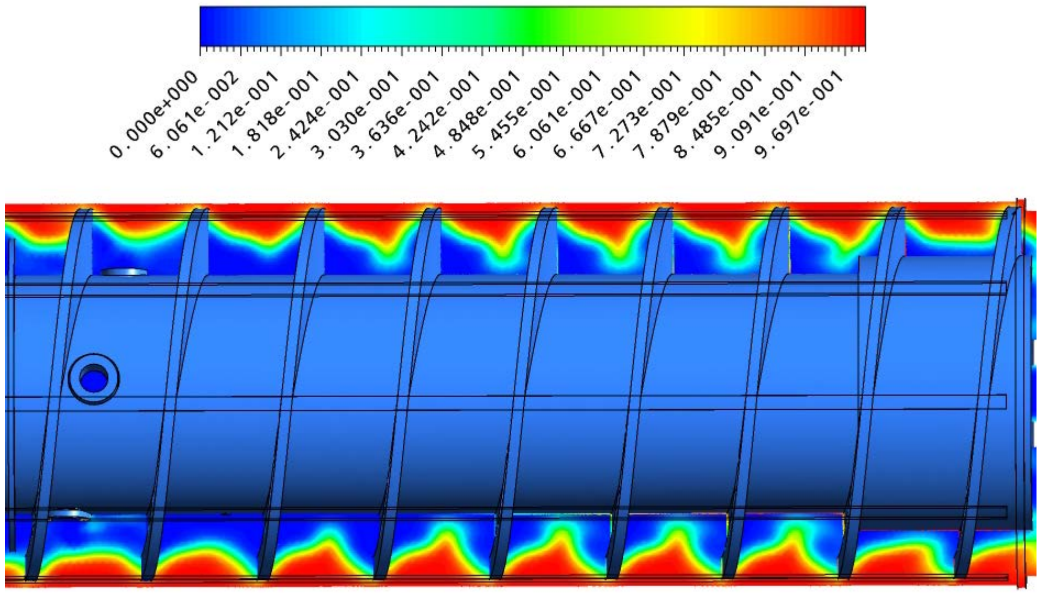


Fig. 3 Water volume fraction around the centrifugal rotor

As you can see in fig.3 the biggest water concentration is near the casing, and this is due to higher water density than the density of oil. Also the water concentration is zero or almost zero close to centrifugal rotor body.

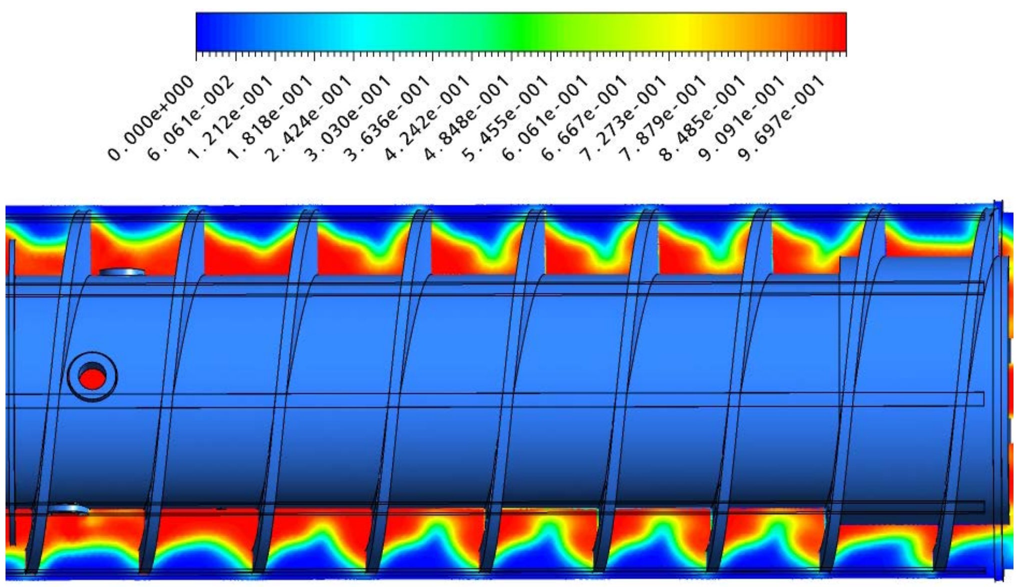
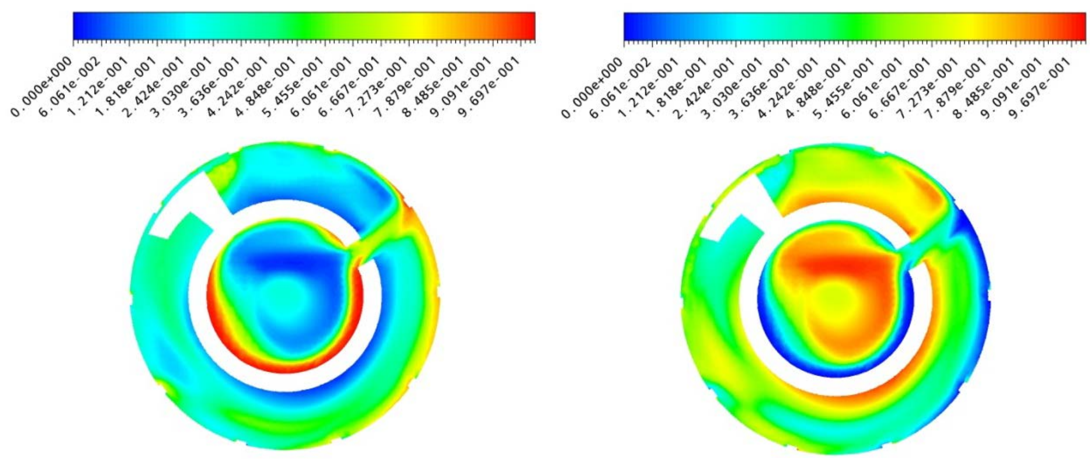


Fig. 4 Oil volume fraction around the centrifugal rotor

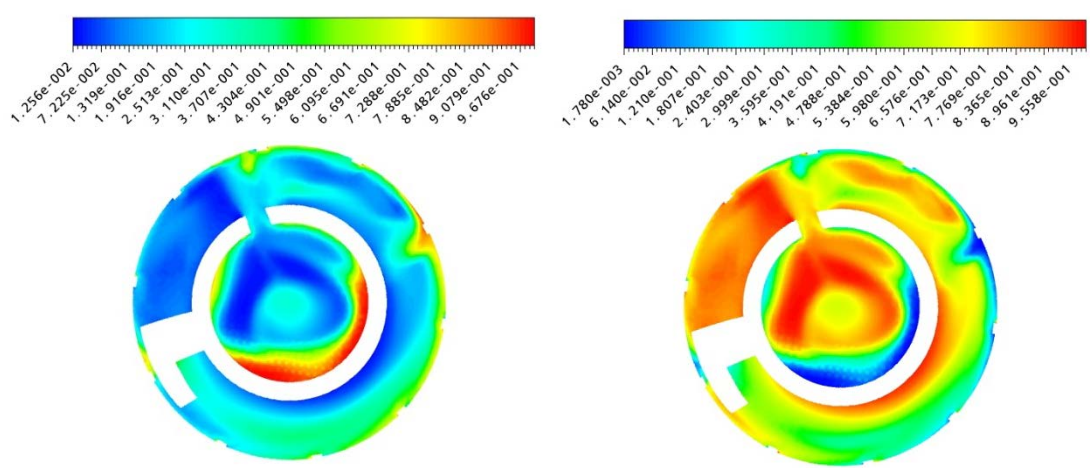
In figure 4 is it possible to see that oil concentration is almost zero or zero exactly where the water concentration is the biggest (fig. 3). This shows that the separation of the mixture starts around the centrifugal rotor.



a b

Fig. 5 Water (a) and oil (b) volume fraction at the first entrance in the centrifugal rotor

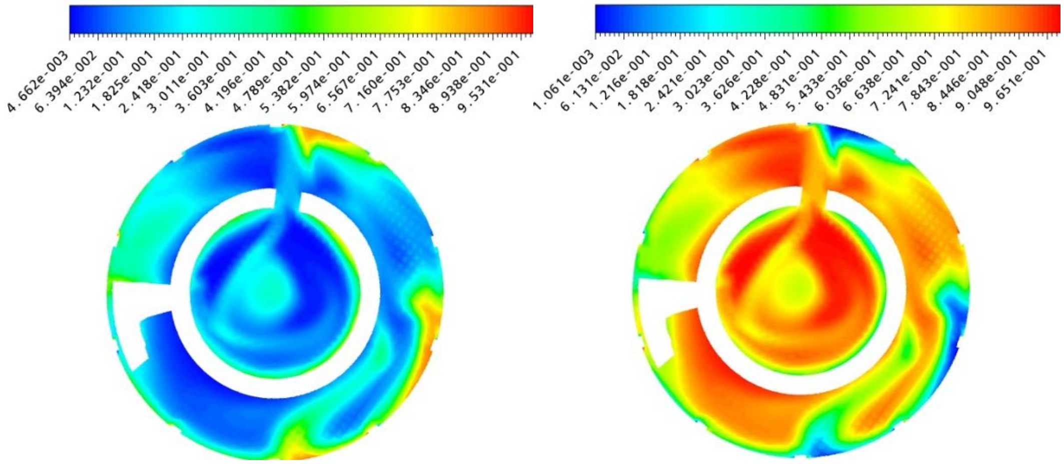
In figure 5 it can be observed the irregularity of the flow due to complex geometry. Also it can be seen that the mixture separation starts before entering the centrifugal rotor, as it can be observed the water is concentrated on the walls and the oil in the middle.



a b

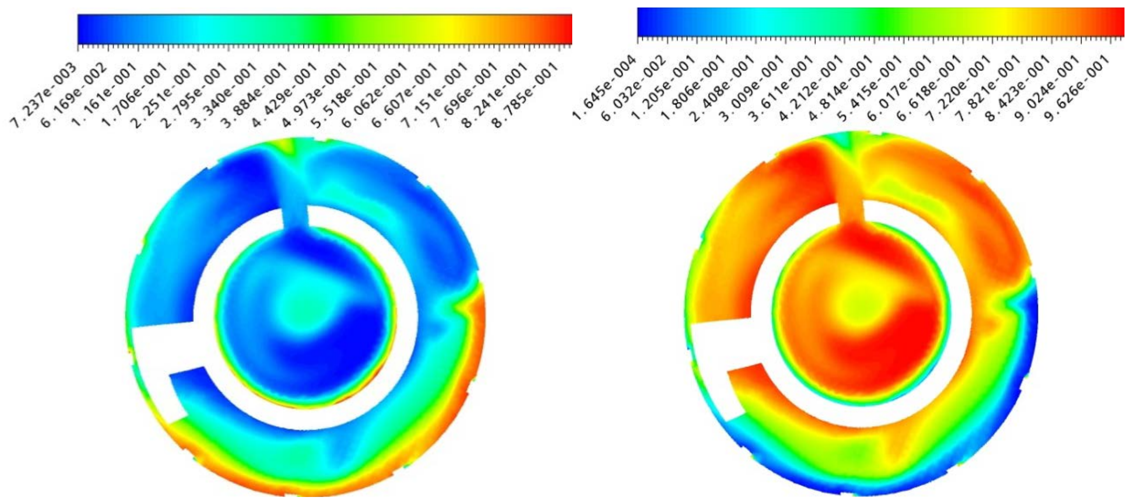
Fig. 6 Water (a) and oil (b) volume fraction at the second entrance in the centrifugal rotor

Also in figure 6 we can see the same characteristic of the flow.



a b

Fig. 7 Water (a) and oil (b) volume fraction at the third entrance in the centrifugal rotor



a b

Fig. 8 Water (a) and oil (b) volume fraction at the fourth entrance in the centrifugal rotor

In figures 5-8 it can be observed how the water concentration is decreasing as the mixture aproces the fourth entrance. A possible explanation is that the water enters the centrifugal rotor faster then the oil through the first entrances.

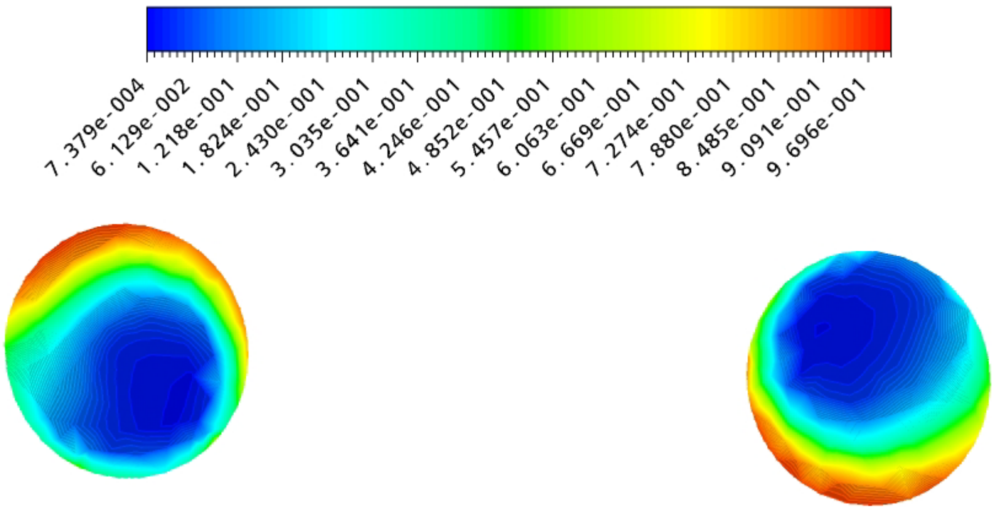


Fig. 9 Water volume fraction at oil outlet

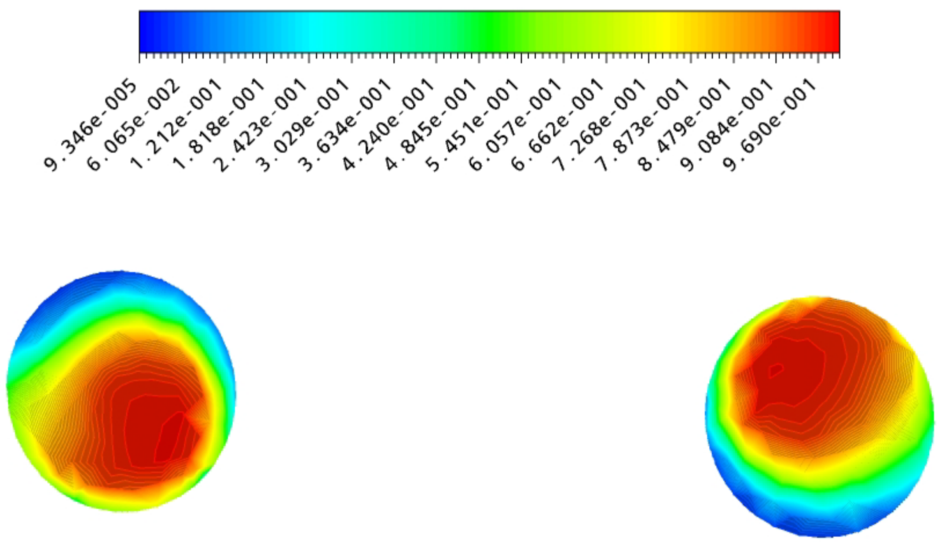


Fig. 10 Oil volume fraction at oil outlet

In figure 9 and 10 it can be observed that on the oil outlet the dominant fluid that exit through this outlet is oil.

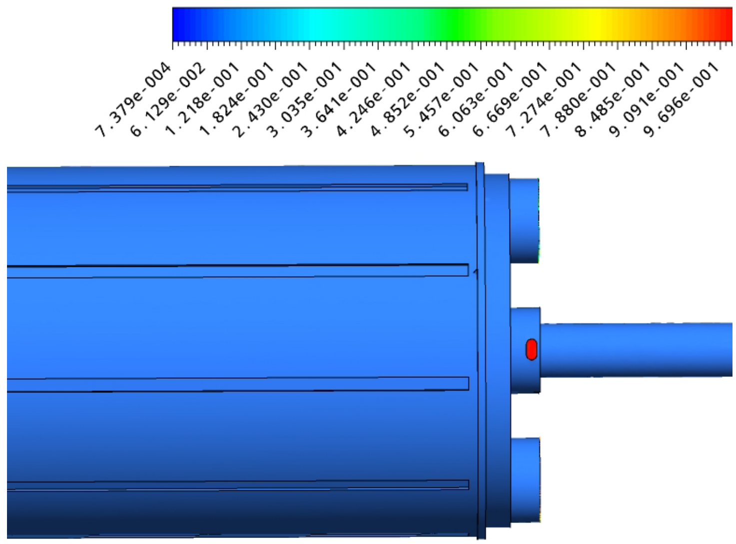


Fig. 11 Water volume fraction at water outlet

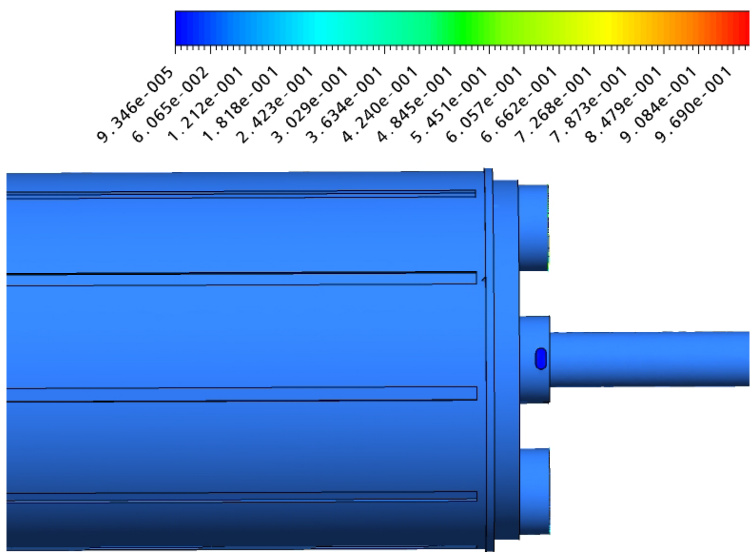
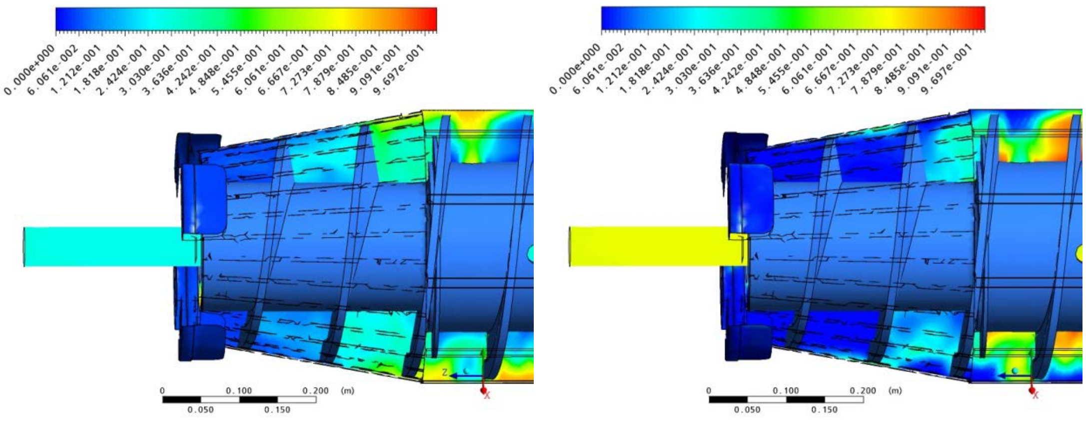


Fig. 12 Oil volume fraction at water outlet

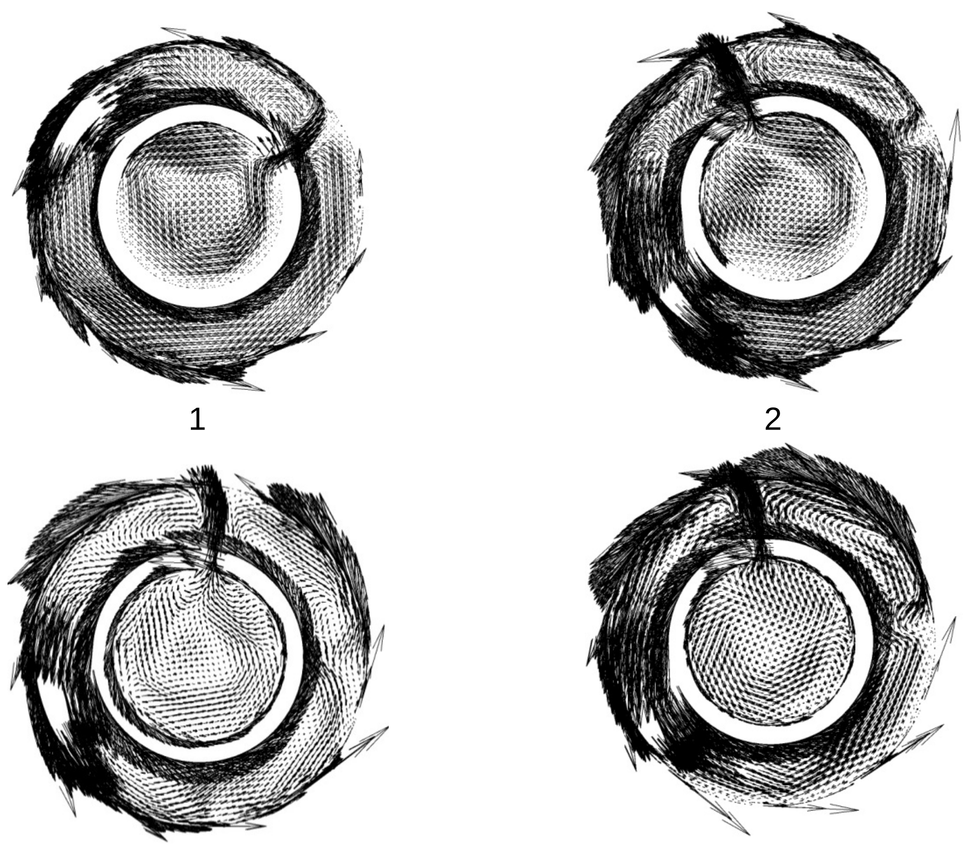
In figures 11 and 12 it can be observed that on the water outlet exit only water.



a b

Fig. 13 Water (a) and oil (b) volume fraction in frontal part of the trincanter centrifuge

In figure 13 it can be seen that the water and oil concentration is low due to the fact that solid particles partially blocks the flow channel.



1 2

3 4

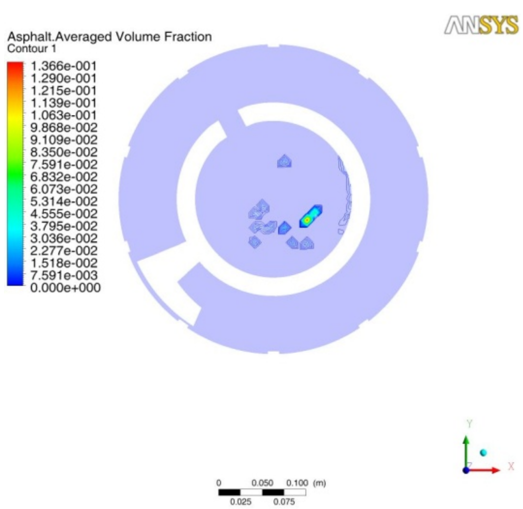
Fig. 14 Vector field at the entrances inside the centrifugal rotor

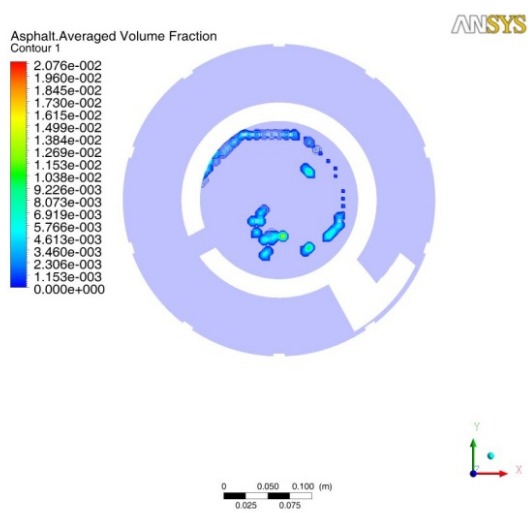
To understand how these solid particles behaves we have to observe first the vectorial field, fig. 14.

Here it can be observed the recirculation zones that produce before entering the centrifugal rotor and also inside the centrifugal rotor.

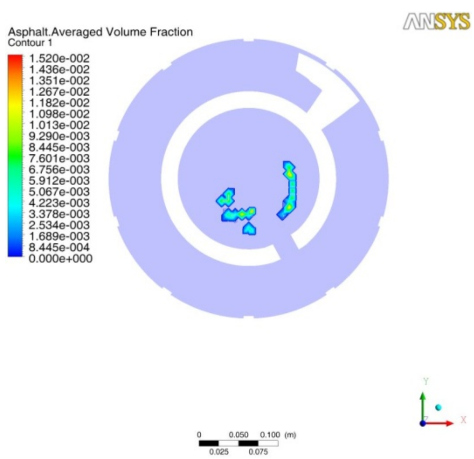
The recirculation zones affect not only the flow but also the solid particles behavior.

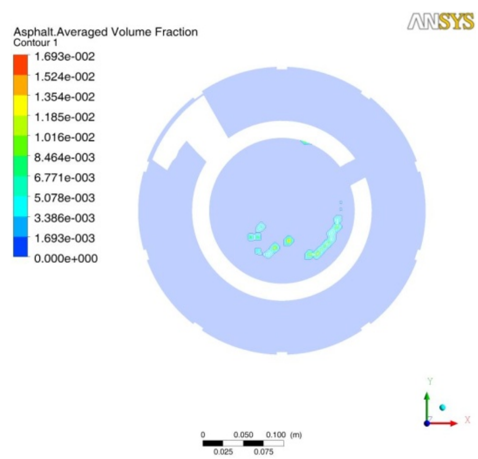
In figure 15 it can be observed where is the highest concentration of particles at the four entrances. This evolution show that the particles are cought inside the trincanter centrifuge between the recirculation zones.





1 2





3 4

Fig. 15 Volume fraction of the solid particles in the domain

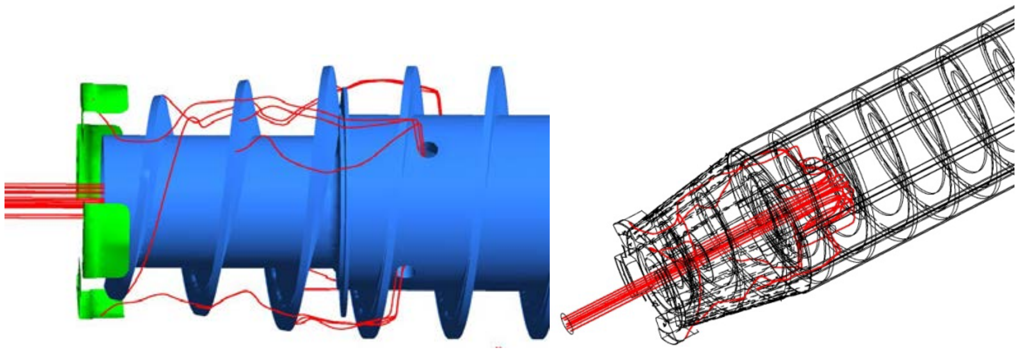
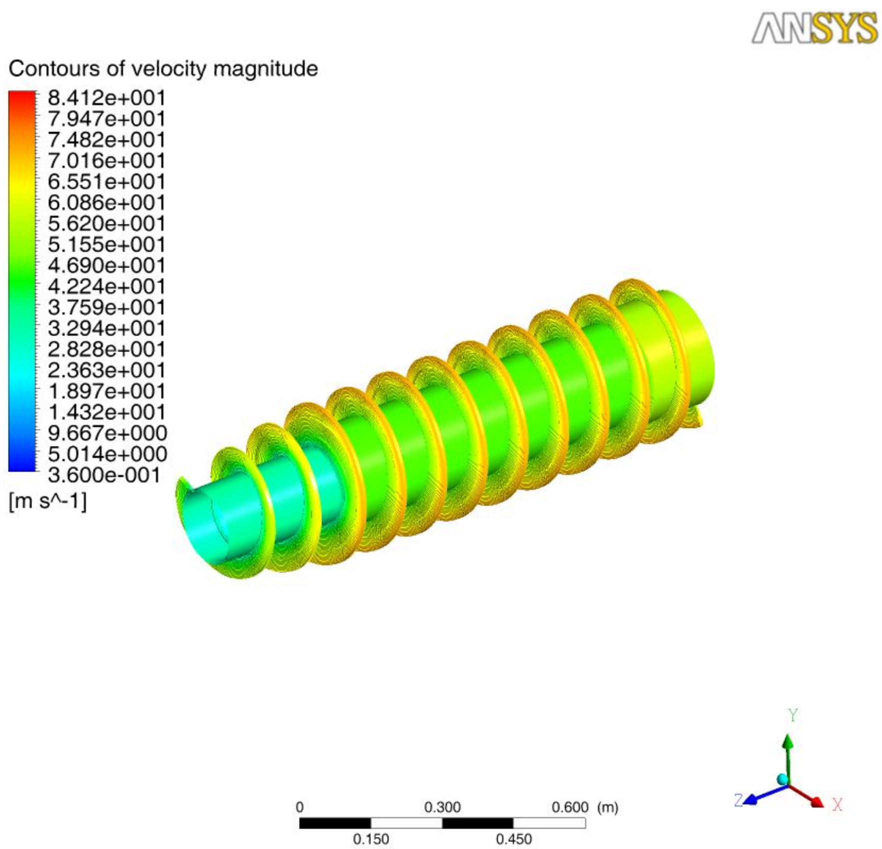


Fig. 16 Solid particles behavior in the domain



Particles evolution it is correct because the flow has an inverse sense of rotation than the casing and centrifugal rotor (fig.14). So the flow directs the particles that passes through the space between centrifugal rotor and casing (fig. 15) towards the outlet situated in the frontal part of the tricanter centrifuge.

4.10.4. Conclusion

1. The study was done using ANSYS CFX.
2. It was done the flow analysis of the flow inside the tricanter centrifuge and during this analysis has been consider the influence of oil, water and solid particles.
3. Inside the tricanter centrifuge the separation of water, oil and solid parts is done efficiently.
4. At the outlet it is possible to see that on the water outlet is comes out water, on the oil outlet comes out oil and on the solid particles outlet it comes out solid particles mainly.

2. Simulare numerica efectuata de partenerul bulgar

Nomenclature

D_I kinematic diffusivity [m^2/s]
h specific thermodynamic enthalpy [J/kg]
k specific turbulent kinetic energy per unit mass [m^2/s^2]
w molecular weight [$kg/kmol$]
p pressure [N/m^2]
R universal gas constant [J/kgK]
S_I is the source term due to chemical reaction rate involving component I
T temperature [K]
u velocity [m]
P_k turbulence production due to viscous forces
t time [s]
R_K elementary reaction rate of progress for reaction k
W_I molar mass [$kg/kmol$]
Y mass fraction [-]
C_{S1} model constant [-]
C_{S2} model constant [-]

Greek characters

δ Kronecker delta [-]
ε dissipation rate of the turbulent kinetic energy per unit mass [m^2/s^3]
μ dynamic viscosity [$kg/(ms)$]
ν kinematic viscosity [m^2/s]
ρ density [kg/m^3]

ν_{kI} stoichiometric coefficient for component *I*

τ_{ij} turbulent stress tensor [m^2/s^2]

σ_k model constant [-]

σ_ε model constant [-]

Γ_i diffusion coefficient of component I [m^2/s]

Dimensionless numbers

Pr Prandtl number

Statistical quantities

$\overline{\phi}$ time or ensemble average of variable ϕ

ϕ' fluctuating part of variable ϕ

$\tilde{\phi}$ filtered variable ϕ

For this study, the flow was assumed compressible, the ecuations that govern the flow, written in Reynolds averaged form, time and mass averaged [4] , being, in the repeated indices summation convention:

The Continuity Equation**:**

$$\frac{\partial \overline{\rho}}{\partial t} + \frac{\partial \overline{\rho}\tilde{u}_j}{\partial x_j} = 0 \qquad (4)$$

The Momentum Equations:

$$\frac{\partial \overline{\rho}\tilde{u}_i}{\partial t} + \frac{\partial \overline{\rho}(\tilde{u}_i\tilde{u}_j)}{\partial x_j} = -\frac{\partial \overline{p}}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\overline{\tau_{ij}} - \overline{\rho u_i' u_j'}\right) \qquad (5)$$

, where

$$\overline{\tau_{ij}} = \mu\left[\frac{\partial \tilde{u}_i}{\partial x_j} + \frac{\partial \tilde{u}_j}{\partial x_i} - \frac{2}{3}\delta_{ij}\left(\frac{\partial \tilde{u}_k}{\partial x_k}\right)\right]$$

represent the stress tensor.

3. The Total Energy Equation:

$$\frac{\partial}{\partial t}\left(\overline{\rho}\tilde{h}\right) + \frac{\partial\left(\overline{\rho}\tilde{u}_j\tilde{h}\right)}{\partial x_j} = \frac{\partial \overline{p}}{\partial t} + \frac{\partial}{\partial x_j}\left(\overline{\frac{\mu}{\mathrm{Pr}}\frac{\partial h}{\partial x_j}}\right) + \frac{\partial}{\partial x_j}\left(-\overline{\rho h' u_j'}\right), \qquad (6)$$

where h is the enthalpy.

Scalar transport equation:

$$\frac{\partial\left(\overline{\rho}\widetilde{Y}_I\right)}{\partial t}+\frac{\partial\left(\overline{\rho}\widetilde{u}_j\widetilde{Y}_I\right)}{\partial x_j}=\frac{\partial}{\partial x_j}\left(\Gamma_{I_{eff}}\frac{\partial Y_I}{\partial x_j}\right)+S_I\ , \qquad (7)$$

$\widetilde{Y}_I=\frac{\widetilde{\overline{\rho}_i}}{\overline{\rho}}$,

S_I – is the source term due to chemical reaction rate involving component I,

$S_I=W_I\sum_{k=1}^{K}(\nu''_{kI}-\nu'_{kI})R_K$,

ν_{kI} - is the stoichiometric coefficient for component *I* in the elementary reaction *k*

R_K – is the elementary reaction rate of progress for reaction k, and is calculated using Eddy Dissipation model

$$\Gamma_{I_{eff}}=\Gamma_I+\frac{\mu_t}{Sc_t}\ , \qquad (5)$$

$\Gamma_I=\rho D_I$, D_I – kinematic difusivity

Ideal Gas Equation of State:

$$\widetilde{\rho}=\frac{w\left(\widetilde{p}+p_{ref}\right)}{R_0\widetilde{T}} \qquad (6)$$

, where w is the molecular weight

To close the correlation type terms that appear in the above equations, the k-ε two-equation turbulence model is employed. The model uses the gradient diffusion hypothesis to relate the Reynolds stresses to the mean velocity gradients and the turbulent viscosity. The turbulent viscosity is modeled as the product of a turbulent velocity and turbulent length scale.

In the two-equation class models, the turbulence velocity scale is computed from the turbulent kinetic energy, which is provided by numerically solving its transport equation along with the governing equations presented earlier. The turbulent length scale is estimated from two properties of the turbulence field, in this case the turbulent kinetic energy, k, and its dissipation rate, ε. The dissipation rate of the turbulent kinetic energy is also provided by numerically solving its transport equation.

$$\frac{\partial(\rho k)}{\partial t}+\nabla(\rho U k)=\nabla\left[\left(\mu+\frac{\mu_t}{\sigma_k}\right)\nabla k\right]+P_k-\rho\varepsilon \tag{7}$$

$$\frac{\partial(\rho\varepsilon)}{\partial t}+\nabla(\rho U\varepsilon)=\nabla\left[\left(\mu+\frac{\mu_t}{\sigma_\varepsilon}\right)\nabla\varepsilon\right]+\frac{\varepsilon}{k}\left(C_{S_1}P_k-C_{S_2}\rho\varepsilon\right) \tag{8}$$

Where C_{S1} , C_{S2} , σ_k , σ_ε are model constants, and P_k is the turbulence production due to viscous forces which is modeled using the following formula [3]:

$$P_k=\mu_t\nabla U\left(\nabla U+\nabla U^T\right)-\frac{2}{3}\nabla U\left(3\mu_t\nabla U+\rho k\right) \tag{9}$$

These equations are discretized using a second order upwind scheme.

For combustion modeling Eddy Dissipation model was employed [4]. For this model it is sufficient that fuel and oxidant be available in the control volume for combustion to occur. The eddy dissipation model is based on the concept that chemical reaction is fast relative to the transport processes in the flow. When reactants mix at the molecular level, they instantaneously form products. The model assumes that the reaction rate may be related directly to the time required to mix reactants at the molecular level. In turbulent flows, this mixing time is dominated by the eddy properties and, therefore, the rate is proportional to a mixing time defined by the turbulent kinetic energy, *k, and dissipation, ε.*

$$rate\propto\frac{\varepsilon}{k}$$

Setup and Boundary conditions of the numerical simulations

The model for hidrodynamic computation has to be modified from the real model because some parts have no effect on the hidrodynamic analysis and also to deacrease number of cells. Bassically are mantained the parts that have an influence on the fluid. In figure 2 is presented the computational domain and it can be observed the inlet and the outlet for water and for oil-fuel.

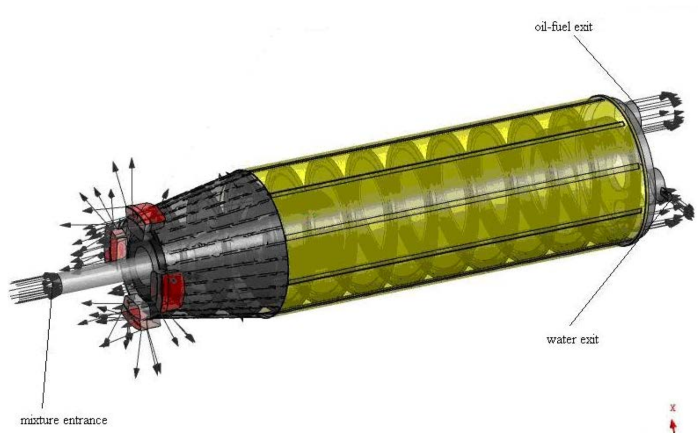


Fig.1 Computational Domain

The boundary conditions are the following:
Mass flow: 20 m^3/h
Inlet:
Mixture: water + oil-fuel in liquid form
Temperature: 293 K
Absolute pressure: 5 bar
Turbulence Intensity: 5 %
Volume fraction for oil-fuel: 0.7116
Volume fraction for water: 0.2884
Outlet:
Mass flow: 20 m^3/h
Casings :
RPM: 4000 rot/min
Helicoidal device :
RPM: 3960 rot/min

Results

Next we will show the results of the hydro analysis of the device. As you can see once the mixture enters the helicoidally shape device starts to separate, the phenomenon it can be seen better in figure 3.

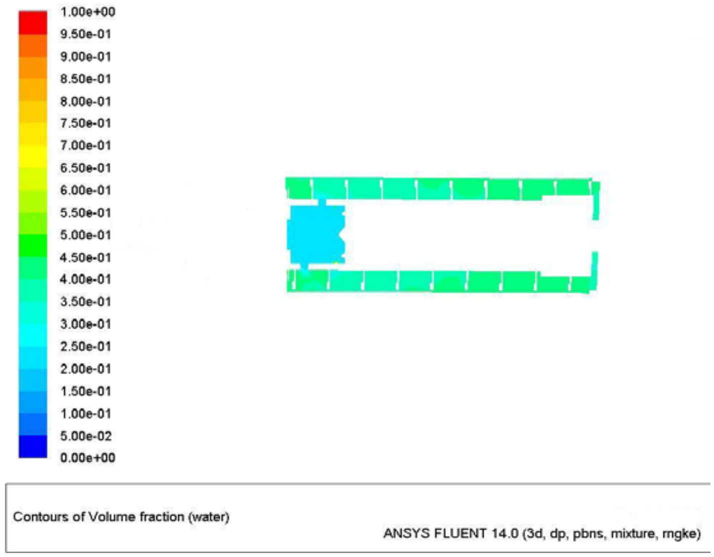


Fig. 2 Contours of water volume fraction in the domain

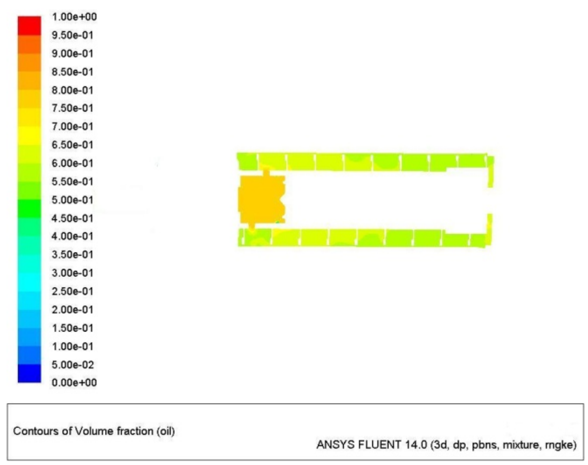
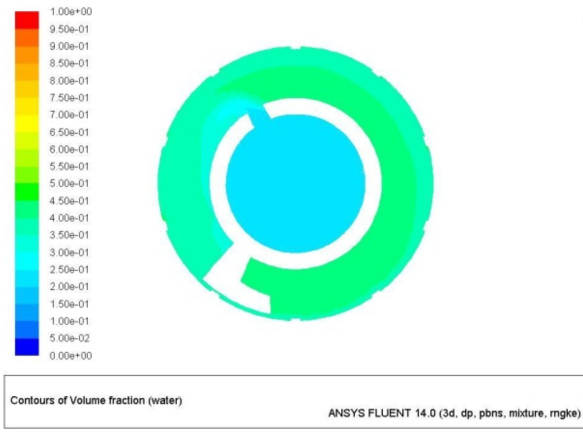


Fig. 3 Contours of oil-fuel volume fraction in the domain

In figure 4 are presented the four orifices through which the mixture enters the helicoidally shape device. And it can be seen the oil-fuel concentration is bigger close to the hub of the device.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9.00e-01
8.50e-01
8.00e-01
7.50e-01
7.00e-01
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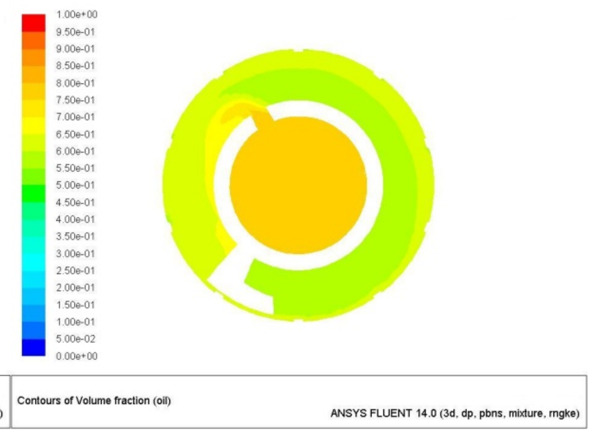
6.00e-01
5.50e-01
5.00e-01
4.50e-01
4.00e-01
3.50e-01
3.00e-01
2.50e-01
2.00e-01
1.50e-01
1.00e-01
5.00e-02
0.00e+00
Contours of Volume fraction (water)
ANSYS FLUENT 14.0 (3d, dp, pbns, mixture, rngke)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9.50e-01
9.00e-01
8.50e-01
8.00e-01
7.50e-01
7.00e-01
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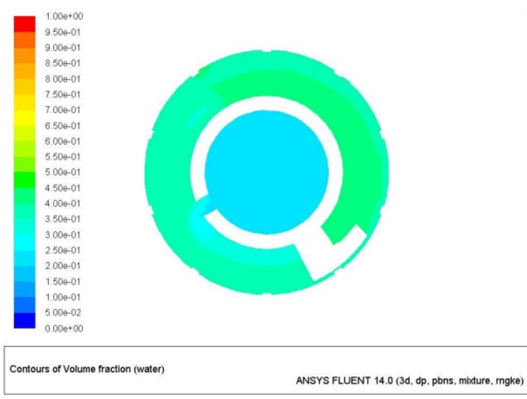
6.00e-01
5.50e-01
5.00e-01
4.50e-01
4.00e-01
3.50e-01
3.00e-01
2.50e-01
2.00e-01
1.50e-01
1.00e-01
5.00e-02
0.00e+00
Contours of Volume fraction (oil)
ANSYS FLUENT 14.0 (3d, dp, pbns, mixture, rngke)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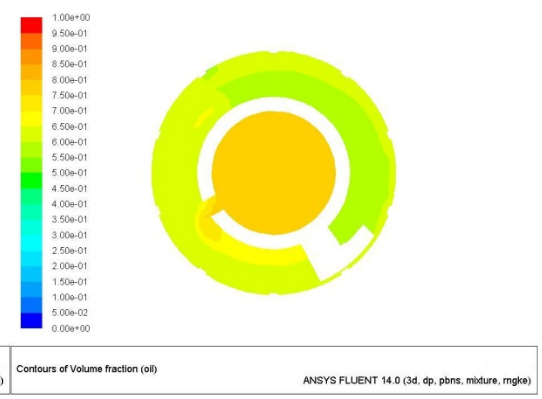
3.50e-01
3.00e-01
2.50e-01
2.00e-01
1.50e-01
1.00e-01
5.00e-02
0.00e+00
Contours of Volume fraction (water)
ANSYS FLUENT 14.0 (3d, dp, pbns, mixture, rngke)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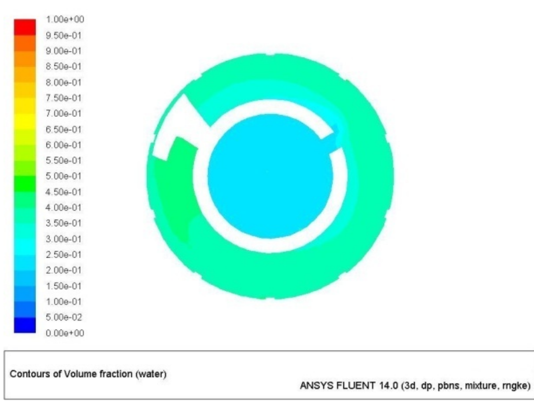
3.50e-01
3.00e-01
2.50e-01
2.00e-01
1.50e-01
1.00e-01
5.00e-02
0.00e+00
Contours of Volume fraction (oil)
ANSYS FLUENT 14.0 (3d, dp, pbns, mixture, rngke)


1.00e+00
9.50e-01
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8.00e-01
7.50e-01
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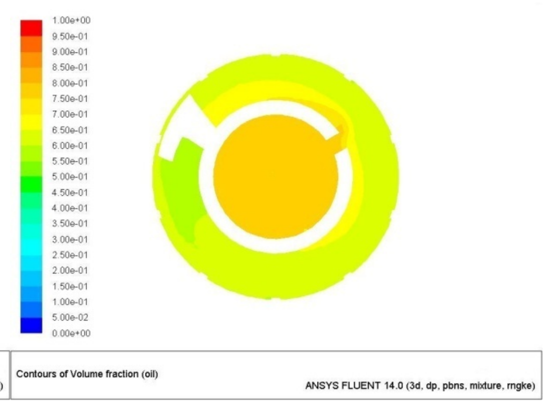
6.00e-01
5.50e-01
5.00e-01
4.50e-01
4.00e-01
3.50e-01
3.00e-01
2.50e-01
2.00e-01
1.50e-01
1.00e-01
5.00e-02
0.00e+00
Contours of Volume fraction (water)
ANSYS FLUENT 14.0 (3d, dp, pbns, mixture, rngke)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8.00e-01
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7.00e-01
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6.00e-01
5.50e-01
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4.50e-01
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3.50e-01
3.00e-01
2.50e-01
2.00e-01
1.50e-01
1.00e-01
5.00e-02
0.00e+00
Contours of Volume fraction (oil)
ANSYS FLUENT 14.0 (3d, dp, pbns, mixture, rngke)

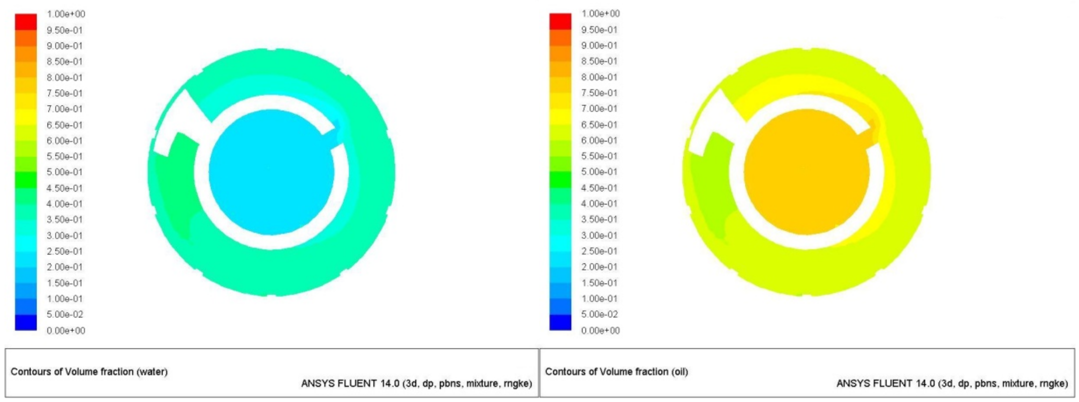


Fig. 4 Contours of the volume fraction at the four orifices

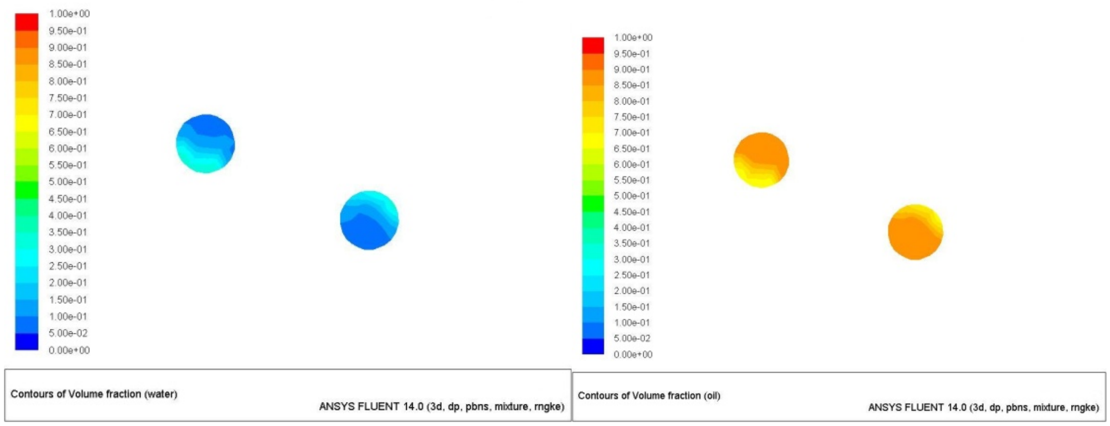


Fig. 5 Contours of the volume fraction at oil-fuel outlet

In figure 5 it can be observed that water practically does not exit through this outlet which confirms the theory that the fuel-oil and water separates due to centrifugal forces.

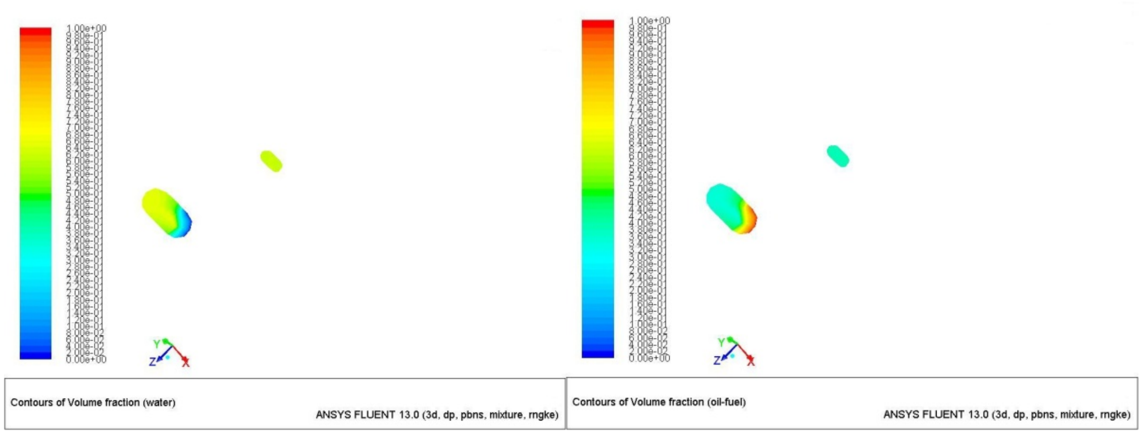


Fig. 6 Contours of the volume fraction at water outlet

In fig. 6 we can observe that the water concentration is bigger but there is an important quantity of oil-fuel that gets out through here too.

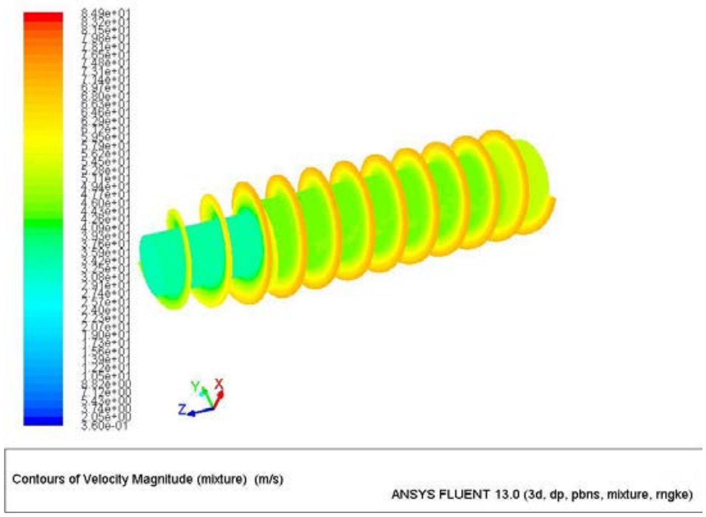
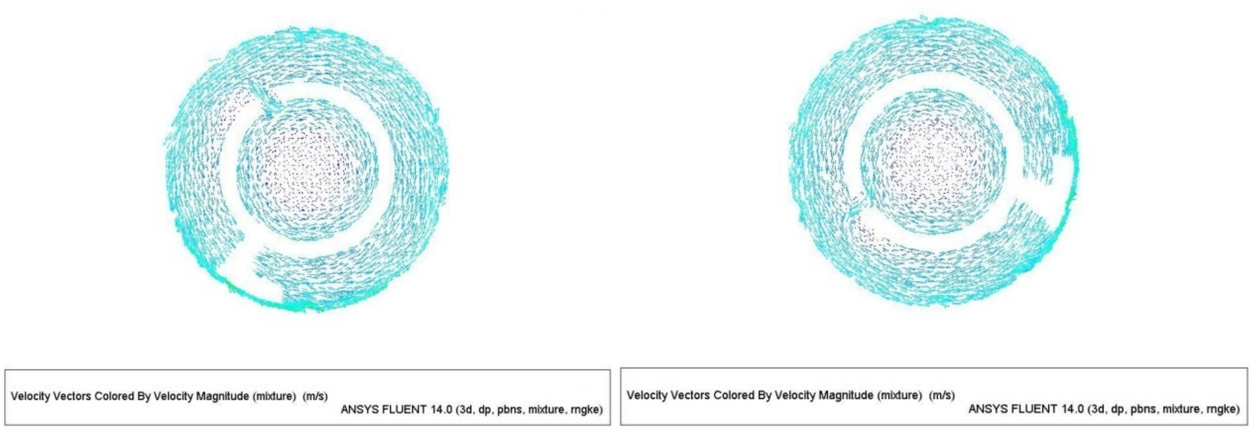
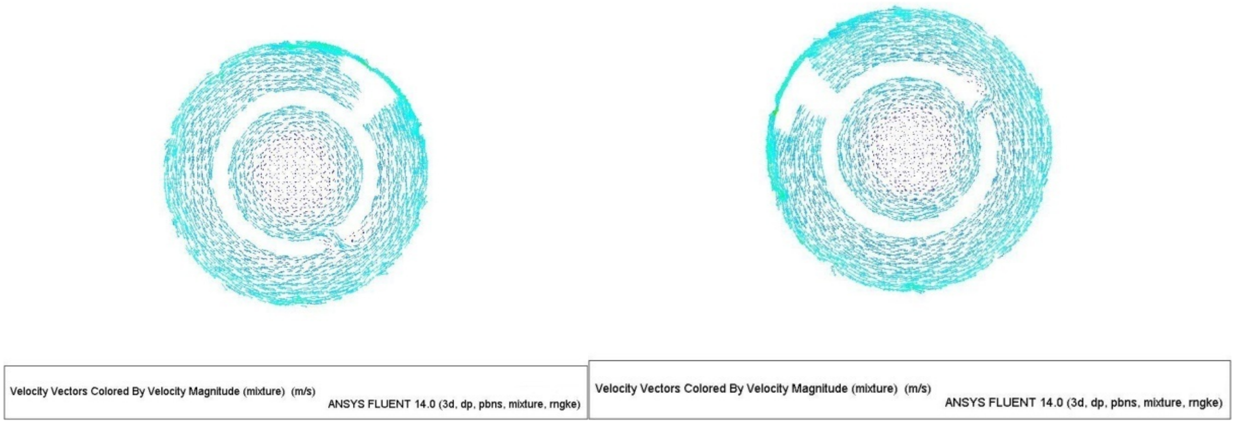


Fig. 7 Contours of Velocity Magnitude for the mixture

In fig 7 it can be observed the velocity field close to the helicoidally shape device.



1 2



3 4

Fig. 8 Vector field at the entrance of the four orifices

In fig. 8 it can be observed the vector field inside the device.

Conclusions

5. it has been analyzed the flow inside a separator and we took into consideration the water and fuel-oil mixture.

   In the separator was observed the separation of water and oil-fuel mixture

3. Simularea numerica pompa de suctiune

File Report

Table 1. File Information for pompa_001

Case	pompa_001
File Path	D:\john\Proiecte COMOTI\test fluent-Bulgaria\pompa\pompa_001.res
File Date	02 martie 2012
File Time	09:19:22
File Type	CFX5
File Version	12.0

2. Mesh Report

Table 2. Mesh Information for pompa_001

Domain	Nodes	Elements
R1	84906	77458

Table 3. Mesh Statistics for pompa_001

Domain	Maximum Edge Length Ratio
R1	5345.48

3. Physics Report

Table 4. Domain Physics for pompa_001

Domain - R1	
Type	Fluid
Location	Passage
Materials	
Water	
Fluid Definition	Material Library
Morphology	Continuous Fluid
Settings	
Buoyancy Model	Non Buoyant
Domain Motion	Rotating
Alternate Rotation Model	true

Angular Velocity	-2.8000e+03 [rev min^-1]
Axis Definition	Coordinate Axis
Rotation Axis	Coord 0.3
Reference Pressure	1.0000e+00 [atm]
Heat Transfer Model	Total Energy
Include Viscous Work Term	On
Turbulence Model	SST
Turbulent Wall Functions	Automatic
Domain Interface - R1 to R1 Internal	
Boundary List1	R1 to R1 Internal Side 1
Boundary List2	R1 to R1 Internal Side 2
Interface Type	Fluid Fluid
Settings	
Interface Models	General Connection
Mass And Momentum	Conservative Interface Flux
Mesh Connection	GGI
Domain Interface - R1 to R1 Periodic 1	
Boundary List1	R1 to R1 Periodic 1 Side 1
Boundary List2	R1 to R1 Periodic 1 Side 2
Interface Type	Fluid Fluid
Settings	
Interface Models	Rotational Periodicity
Axis Definition	Coordinate Axis
Rotation Axis	Coord 0.3
Mesh Connection	Automatic

Table 5. Boundary Physics for pompa_001

Domain	Boundaries	
R1	Boundary - R1 Inlet	
	Type	INLET
	Location	INFLOW
	Settings	
	Flow Direction	Normal to Boundary Condition
	Flow Regime	Subsonic
	Heat Transfer	Stationary Frame Total Temperature
	Stationary Frame Total	4.0000e+01 [C]

Temperature	
Mass And Momentum	Stationary Frame Total Pressure
Relative Pressure	0.0000e+00 [atm]
Turbulence	Medium Intensity and Eddy Viscosity Ratio
Boundary - R1 to R1 Internal Side 1	
Type	INTERFACE
Location	SHROUD TIP GGI SIDE 1
Settings	
Heat Transfer	Conservative Interface Flux
Mass And Momentum	Conservative Interface Flux
Turbulence	Conservative Interface Flux
Boundary - R1 to R1 Internal Side 2	
Type	INTERFACE
Location	SHROUD TIP GGI SIDE 2
Settings	
Heat Transfer	Conservative Interface Flux
Mass And Momentum	Conservative Interface Flux
Turbulence	Conservative Interface Flux
Boundary - R1 to R1 Periodic 1 Side 1	
Type	INTERFACE
Location	PER1
Settings	
Heat Transfer	Conservative Interface Flux
Mass And Momentum	Conservative Interface Flux
Turbulence	Conservative Interface Flux
Boundary - R1 to R1 Periodic 1 Side 2	
Type	INTERFACE
Location	PER2
Settings	
Heat Transfer	Conservative Interface Flux
Mass And Momentum	Conservative Interface Flux
Turbulence	Conservative Interface Flux

Boundary - R1 Outlet	
Type	OUTLET
Location	OUTFLOW
Settings	
Flow Regime	Subsonic
Mass And Momentum	Mass Flow Rate
Mass Flow Rate	1.6600e+00 [kg s^-1]
Boundary - R1 Blade	
Type	WALL
Location	BLADE
Settings	
Heat Transfer	Adiabatic
Mass And Momentum	No Slip Wall
Wall Roughness	Smooth Wall
Boundary - R1 Hub	
Type	WALL
Location	HUB
Settings	
Heat Transfer	Adiabatic
Mass And Momentum	No Slip Wall
Wall Roughness	Smooth Wall
Boundary - R1 Shroud	
Type	WALL
Location	SHROUD
Settings	
Heat Transfer	Adiabatic
Mass And Momentum	No Slip Wall
Wall Velocity	Counter Rotating Wall
Wall Roughness	Smooth Wall

4. Tabulated Results

The first table below gives a summary of the performance results for the pump impeller. The second table lists the mass or area averaged solution variables and derived quantities computed at the inlet, leading edge (LE Cut), trailing edge (TE Cut) and outlet locations. The flow angles Alpha and Beta are relative to the meridional plane; a positive angle implies that the tangential velocity is the same direction as the machine rotation.

Table 6. Performance Results

Rotation Speed	-293.2150	[radian s^-1]
Reference Diameter	0.1616	[m]
Volume Flow Rate	0.0100	[m^3 s^-1]
Head (LE-TE)	54.1862	[m]
Head (IN-OUT)	50.9800	[m]
Flow Coefficient	0.0081	
Head Coefficient (IN-OUT)	0.2227	
Shaft Power	6331.3000	[W]
Power Coefficient	0.0023	
Total Efficiency (IN-OUT) %	78.6403	
Static Efficiency (IN-OUT) %	42.1286	

Table 7. Summary Data

Quantity	Inlet	LE Cut	TE Cut	Outlet	TE/LE	TE-LE	Units
Density	997.0000	997.0000	997.0000	997.0000	1.0000	0.0000	[kg m^-3]
Pstatic	0.9102	0.8729	2.7750	3.6524	3.1792	1.9021	[atm]
Ptotal	1.0034	0.9711	6.1997	5.9227	6.3843	5.2286	[atm]
Ptotal (rot)	1.0009	0.9330	0.2520	0.1290	0.2701	-0.6810	[atm]
U	6.1529	7.4930	23.6906	27.8842	3.1617	16.1976	[m s^-1]
Cm	4.3366	4.1481	2.5357	1.9250	0.6113	-1.6124	[m s^-1]
Cu	-0.0156	-0.7638	-23.7967	-21.9765	31.1564	-23.0330	[m s^-1]
C	4.3393	5.0802	24.0313	22.1250	4.7304	18.9511	[m s^-1]
Distortion Parameter	1.0156	1.5493	1.0311	1.0134	0.6655	-0.5182	
Flow Angle: Alpha	0.1558	-23.2472	5.8548	2.0523	-0.2519	29.1020	[degree]
Wu	6.1373	6.7322	-0.1043	5.9077	-0.0155	-6.8365	[m s^-1]
W	7.5476	8.2734	3.1759	6.3171	0.3839	-5.0975	[m s^-1]
Flow Angle: Beta	-53.7619	-65.6325	-32.3149	-78.6292	0.4924	33.3176	[degree]

5. Blade Loading Charts

Chart 1. Blade Loading at 20% Span

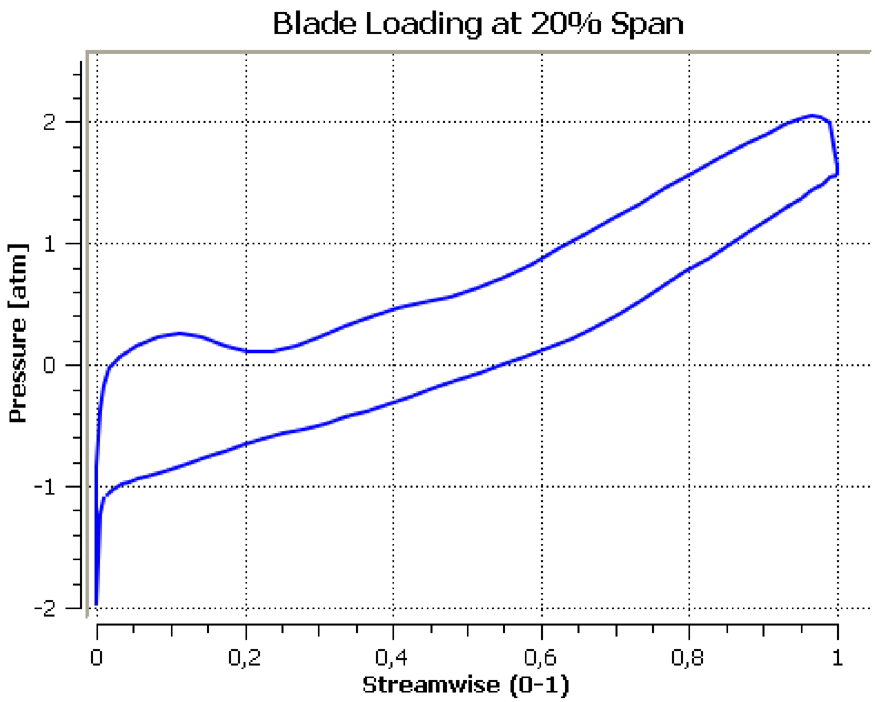


Chart 2. Blade Loading at 50% Span

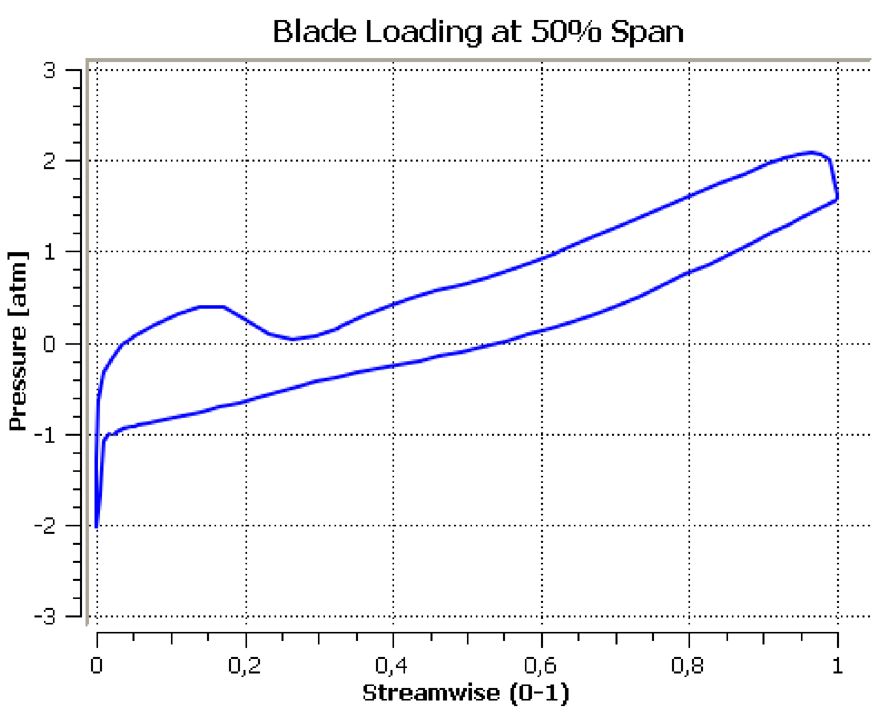
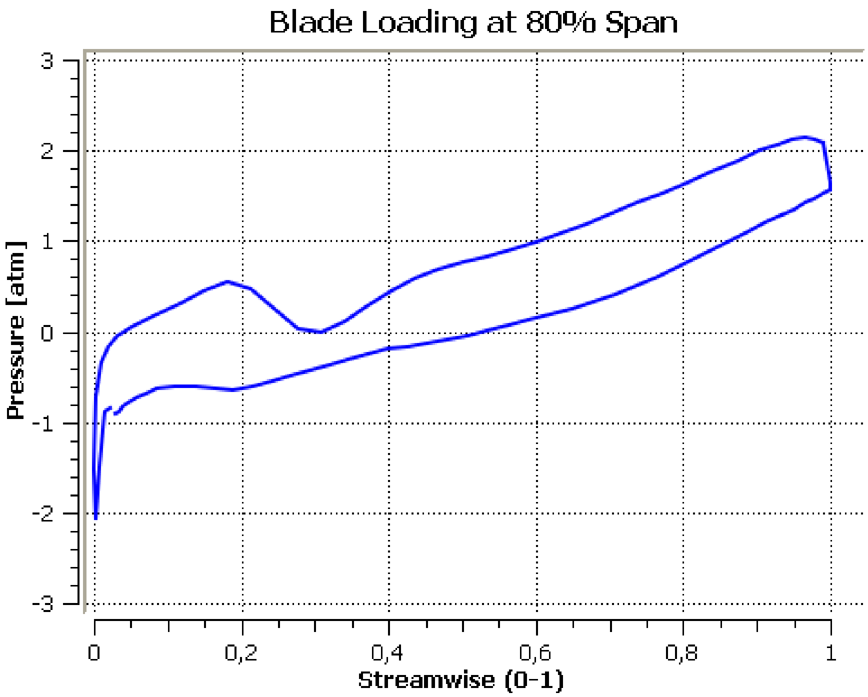


Chart 3. Blade Loading at 80% Span



6. Streamwise Charts

Chart 4. Streamwise Plot of Pt and Ps

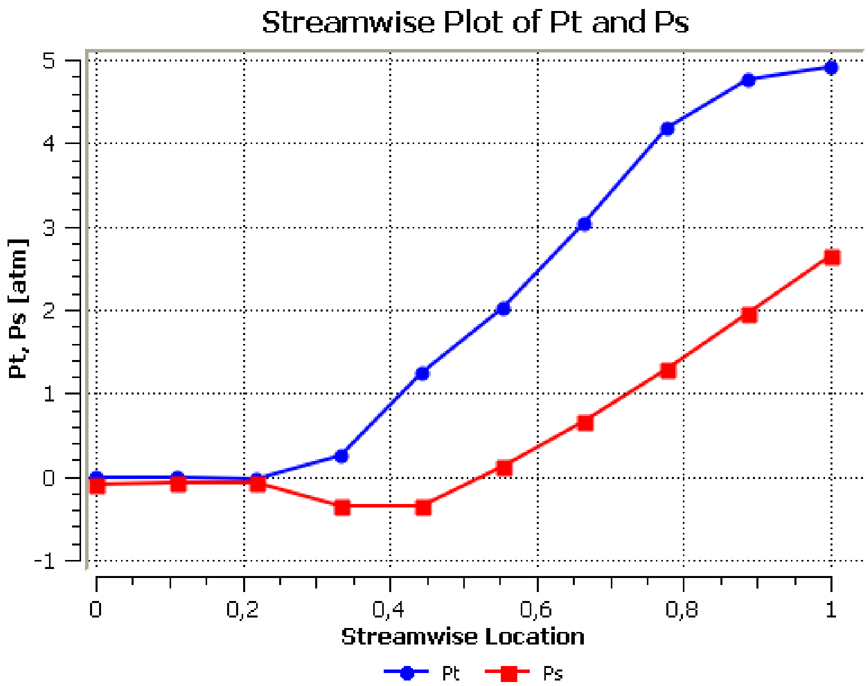


Chart 5. Streamwise Plot of C

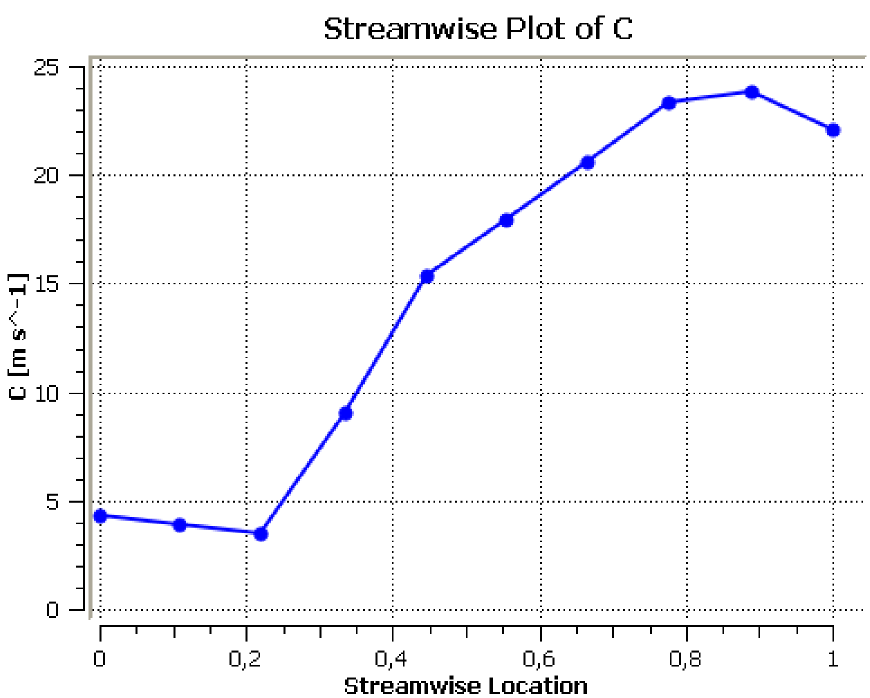


Chart 6. Streamwise Plot of W

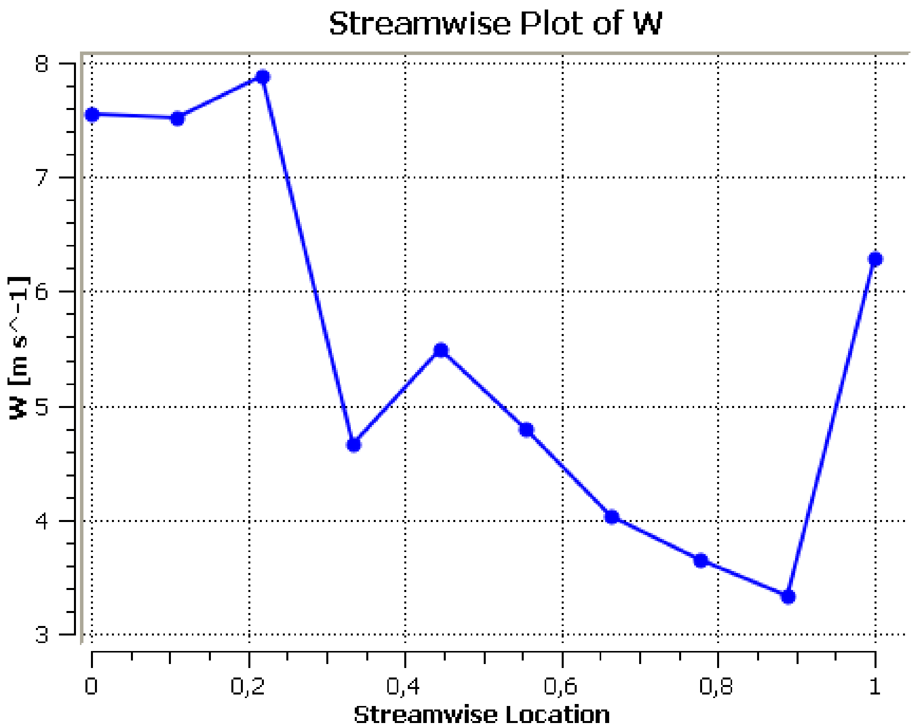
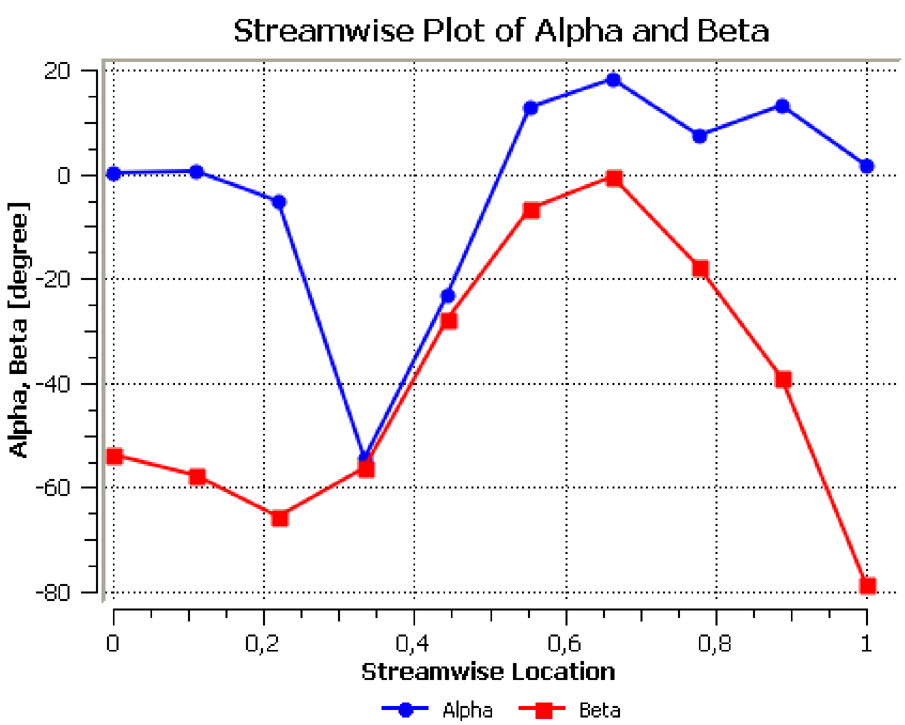


Chart 7. Streamwise Plot of Alpha and Beta



7. Spanwise Charts

Chart 8. Spanwise Plot of Alpha and Beta at LE

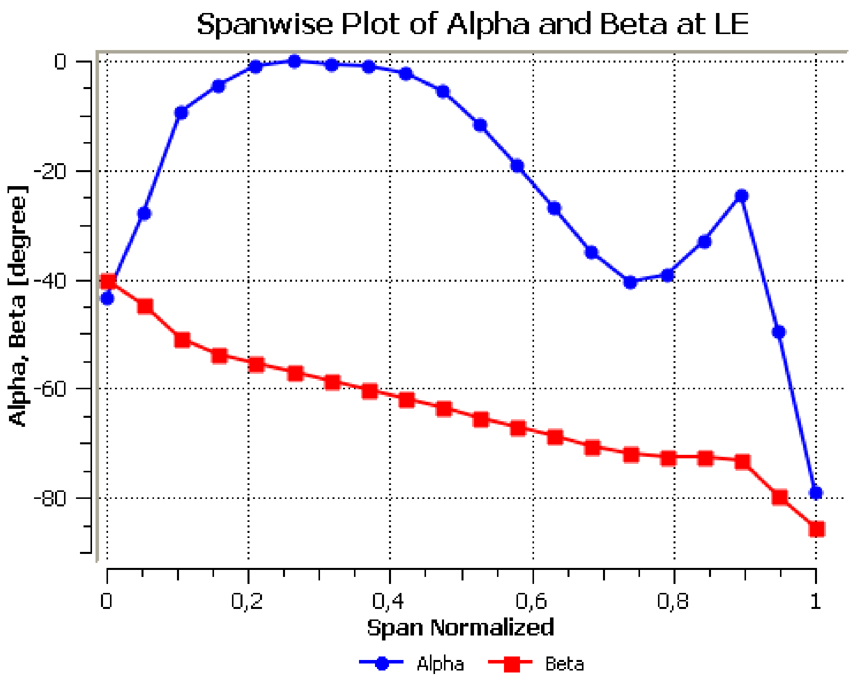
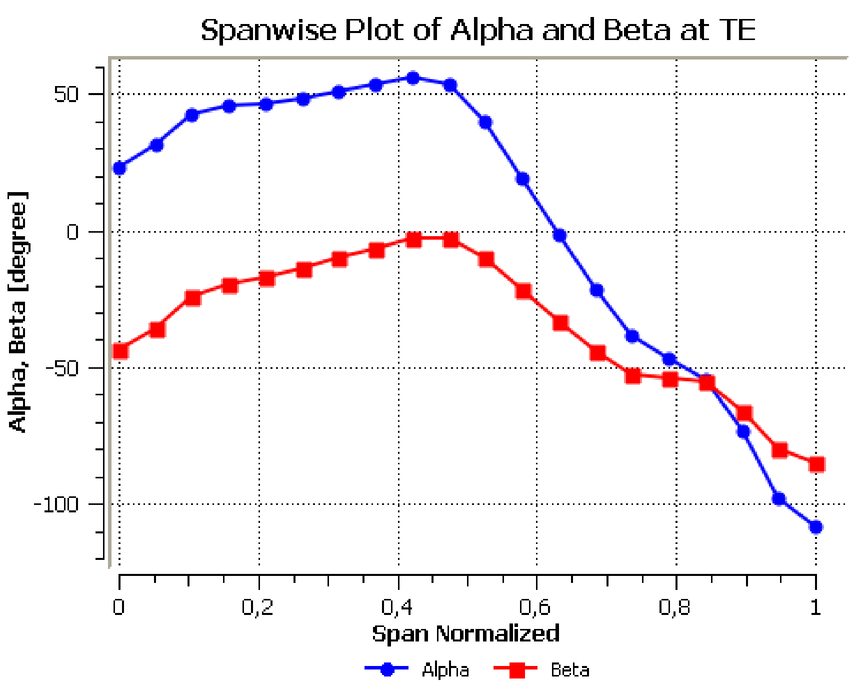


Chart 9. Spanwise Plot of Alpha and Beta at TE



8. Blade Geometry Plots

Figure 1. Isometric 3D View of the Blade, Hub and Shroud

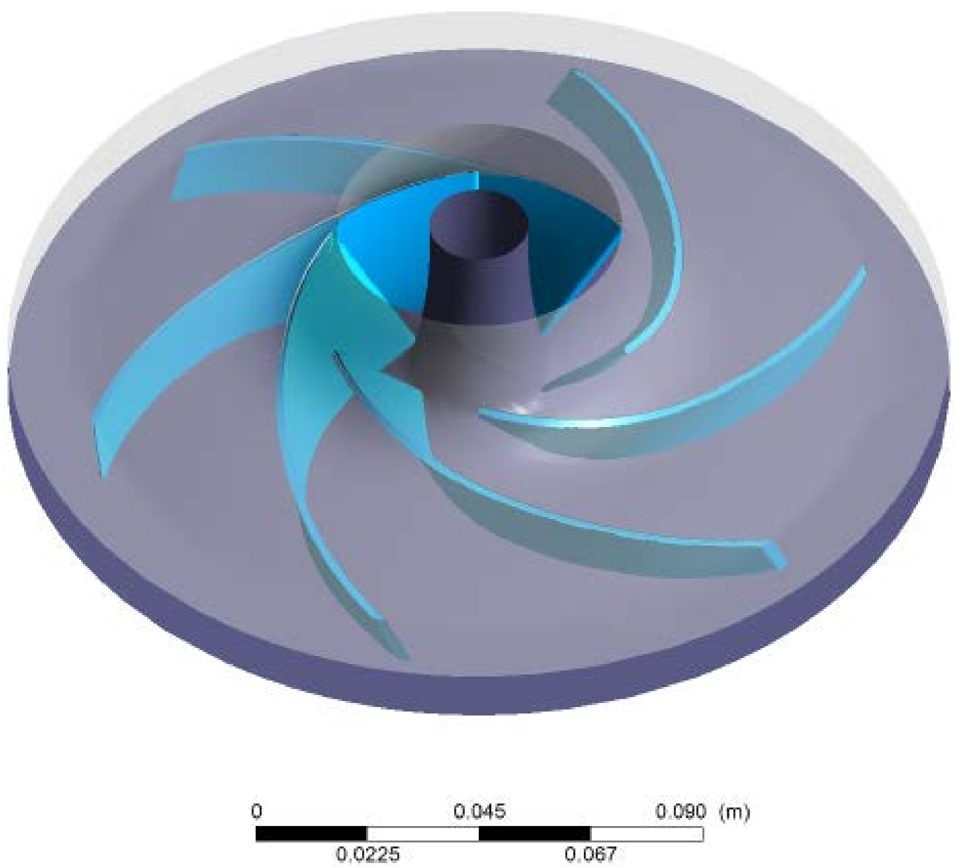
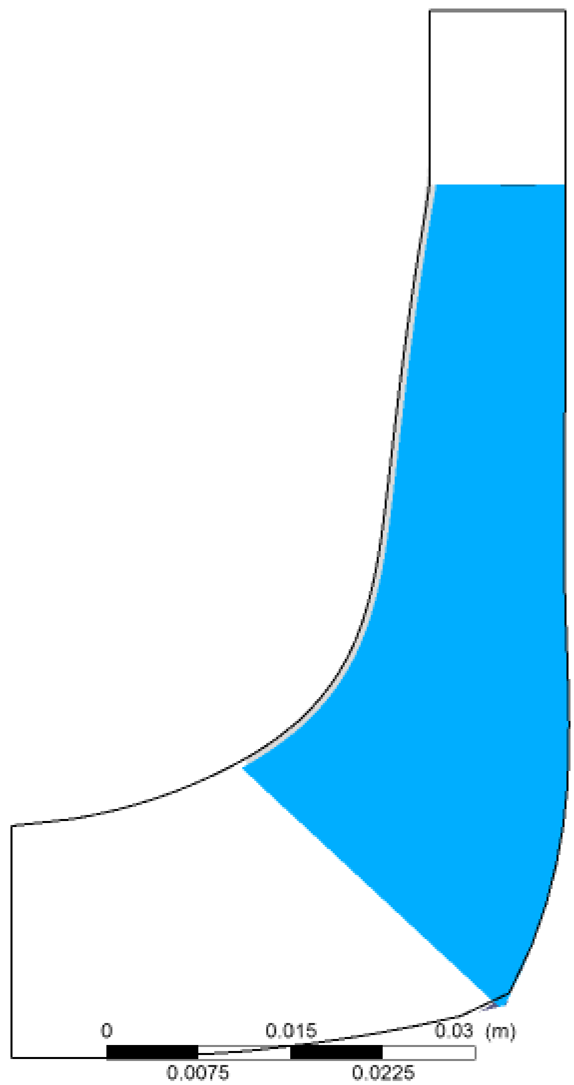
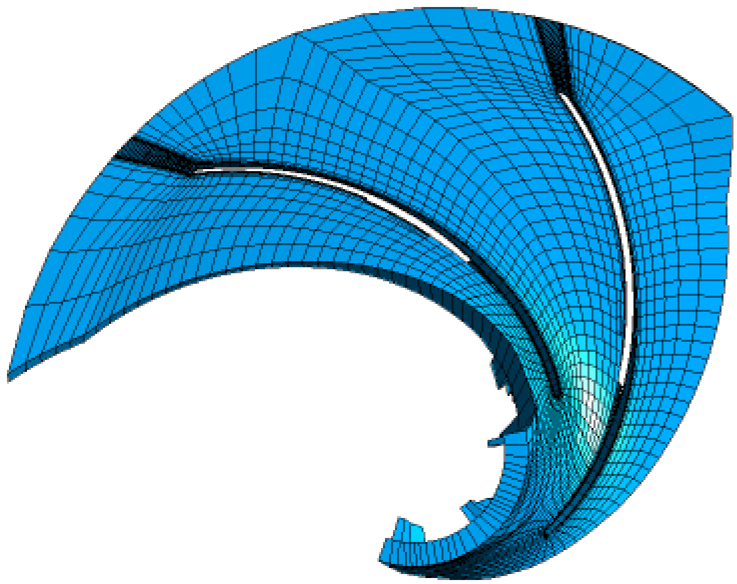


Figure 2. Meridional View of the Blade, Hub and Shroud



9. Blade Mesh Plot

Figure 3. Mesh Elements at 50% Span



10. Blade to Blade Plots

Figure 4. Contour of Pt at 50% Span

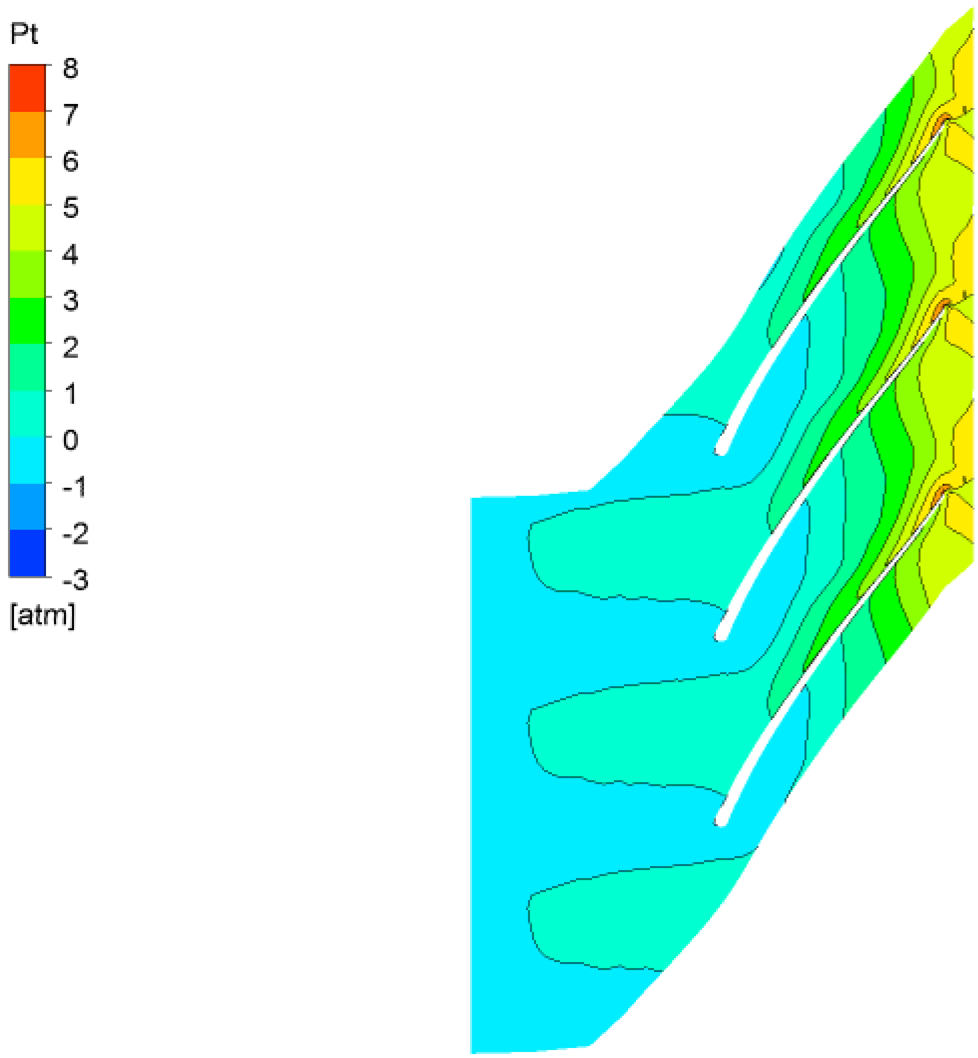


Figure 5. Contour of Ptr at 50% Span

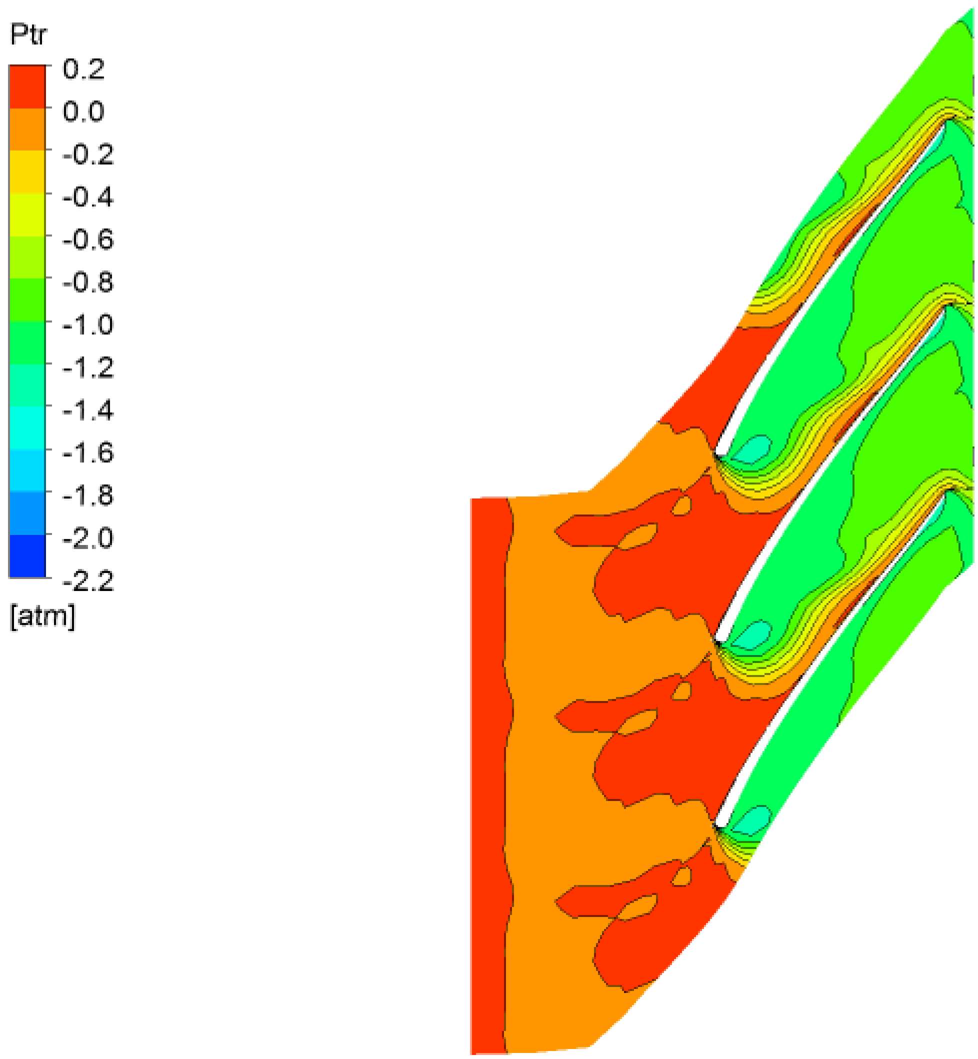


Figure 6. Contour of Ps at 50% Span

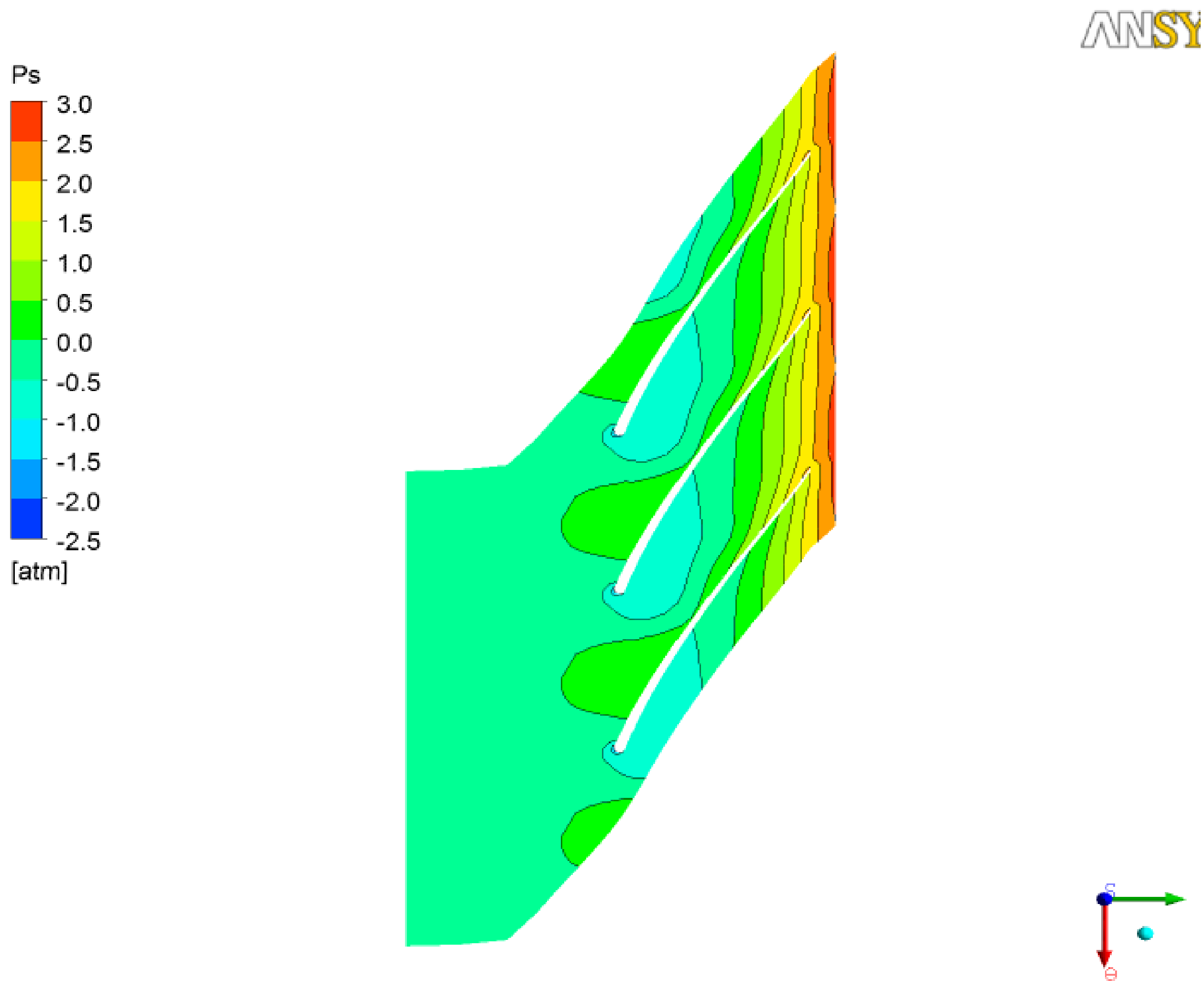


Figure 7. Contour of W at 50% Span

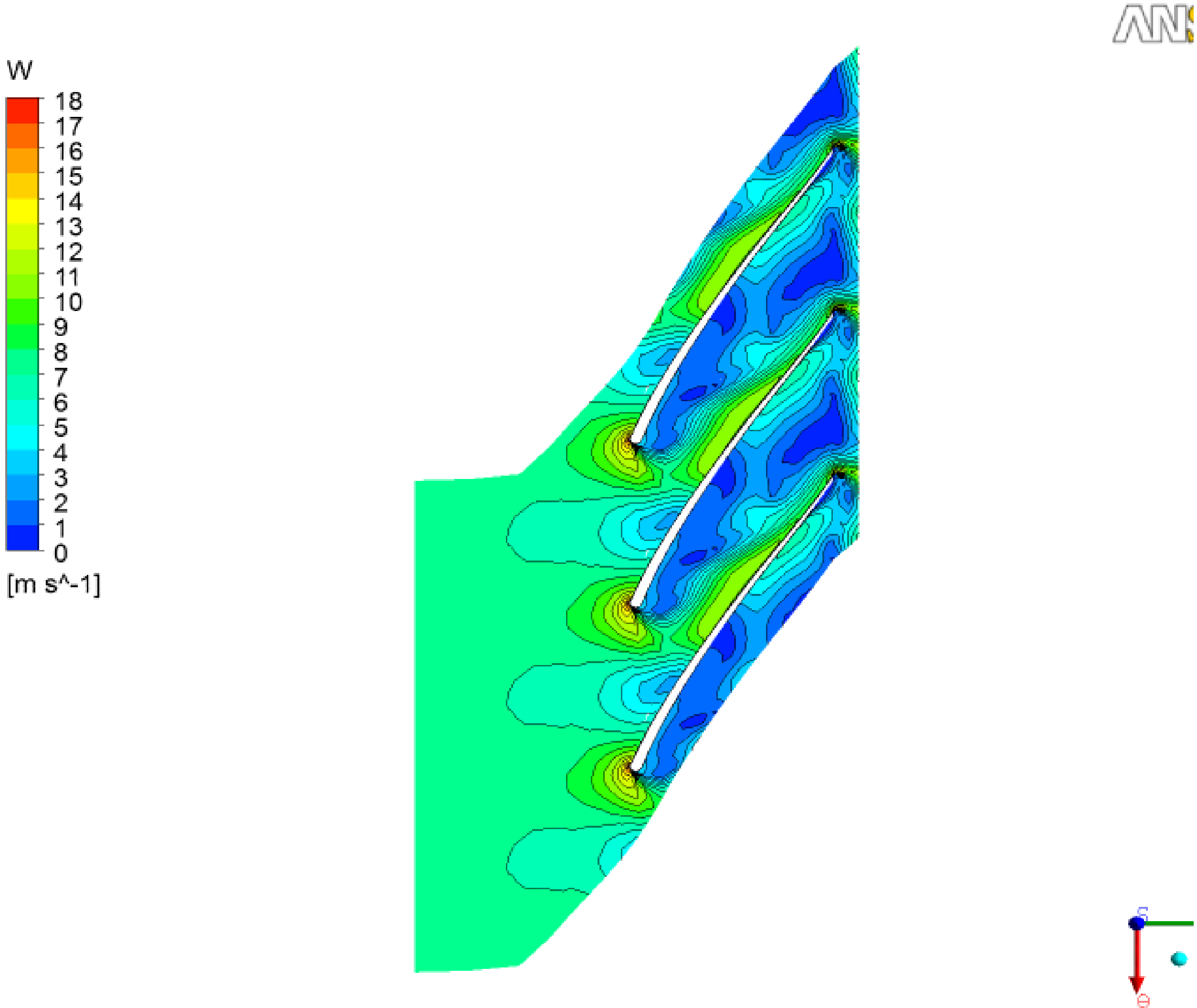


Figure 8. Velocity Vectors at 20% Span

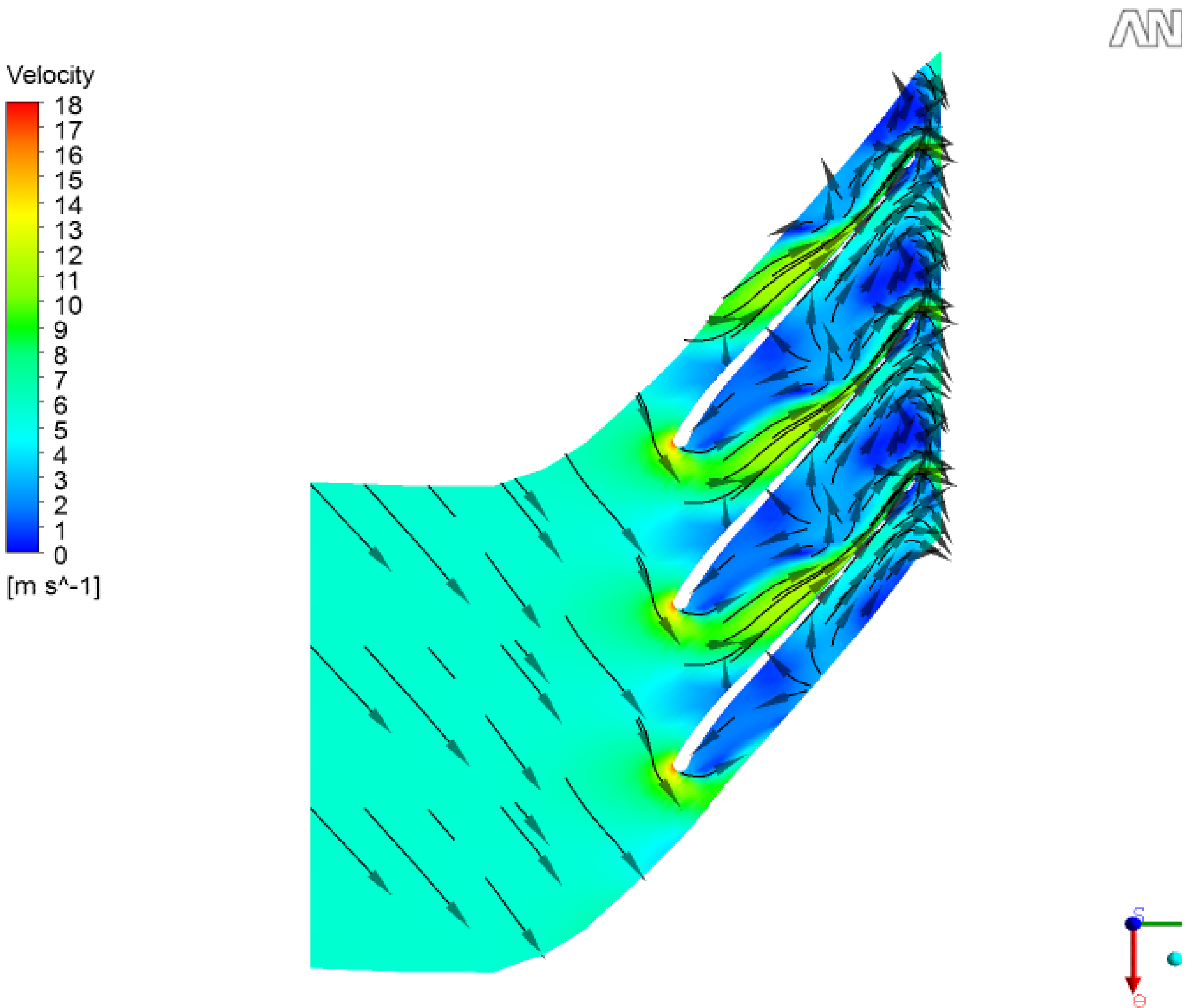


Figure 9. Velocity Vectors at 50% Span

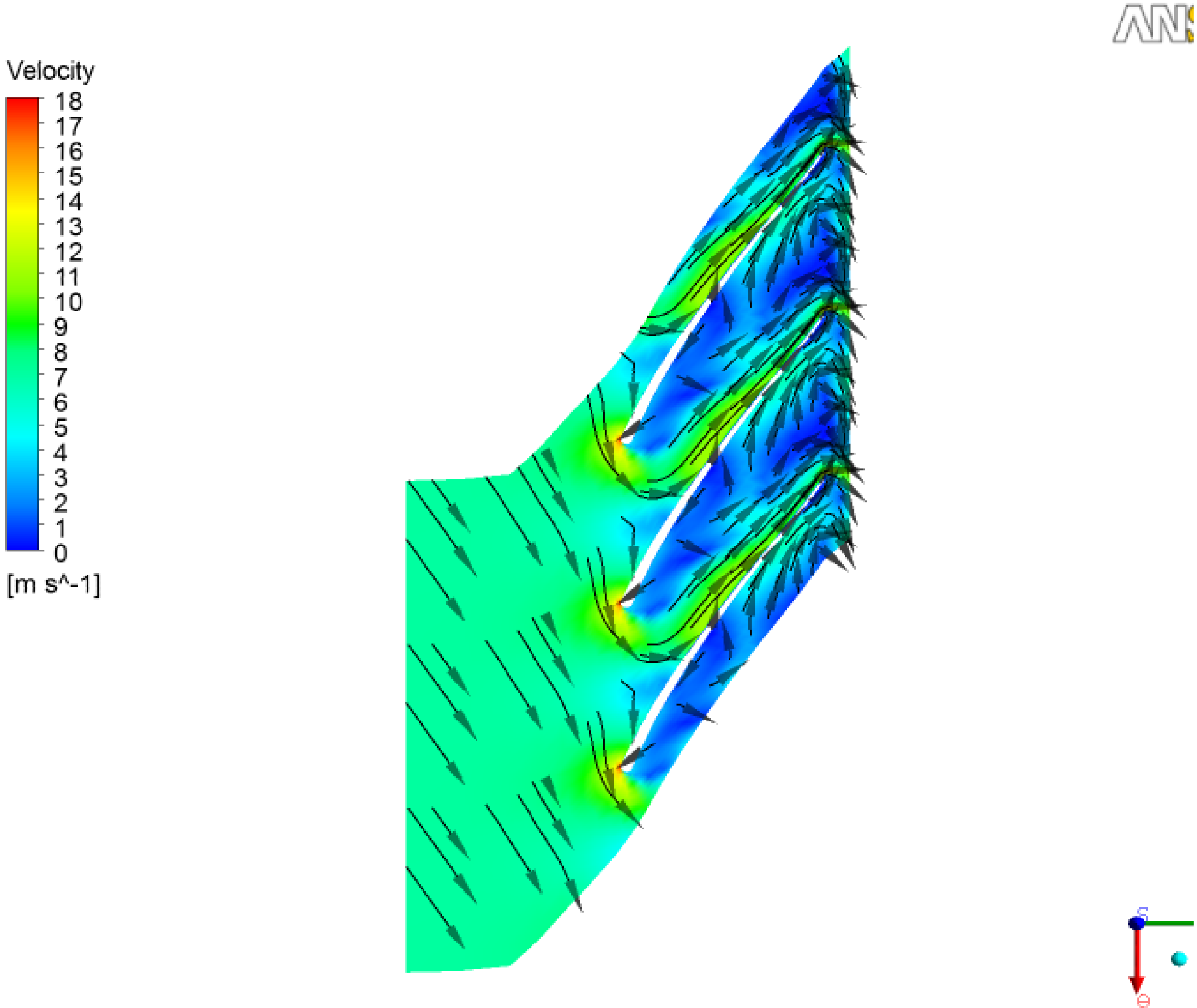
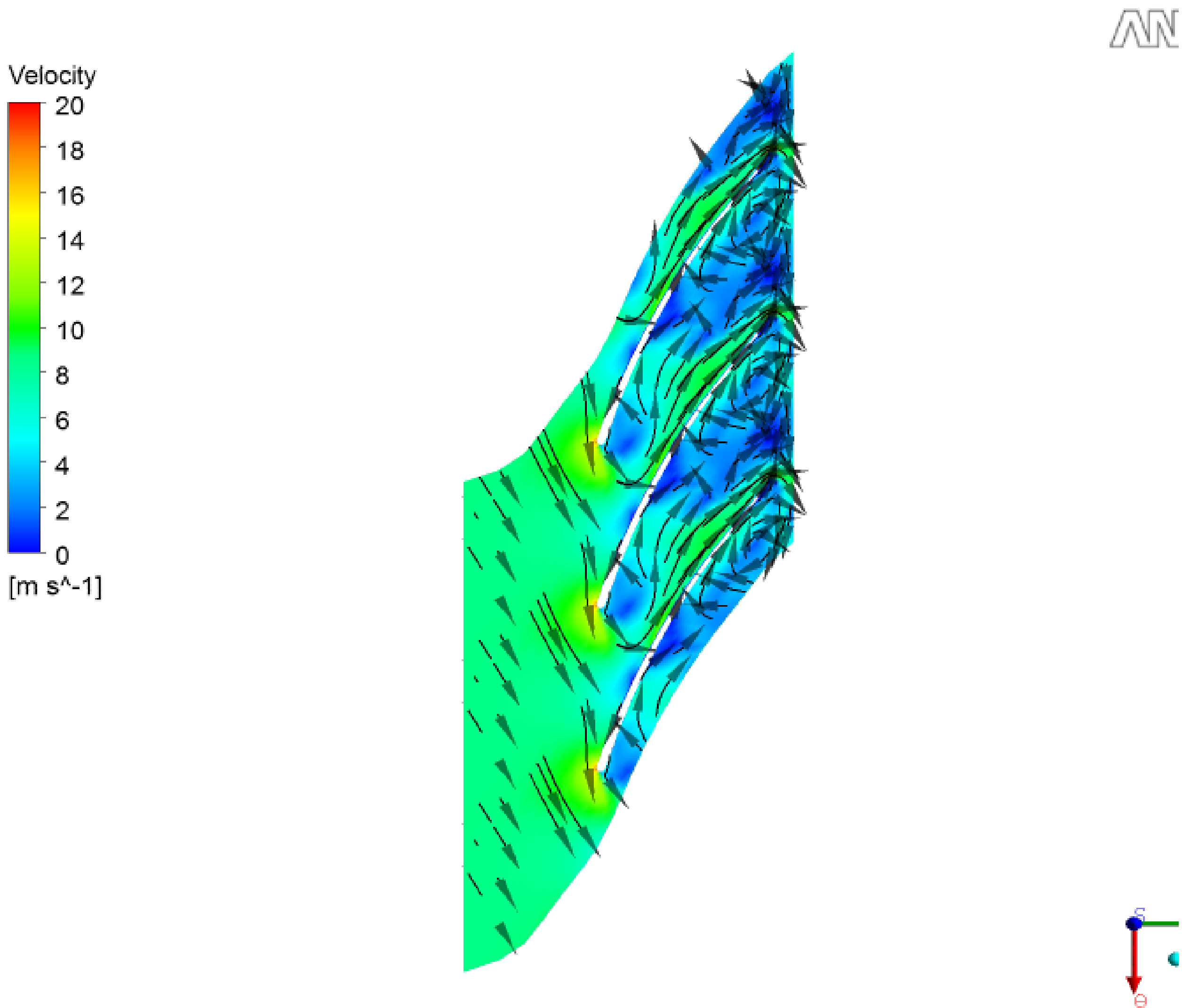


Figure 10. Velocity Vectors at 80% Span



11. Meridional Plots

Figure 11. Contour of Mass Averaged Pt on Meridional Surface

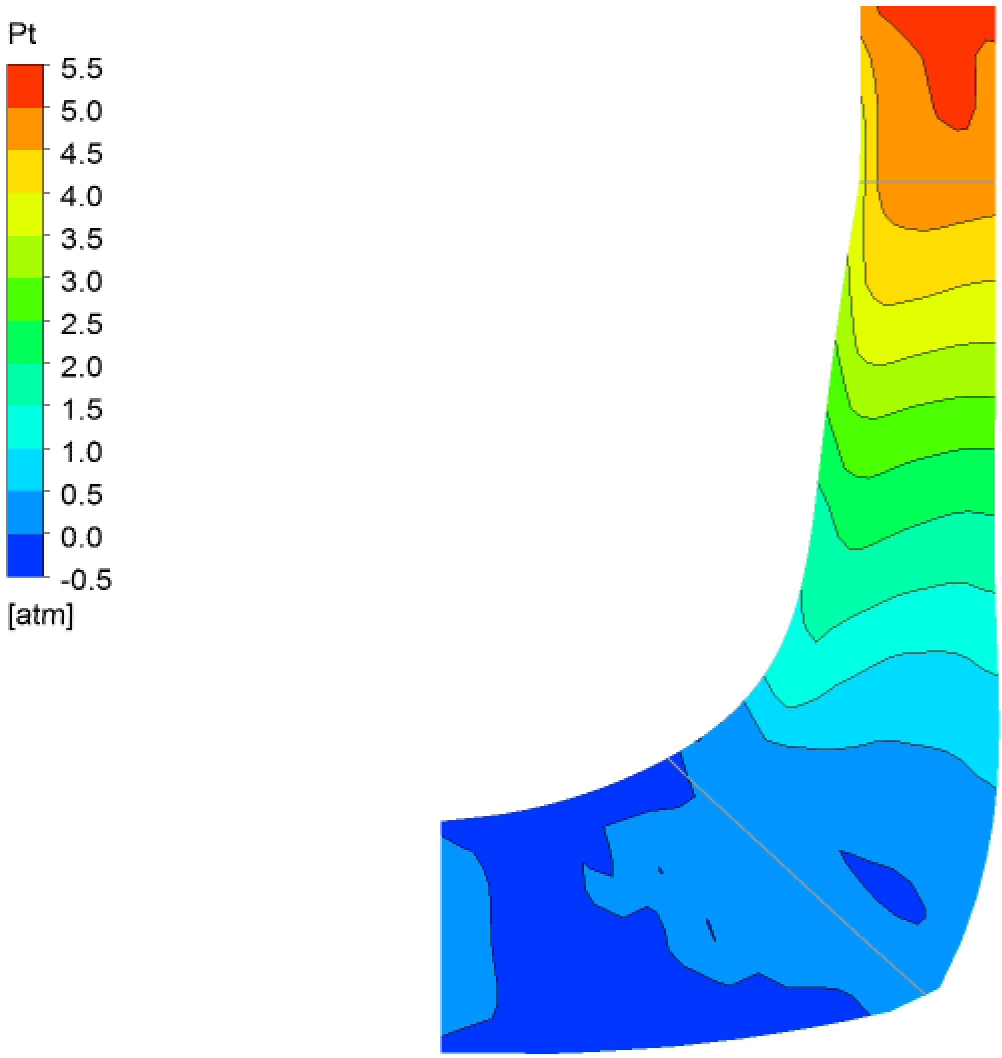


Figure 12. Contour of Mass Averaged Ptr on Meridional Surface

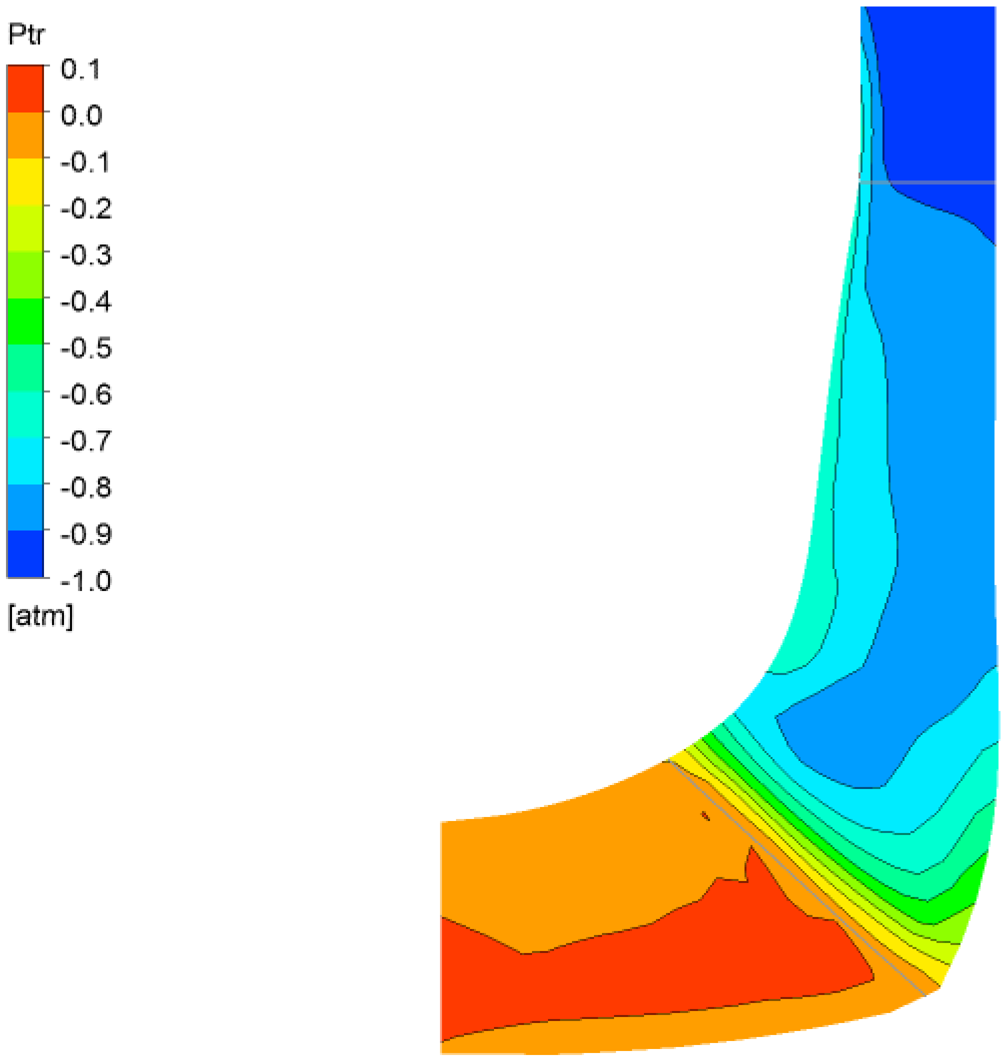


Figure 13. Contour of Mass Averaged W on Meridional Surface

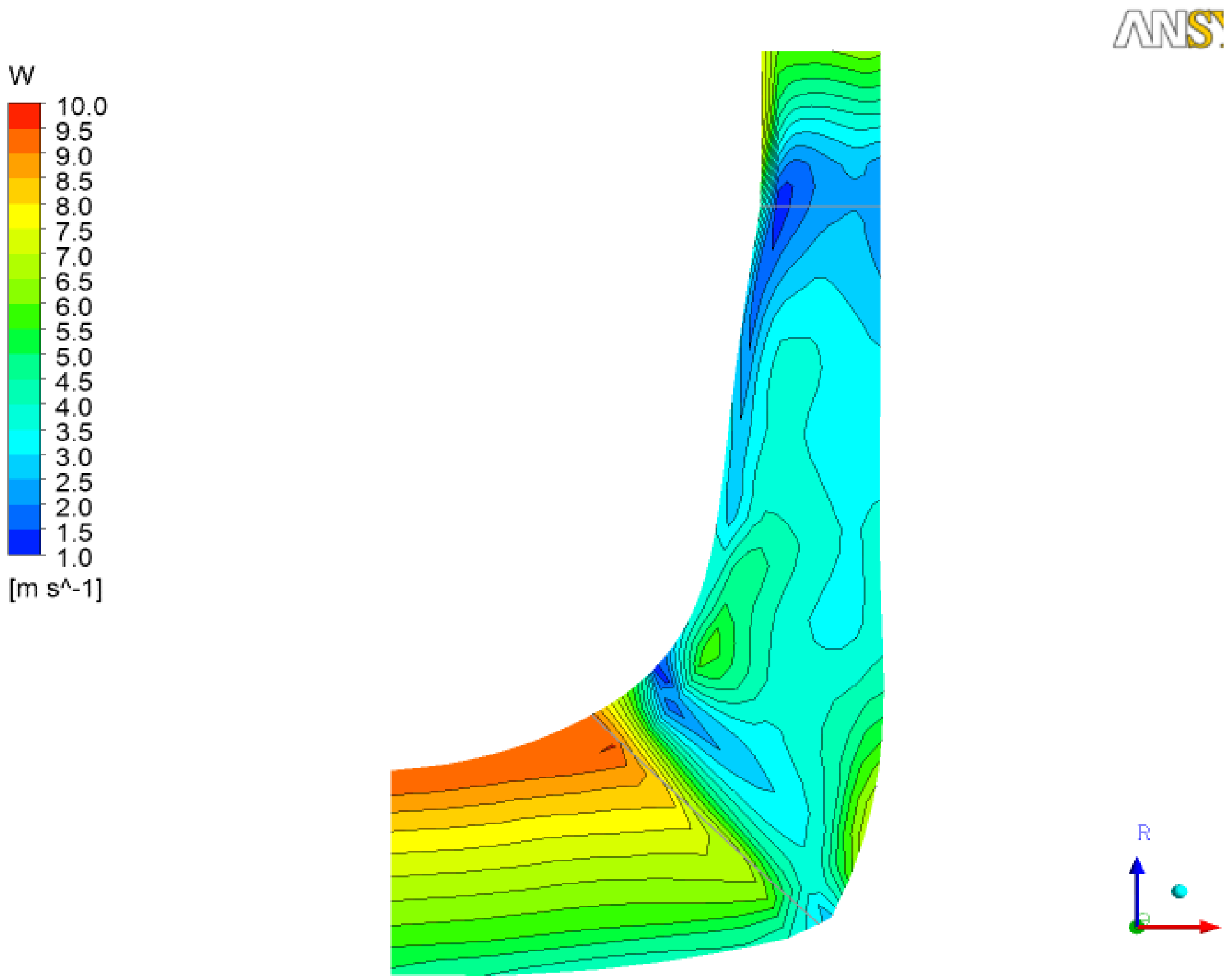
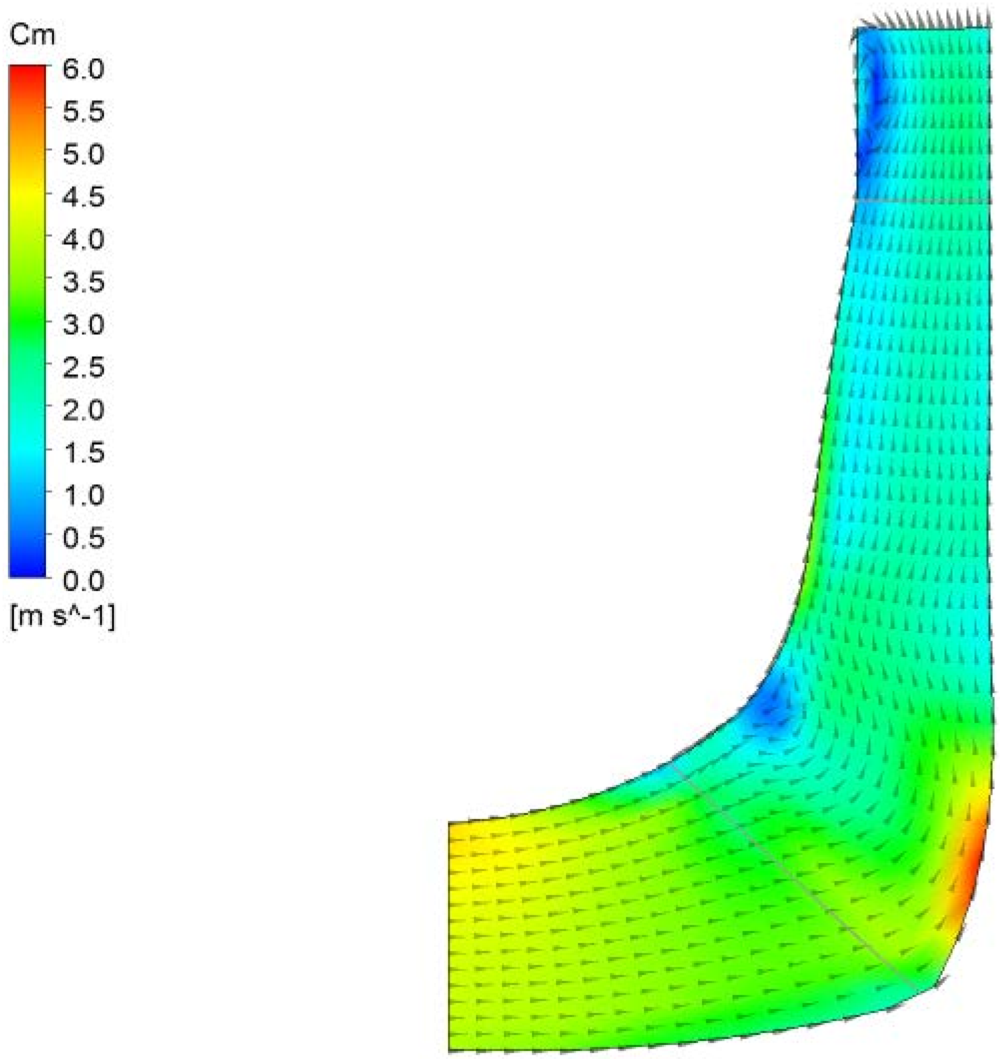


Figure 14. Vector of Area Averaged Cm on Meridional Surface



12. Circumferential Plots

Figure 15. Contour of Pt at Blade LE

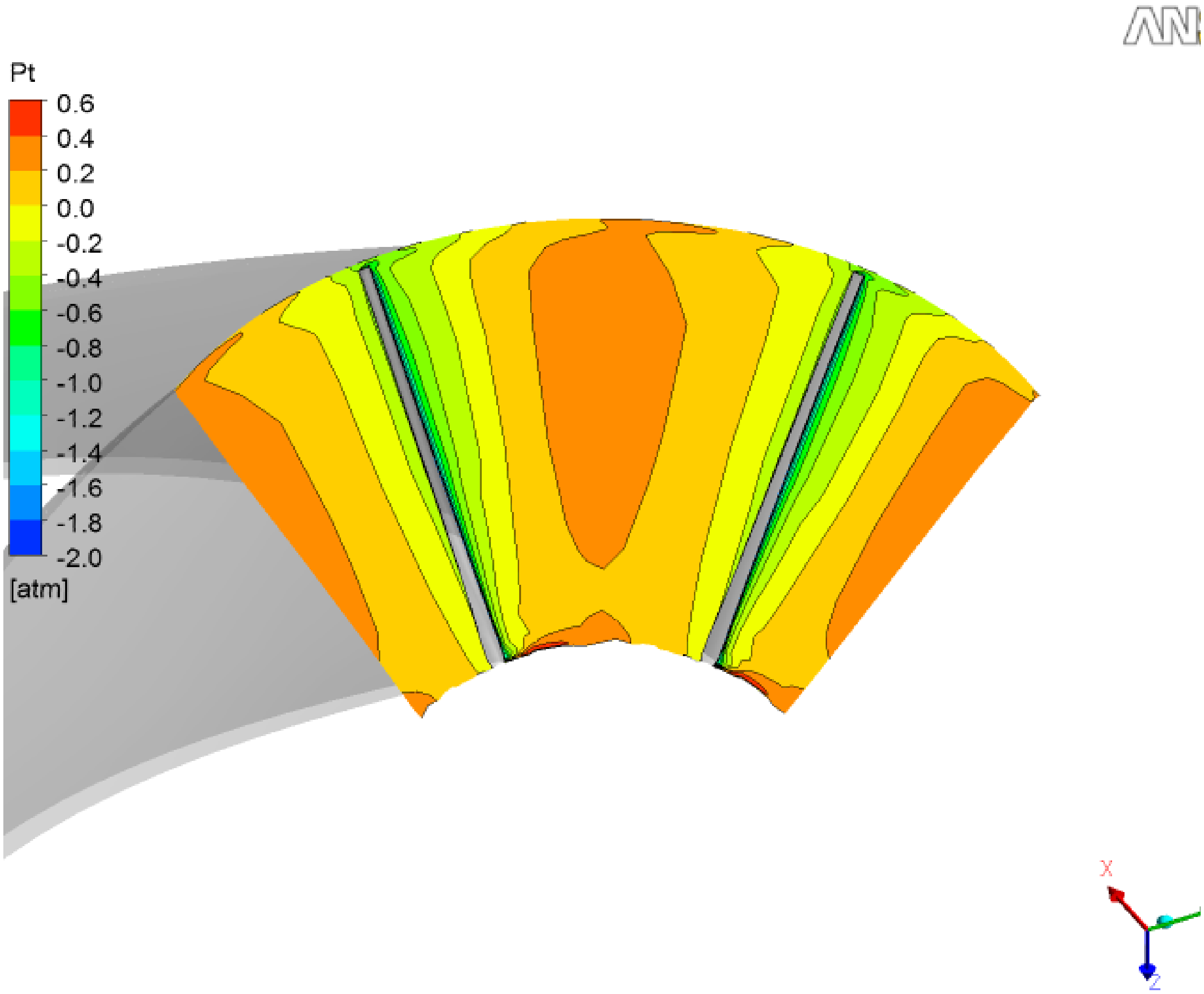


Figure 16. Contour of Ptr at Blade LE

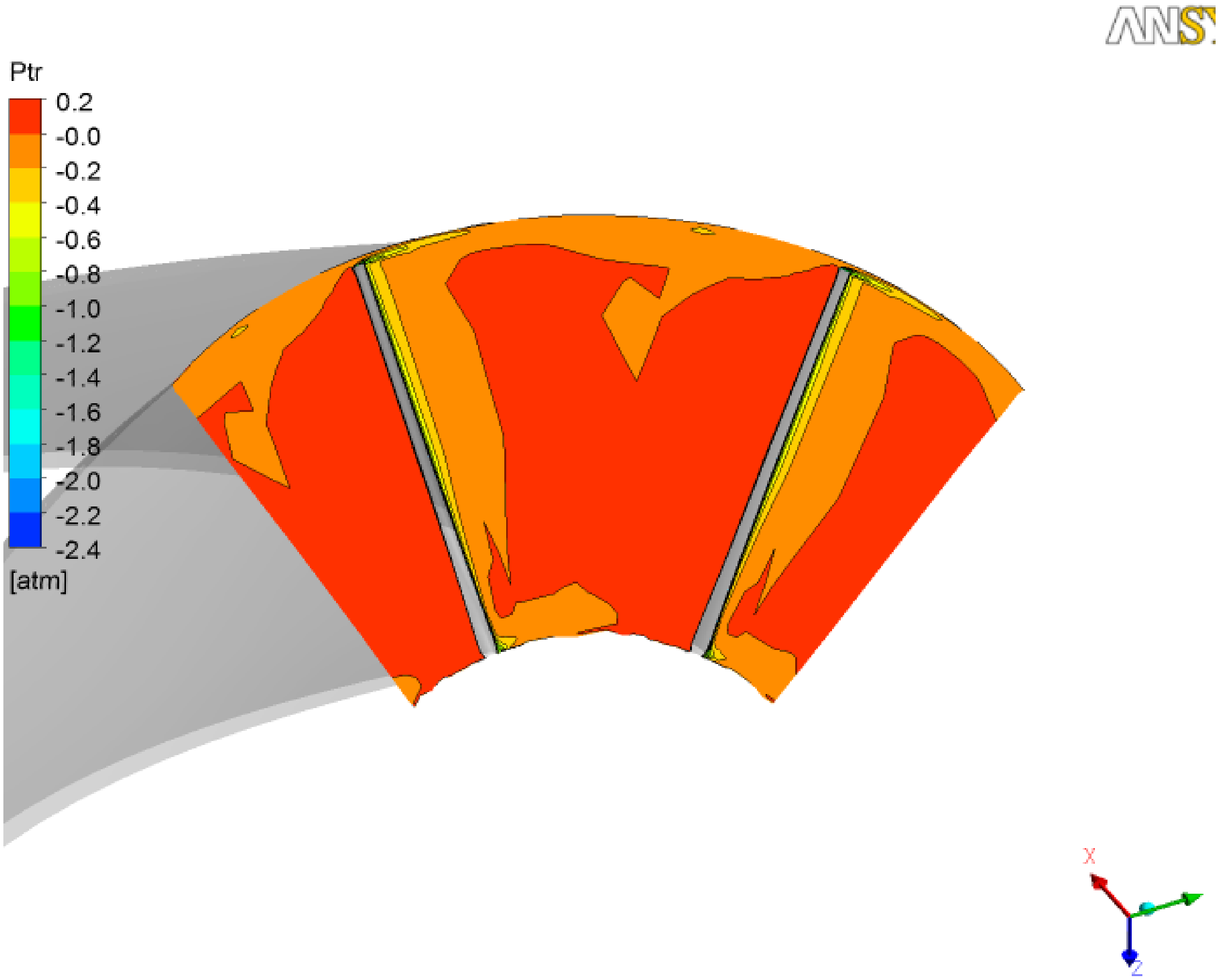


Figure 17. Contour of W at Blade LE

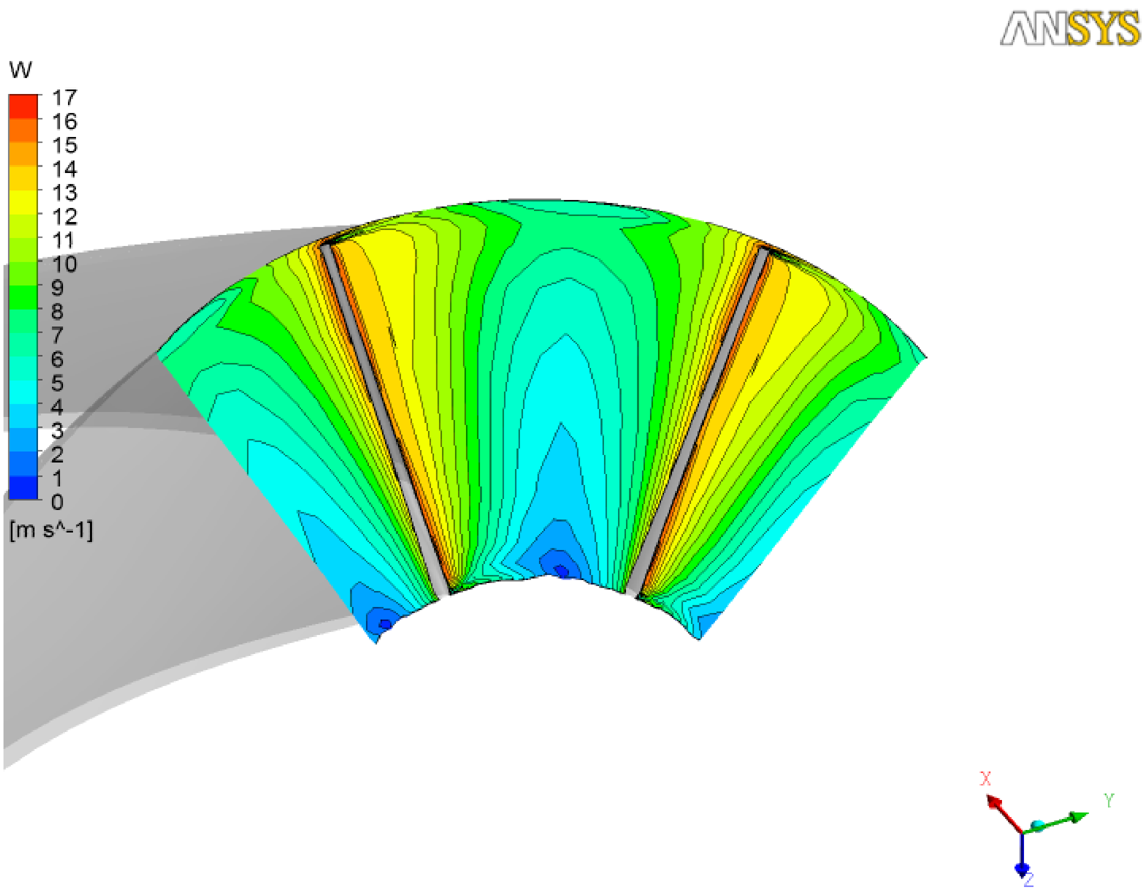


Figure 18. Contour of Pt at Blade TE

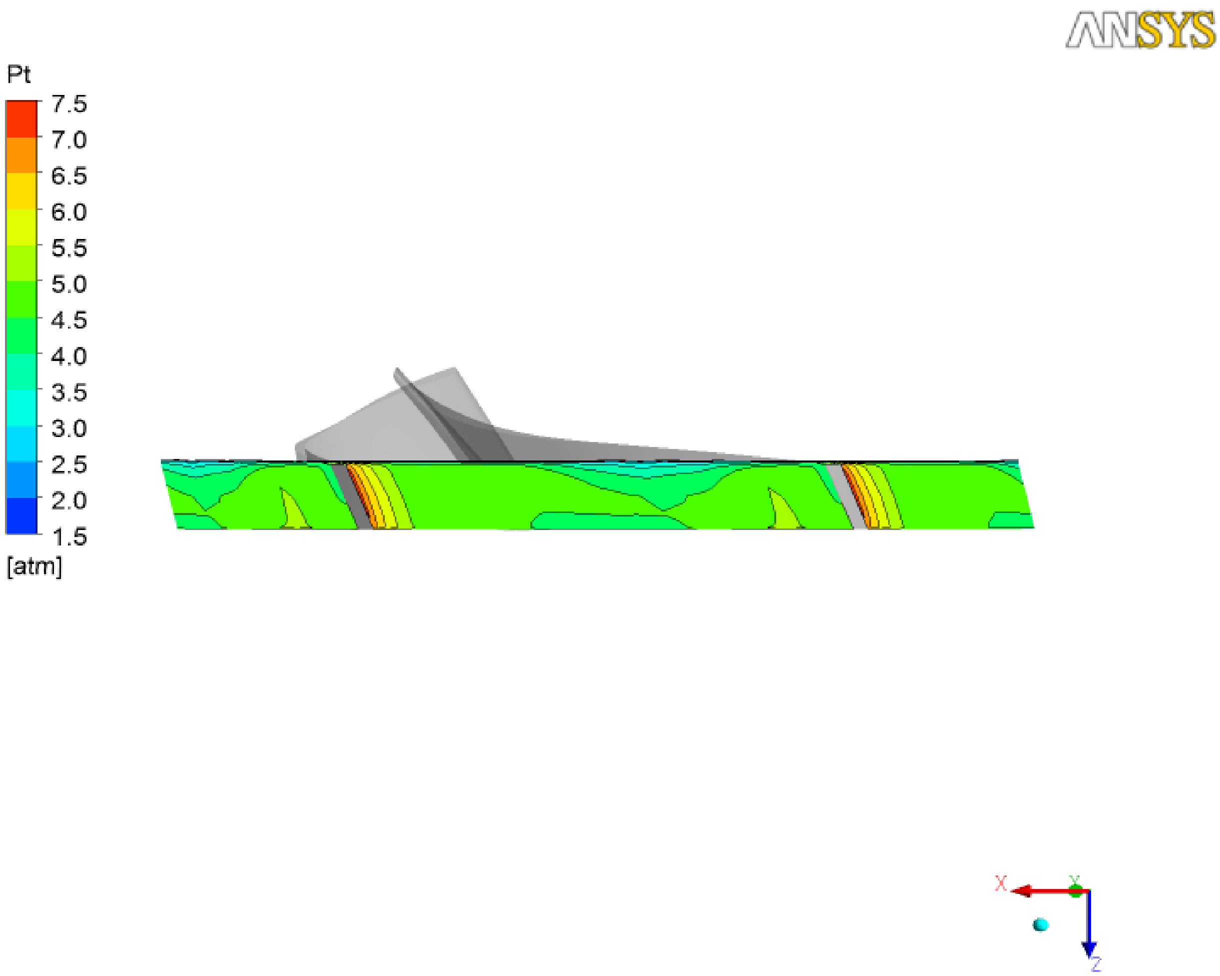


Figure 19. Contour of Ptr at Blade TE

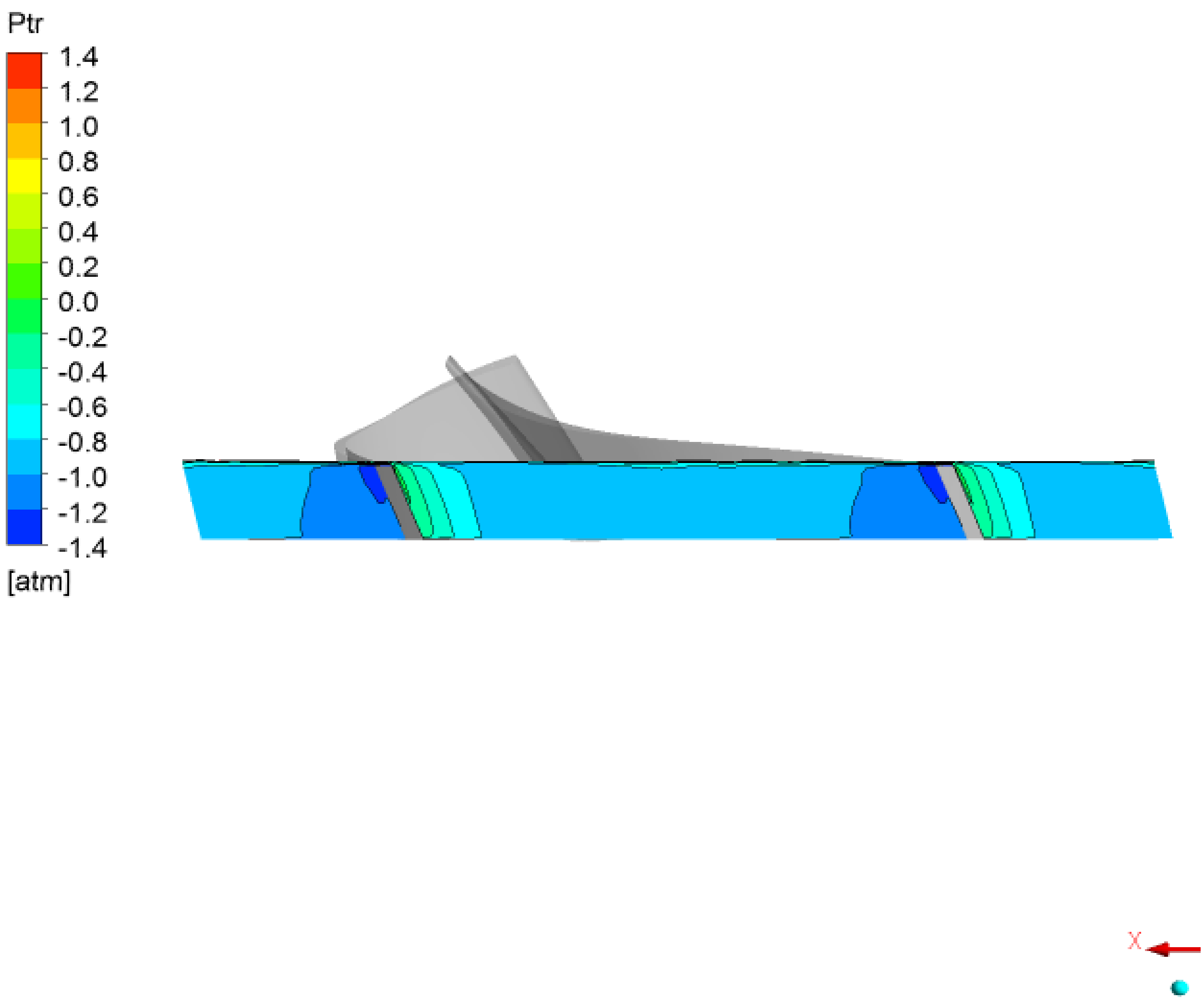
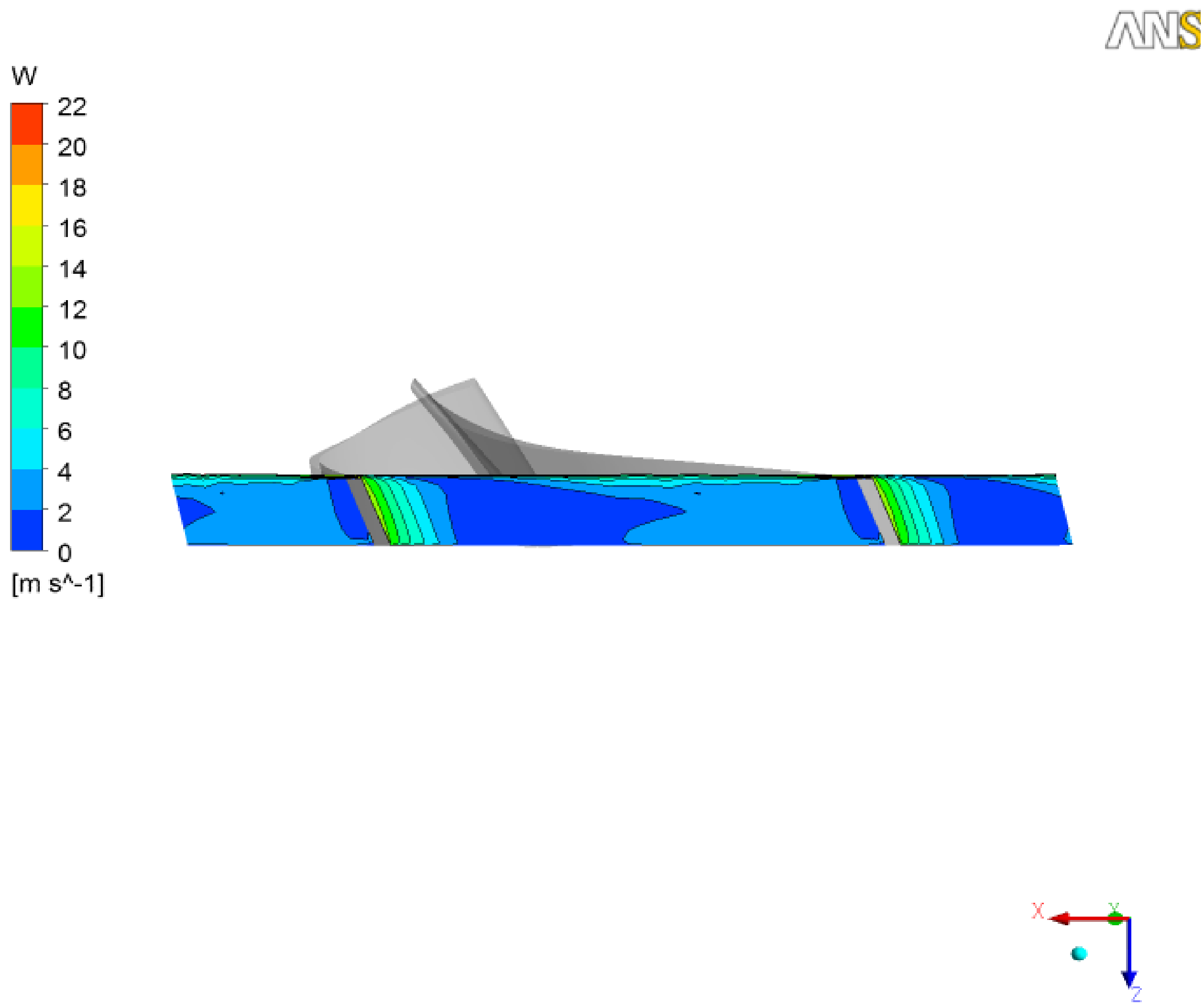


Figure 20. Contour of W at Blade TE



13. Streamline Plot

Figure 21. Velocity Streamlines at Blade TE