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Design of air pipelines

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ABSTRACT
The work presents the results of the analysis of possible air pipelines constructions, the conditions of designing airways and considers the basic physical and mechanical properties of various materials for the manufacture of branch pipes. This will enable the air flow system to be efficiently designed with minimum energy and resource costs, providing all the needs of the air distribution.
Keywords: pipeline, air distribution system, air distribution

INTRODUCTION

The object of the air distribution system is to transport compressed air from its point of production (compressors) to *its* points of *use* (applications) in sufficient quantity with minimal loss of pressure and change in air quality.

The design of the pipelines causes the friction of air masses and leaks, which lead to a drop in pressure from the compressor to the point of direct use. Therefore, the optimal calculation of the diameter of the pipe, the choice of the distribution circuit and the elements of the design of the main line play a very important role.

Consequently, the diameter of the air supply pipe is one of the main indicators in the design of the air pipelines system. In most cases it is believed that decreasing the diameter of the pipe reduces energy costs. However, with a decrease in the diameter of the pipe, the air resistance increases, which causes a significant drop in pressure in the air transport system and leads to increased energy consumption. This will negatively affect the compressor and branch pipes in the future. Therefore, the diameter of the pipe should be designed to maximize energy savings, maintaining the required pressure and taking into account the technical capabilities of the available air flow equipment [I].

PIPELINES DESIGN CONDITIONS

All compressed air pipelines must be designed in accordance with the following requirements:

- the selection of the diameter of the pipes should be aimed at minimizing the pressure drop and allow the expansion of the current system;
- fittings and valves should be selected according to the principle of creating the least resistance to air flow in the system.
- all pipes should have strong supports and securely affix to fittings to minimize displacement and overload.
- depending on the operational requirements for air lines, it is necessary to select the materials of the pipelines [II-III].

PIPELINE DESIGN SCHEMES

There are two main schemes of organization of compressed air distribution systems: single-line and ring-ducting supply systems.

The single-line scheme of the distribution of compressed air is considered more convenient for the middle class complexity of the installations, where places of the air consumption are located not far from each other and from the compressor.

For more sophisticated systems with many airborne points, preference is given to the ring-ducting system. As air distributes to any equipment in two directions, the feed speed is halved and the pressure drop decreases. Another advantage of the ring-ducting system is that you can shut down a part of the pipeline for maintenance without affecting other consumers. Such systems are considered more energy-efficient [II].

Then, we will consider the possible options for materials for pipelines and analyze their fundamental differences, depending on the operational requirements for air lines.

COMPARISON OF TUBE MATERIALS

The tube for air distribution can be made of different materials: polyester, nylon, polyamide, polyethylene. The hoses made from these materials acquire various physical and mechanical properties, depending on the needs and conditions of use of pipelines in general.

The polystyrene pipe is used in systems with low general pressure, where the pressure in the tube does not exceed 15 bar (working pressure), and its maximum possible - 44 bar (pressure on the gap). The operating temperature is from -20 ° to + 100 ° C. The roughness is 6 micrometers, and the working sequence is the purified air.

Nylon tubes are designed for general use in pneumatic systems of machines and piping systems for air distribution. The main technical characteristics include:

- working environment - water, compressed air;
- maximum working pressure - 15 bar (at 20 ° C);
- the operating temperature range of compressed air - -20 ° ... + 60 ° C for compressed air and + 5 ° ... + 40 ° C for water;

The dependence of the maximum pressure on the air temperature, made of nylon material is presented in Fig. 1. It also depends on the inner diameter of the test nozzle, with increasing diameter - the destructive pressure decreases.

The polyamide tube is used in pneumatic systems, when it is necessary to use them at high temperatures and a significant mechanical load. The ambient temperature can range from -30 ° ... + 80 ° C. The operating pressure varies from temperature and can reach values -0.95 ... + 19 bar (Figure 2).

When a high working pressure in the middle of the tube is required, the thickness of its walls is increased by several tens of millimeters (depending on the inner diameter of the tube), which enables to increase the maximum working pressure by almost 2 times. (Figure 3)

The polyethylene tube is highly resistant to chemicals and hydrolysis. The tube withstands washing with many regents and is resistant to lubricants. The ambient air temperature of the hose is -30 ° ... + 80 ° C. Working pressure -0.95 ... + 14 bar.

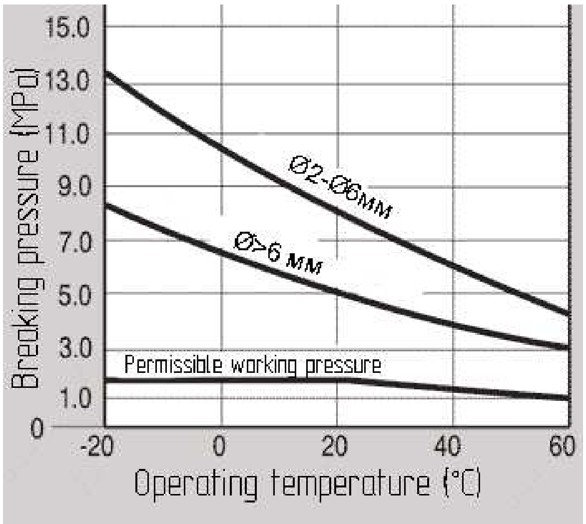

Fig. 1. Dependence of the maximum pressure on the air temperature for nylon tubes

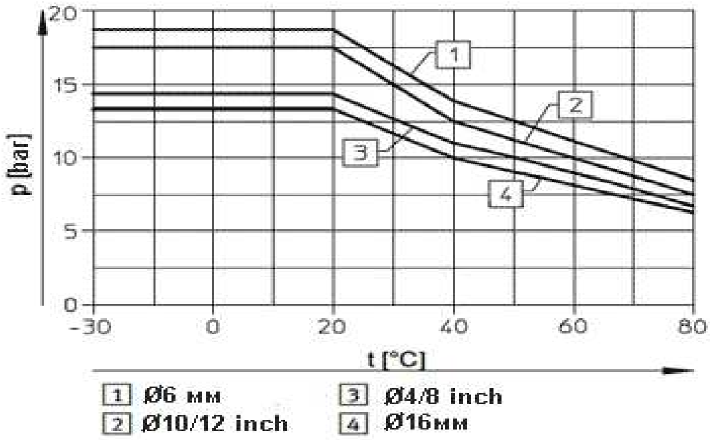

Fig. 2. Graph of pressure dependence on temperature for polyamide tube

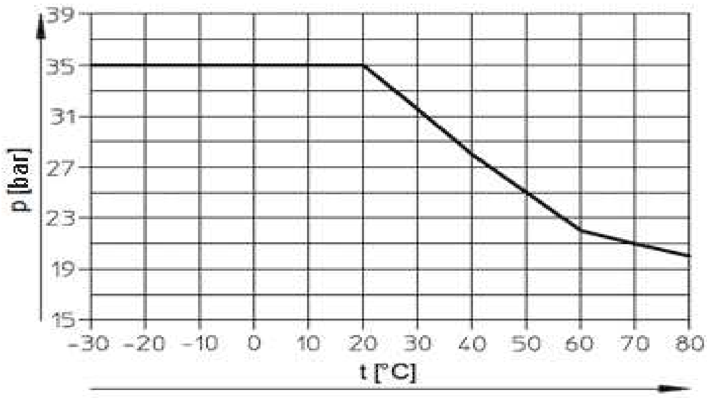

Fig. 3 Graph of pressure dependence on temperature at an increased thickness of tubes

CONCLUSION

In conclusion, the problem of designing air distribution pipelines resulted from minimization of the general drop in pressure in the system, reduction of energy consumption and further possibility of expansion of this pipeline. This problem is solved by analyzing all possible variants of the design of the pipeline and the subsequent calculation of the air distribution system. The material of the nozzles is selected according to the needs, analyzing all conditions of use and pressure in the middle system. Pipes made of polyurethane and nylon are selected for general use. At low total pressure, we can use a polystyrene pipe, and under special conditions (high temperature or load, resistance to chemical compounds and hydrolysis), use polyamide or polyethylene tubes.

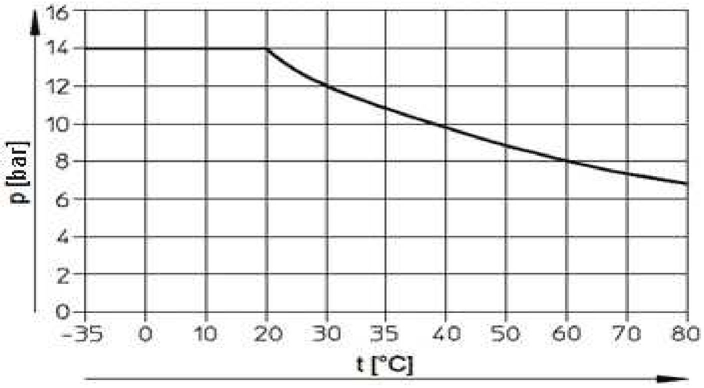

Fig. 4. Graph of pressure dependence on temperature for polyethylene tubes

Polyurethane tube is used for general use in pneumatic systems. Maximum operating pressure 8 bar (at 20 ° C). Operating temperature range -20 ... + 60 ° C.

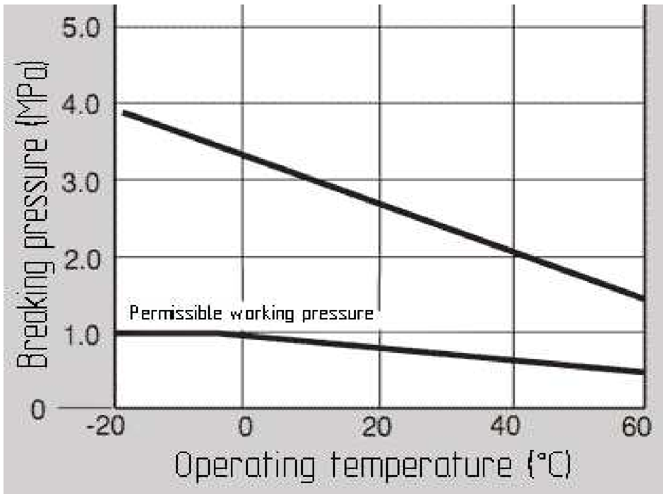

Figure 5. Graph of pressure dependence on temperature fracture for polyurethane pipes

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The rationality of plastic recycling

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ABSTRACT
In the article the basic directions of plastic utilization were considered, and the most rational one was chosen, namely, secondary processing. Proceeding from this, the technological process of plastic processing was presented, and the analysis of its stages. Identified its weakest link and suggested a solution to the problem.
Keywords: plastics, waste recycling, utilization

INTRODUCTION

Plastics - these are materials based on natural or synthetic polymers, which are capable of forming under the influence of heating and pressure in products of complex configuration and then to maintain the attached form. Depending on the technological process of the production of plastics, namely the type of filler and the binding component (resin) used, distinguish the composite, layered and cast plastics, and the nature of the resin used is thermosetting and thermoplastic. The latter is of great importance for the recycling of plastic waste.

METHODS

Identification of plastics is one of the most important problems arising in the recycling of plastics, the main thing - the definition of the nature of the material, that is, its identification. If there is no special equipment for conducting chemical, physic-chemical and other types of special analysis, then simple, but fairly accurate identification methods can be used, namely, the method of exclusion or comparison with precisely known samples or by analyzing information about the possibilities of using certain types of plastics for certain purposes.

It should be noted that today in the world insufficient attention is paid to the recycling of plastics and related products from it. This is explained, above all, by the variety of types of plastics and products manufactured from them, as well as the complexity of the physical and chemical structure, which complicates the sorting and processing of plastic waste, especially household. At the same time, there is a steady growth in the production of all kinds of plastics products. Plastics are primarily used in industry for the manufacture of various kinds of semi-finished products and products. Quite often they are replaced by expensive and heavier metals. Different film materials for packaging are made from plastics, as well as pallets, pipes, glue warehouses, etc. Plastic packaging causes significant environmental pollution, since it has a one-time and often short-lived use. It is also possible to distinguish wear-resistant multiple plastic products, the period of operation of which is much longer [VI].

Next, consider the main areas of disposal and disposal of plastic waste such as landfills and landfills; processing of plastic waste in industrial conditions; incineration of plastic waste without preliminary sorting together with municipal debris; pyrolysis and separate combustion in special furnaces; the use of waste plastics for use in other technological processes. The burial of plastic waste at landfills and landfills is one of the most dangerous and harmful methods of disposal, which should be considered only as a temporary measure, as the period of disintegration of plastics is extremely long [IV]. This eliminates the possibility of using valuable secondary raw materials for further processing or utilization. Processing of plastic waste in industrial conditions is the most optimal method of their use. Despite all the variety of methods for processing plastics, you can present the general scheme of the technological process in the following way: (fig. 1) [II].

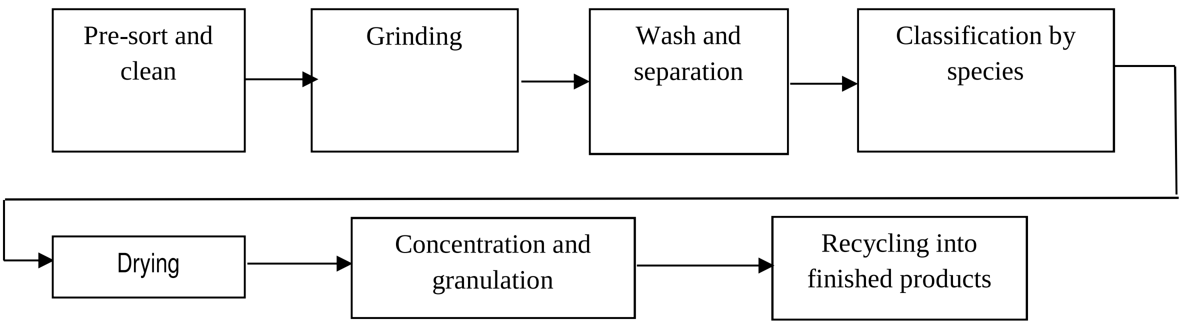

Fig. 1. The classic technological process of recycling of plastics waste

In the process of recycling plastics, it is necessary to control their physical and mechanical and rheological properties, due to aging caused by shear stress and heating - the thermomechanical effect that polymers undergo when melting and forming. For this purpose additional stabilizers [III] are introduced into the structure of plastics on the basis of secondary polymeric materials, which allow to maintain their performance characteristics without changing the technological properties of polymers. Appropriate stabilizing agents have been developed for different types of polymers.

RESULTS

The collection and sorting of plastic waste is the weakest link in the process of processing the processing of technological waste [5] and even more waste of consumption. The ideal sorting of waste should ensure separation of them not only by types, brands, colors, but also in form, degree of pollution, content of foreign materials, physical and mechanical properties, etc., which requires high costs and makes waste disposal inefficient. The easiest way is to sort it directly into the process of waste collection and at the workplace, that is, at the stage of their formation (the so-called home waste collection). Domestic processing of waste allows to add to the primary raw materials the most similar in structure secondary materials [I]. This reduces the possibility of their contamination, the need to sort them by color, the need for storage, checking the quality of secondary materials, drying them, etc., disappears. The most effective is the collection and sorting of industrial waste, which occurs when a completely closed cycle of plastic processing. The constructive organization of such schemes for the processing of plastics involves the automatic collection of waste, their shredding addition in a certain proportion to the raw material. If an enterprise does not process waste, but only deals with its collection, then it would be advisable to sort it directly at the collection sites, as this would significantly reduce the costs of the processor to sort. Consequently, the process of utilization of plastics is very costly, especially at the waste disposal stage due to the high complexity and a large number of operations, which includes the technological process of cleaning [I, III]. Consider an example of cleaning thin-film polymers. This category of waste includes a variety of plastic bags, packaging and packaging, which are full of landfills in all cities. To wash them away from dirt is easier than PET bottles, because the waste contains very little glue and have a milder structure. Accordingly, the technology of the sink includes fewer operations:

- sorting;
- preparation with preliminary washing;
- washing in a flotation bath;
- a dryer in a centrifuge;
- collection in a hopper - a drive and a filling of running races.

To arrange a complete cycle of processing, at the end of the washing line, an agglomerate is often installed, producing ready-made raw material for granulation and casting of products in thermoplastic automata. In order to make the plastic cleaning process cheaper, the best options at the moment are the installation of advanced equipment, which provides several operations of the process of cleaning, and also such equipment will improve productivity and reduce the number of employees involved.

CONCLUSION

Waste management in Ukraine and around the world is a pressing issue of environmental pollution, which everyone has touched today. Plastic wastes occupy about 10-15% of the volume of household rubbish. Since the term of their decomposition is very long (about 200-300 years) [IV, VII] and at the same time detrimental to the environment, the environmental responsibility of ordinary people is not enough. To cope with this problem, local authorities are in need of assistance, which could help by setting up separate garbage cans in cities and assisting plastic recycling companies by investing them, or by promoting their work in another way. At the same time, plastic-processing enterprises could cooperate with each other and create concerns for increasing productivity and distributing the burden on enterprises.

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Symulowanie wtrysku poliamidu 66 z zastosowaniem programów CAD/CAE

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STRESZCZENIE
Niniejszy artykuł przedstawia symulowanie procesu formowania wtryskowego koła zębatego z tworzywa termoplastycznego. Aby tego dokonać zastosowano program SOLIDWORKS do utworzenia modelu CAD wypraski oraz programu AUTODESK MOLDFLOW do przeprowadzenia symulacji komputerowych procesu wtryskiwania wypraski oraz analiz przebiegu procesu i jego rezultatów. W programie Campus dokonano wyboru materiału do badań. Przeprowadzono symulację wtrysku uwzględniając położenie miejsca wtrysku oraz różne parametry procesu. Wyniki analiz numerycznych procesu wytwarzania koła zębatego umożliwiły uzyskanie odpowiedniej jakości wypraski oraz zoptymalizowane parametry przetwórstwa.
Słowa kluczowe: formowanie wtryskowe, Moldflow, symulacje komputerowe, koło zębate

WSTĘP

Przetwórstwo tworzyw sztucznych jest jedną z najpopularniejszych i najważniejszych technologii wytwarzania wyrobów użytkowych czy konstrukcyjnych. Pomimo powszechnej opinii łatwego przetwórstwa, tworzywa sztuczne przysparzają wiele problemów technicznych konstruktorom, czy technologom, niejednokrotnie większy niż tworzywa metaliczne czy ceramiczne. Z tego powodu przedsiębiorstwa wykorzystują zarówno zasoby literatury jak i komputerowe wspomaganie procesów technologicznych z szczególnym uwzględnieniem technik CAD, CAM, CAE. Pod tym względem umiejętność odpowiedniego przeprowadzenia symulacji komputerowej pozwala na minimalizację wystąpienia problemów technologicznych, a co za tym idzie na uniknięcie znacznych kosztów w przypadku uruchomienia wadliwej produkcji. Znajomość odpowiednich parametrów przetwórstwa wtryskowego takich jak temperatura, ciśnienie czy czas wtrysku skutkuje lepszą kontrolą nad procesem wtrysku, co przekłada się bezpośrednio na jakość i przebieg procesu. Znalezienie odpowiedniego modelu układu wlewowego jest kluczowe w korzystnym zaprojektowaniu przepływu stopionego polimeru [I-III].

W poniższym artykule przeprowadzono proces planowania produkcji koła zębatego z tworzywa sztucznego metodą wtrysku. W początkowej optymalizacji wybrano materiał oraz ustalono optymalne warunki procesu (umieszczenie otworów, rozmieszczenie gniazd formy). Następnie przeprowadzono analizę wpływu temperatury stopionego polimeru na przebieg i efekty procesu takie jak np.: ciśnienie czy jakość wyrobu, co było głównym celem technicznym pracy.

METODYKA I REALIZACJA BADAŃ SYMULACYJNYCH

CHARAKTERYSTYKA MATERIAŁU UŻYTEGO DO BADAŃ

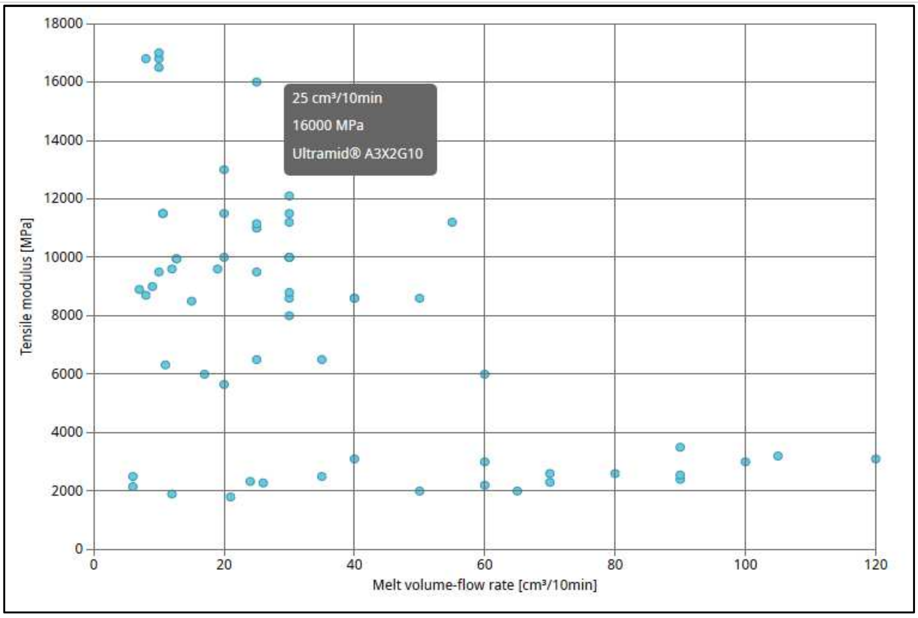
Wysokiej jakości koła zębate muszą w wysokim stopniu spełniać szereg wymagań. Najważniejsze z nich to: wytrzymałość mechaniczna, odporność na ścieranie, niski współczynnik tarcia oraz wysoki objętościowy wskaźnik szybkości płynięcia tworzywa. Do wyboru odpowiedniego gatunku tworzywa zdecydowano się użyć programu CAMPUS . Jako warunki ograniczające wybrano do wykresu punktowego moduł sprężystości z minimalną wartością 10000 MPa i objętościowy wskaźnik płynięcia (MVR) z minimalną wartością 20. Otrzymany wykres punktowy zaprezentowano na rysunku 1.

W związku z tym wybrano materiał o nazwie handlowej Ultramid A3X2G10 od producenta BASF. Jest to poliamid PA66 wzmocniony 50% włóknem szklanym. Charakteryzuje się dobrymi właściwościami sprężystymi, wysoką stabilność wymiarową oraz doskonałymi właściwościami tarcia ślizgowego. Posiada także dużą twardość, sztywność, stabilność termiczną i dobrą przetwarzalność oraz jest odporny na działanie środków chemicznych [IV].

METODYKA BADAŃ

Celem badań komputerowych było przeprowadzenie procesu formowania wtryskowego dla koła zębatego z uwzględnieniem trzech różnych miejsc wtrysku oraz w trzech różnych temperaturach wtrysku. Różne lokalizacje miejsca wtrysku zostały wybrane jako najbardziej charakterystyczne, znajdujące się w trzech najbardziej specyficznych obszarach wypraski. Różne temperatury wtryskiwanego stopu tworzywa zostały wybrane w ramach dostępnego w używanym programie zakresu temperatur, który wynosił od 290º C do 300º C.

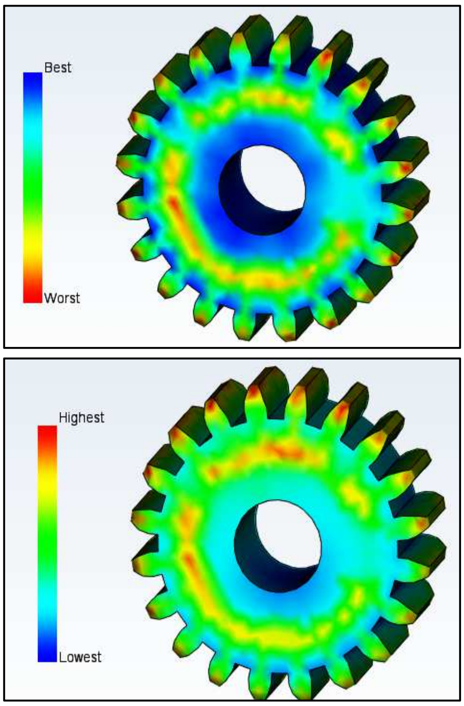
Badania symulacyjne zostały zrobione w programach Solidworks oraz Autodesk Moldflow Adviser. Zawierały następujące czynności:
- zrobienie modelu CAD wypraski,
- import modelu do programu Autodesk Moldflow Adviser,
- nałożenie siatki elementów skończonych MES,
- przeprowadzenie analizy oporu płynięcia,
- ustalenie lokalizacji punktów wtrysku i przeprowadzenie symulacji wypełnienia,
- projekt układu wlewowego i przeprowadzenie symulacji wypełnienia i docisku dla trzech różnych temperatur wtrysku,
- analiza wyników symulacji i wybór rozwiązania optymalnego.



Rys. 1. Mapa doboru materiału w programie Campus w układzie moduł sprężystości- objętościowy wskaźnik płynięcia

ANALIZA WYNIKÓW

Wybór punktu wtrysku tworzywa został dokonany za pomocą jednego z modułów programu Moldflow Adviser o nazwie „Gate location", gdzie na podstawie zaimplementowanych w programie modeli zjawisk reologicznych przeprowadzona została analiza oporów płynięcia oraz w konsekwencji został wyznaczony zakres optymalnego umiejscowienia przewężki łączącej kanał doprowadzający roztopione tworzywo z gniazdem formy. Wyniki tych analiz pokazano na rysunku 2.



Rys. 2. Wyniki obliczeń symulacyjnych: a) analiza wskaźnika oporów płynięcia (flow resistance indicator), b) zakres optymalnego umiejscowienia przewężki (gating suitability) – im wyższa wartość tym lepsze miejsce na umieszczenie otworu wejściowego

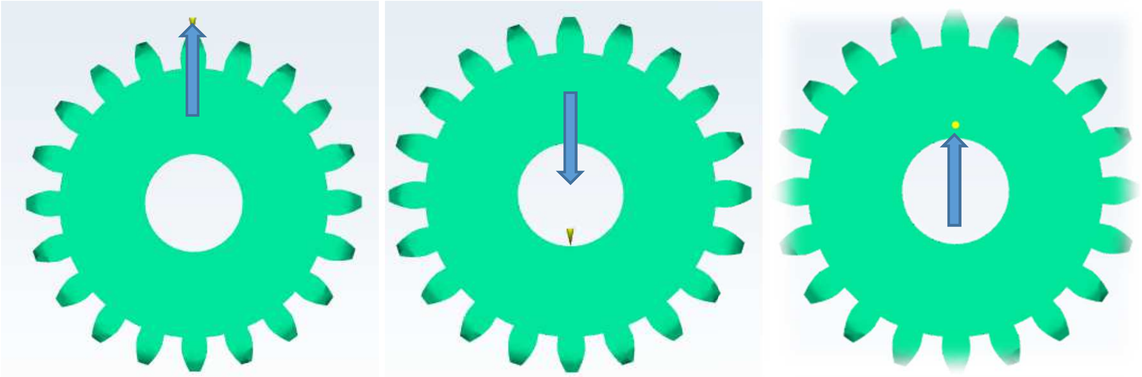
W oparciu o przeprowadzone analizy dokonano wyboru trzech różnych punktów wtrysku (rys. 3) i przeprowadzenia symulacji wypełnienia, w celu dokładniejszej optymalizacji.

Dzięki zastosowanym symulacjom, jesteśmy w stanie przewidzieć, w jakim czasie gniazdo formy wtryskowej zostanie w całości wypełnione tworzywem i czy istnieje możliwość wystąpienia niedolewów. Na rysunku 4 zaprezentowano czas rozpływu tworzywa w formie. We wszystkich trzech przypadkach lokalizacji punktów wlotu miał on praktycznie tą samą wartość, natomiast ukierunkowanie przepływu tworzywa jest w poszczególnych przypadkach zróżnicowane.

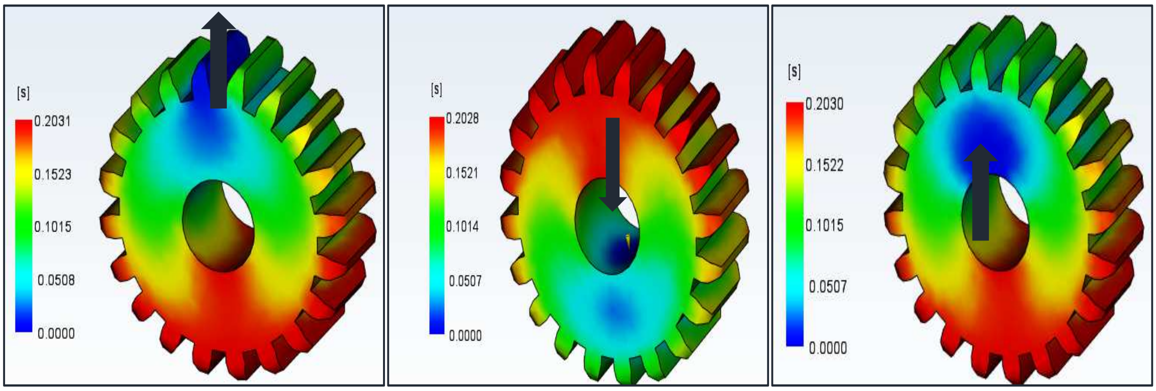
Wyniki analiz przewidywanej jakości powierzchni modelu (pokazane na rysunku 5) ukazały, że są potencjalne obszary, jakie program zakwalifikował jako „średnie". Stwierdzono, że występują one głównie w centralnej części koła zębatego, natomiast nie występują na zębach, które są kluczowym elementem koła.

Możliwe błędy jakościowe takie, jak np.: lokalne zapadnięcie się tworzywa spowodowane skurczem, wynikają najpewniej ze zróżnicowania warunków chłodzenia wypraski. Analizując średnią temperaturę w różnych obszarach wypraski, co pokazano na rysunku 6 stwierdzono, że żaden wariant umieszczenia otworów wlotowych nie gwarantuje równomiernego jej rozkładu. Jednakże, wystarczająco wysoka temperatura w całej objętości wypraski gwarantuje lepkość na poziomie odpowiednio niskim, pozwalającym wypełnić całe gniazdo formy.

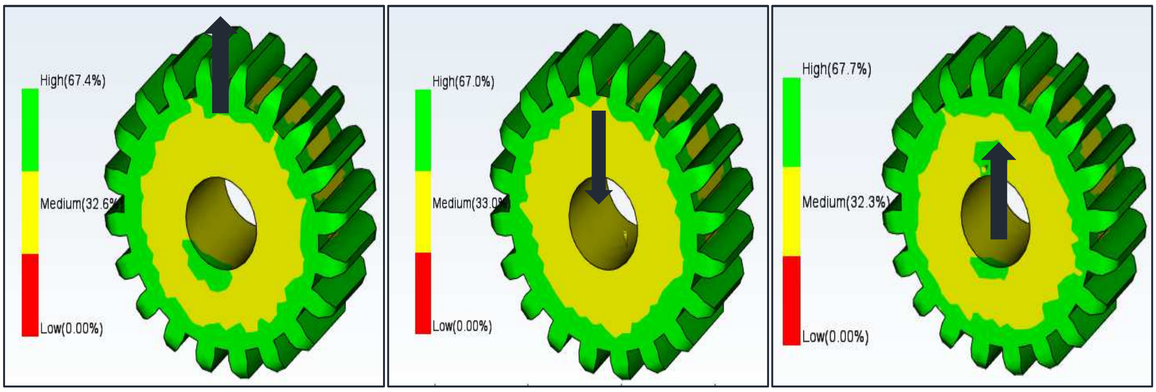
Na podstawie przeglądu literatury dokonano wyboru koncepcji rozkładu kanałów szeregowy [5]. Zdecydowano się wybrać model równoległy, który charakteryzuje się dosyć skomplikowaną geometrią, ale w rekompensacie równoczesnym wypełnieniem gniazd formy [VI]. Następnie przeprowadzono symulację wypełnienia i docisku, w następujących warunkach: temperatura formy: 80º C, maksymalne ciśnienie wtrysku maszyny: 180 MPa oraz czas potrzebny na otwarcie formy, wyrzucenie wyprasek i zamknięcie formy: 5 sekund. Wyniki z symulacji zaprezentowano w tabeli 1.



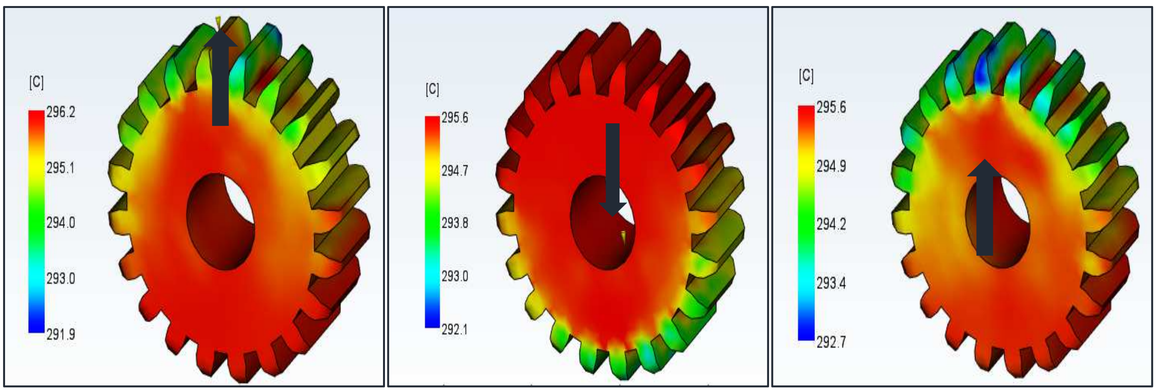
Rys. 3. Różne lokalizacje punktu wtrysku wybrane na podstawie przeprowadzonych analiz numerycznych oraz przy uwzględnieniu stopnia skomplikowania formy



Rys. 4. Czas wypełnienia gniazda formy dla różnych punktów wtrysku



Rys. 5. Przewidywana jakość powierzchni wyprasek dla różnych punktów wtrysku



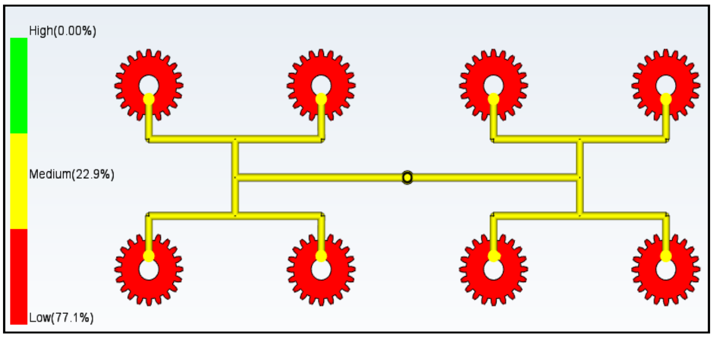
Rys. 6. Rozkład temperatur dla różnych punktów wtrysku

Tabela 1. Zestawienie wyników symulacji wypełnienia formy i docisku przy trzech różnych temperaturach stopionego tworzywa

Parametr:	Temperatura wtrysku 290° C	Temperatura wtrysku 295° C	Temperatura wtrysku 300° C
Skurcz objętościowy [%]	10,18	10,33	10,48
Maksymalna temperatura wypraski [°C]	304,4	309,1	313,2
Maksymalne ciśnienie wtrysku [MPa]	74,89	72,81	69,51
Czas wypełnienia [s]	0,6993	0,5824	0,5815

Analizując wyniki obliczeń można stwierdzić, że skurcz objętościowy rośnie wraz ze wzrostem temperatury stopu, co może doprowadzić do zmiany wymiarów wypraski względem kształtu zaprojektowanego w formie. Jest to rezultatem tego, że bardziej rozgrzane tworzywo zajmuje większą objętość, więc podczas chłodzenia bardziej się kurczy. Może wpłynąć to na powstawanie zapadnięć i wewnętrznych pęknięć w zakrzepłym materiale. Czas wypełnienia formy jest najniższy, gdy temperatura wtrysku jest największa. Decyduje o tym lepkość ciekłego tworzywa, która jest wtedy najmniejsza i w znacznym stopniu ułatwia wypełnianie gniazda formy wtryskowej.

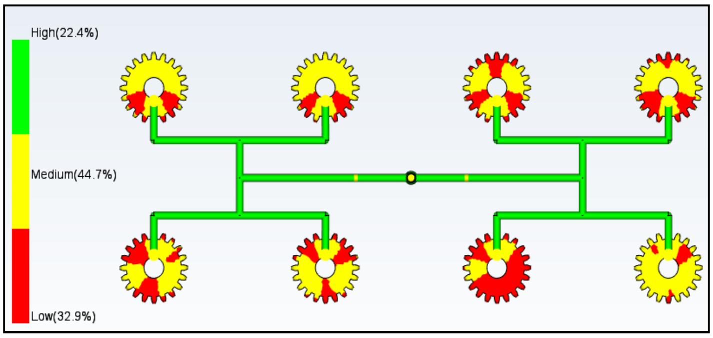
Mając na względzie przewidywaną jakość powierzchni (zaprezentowaną na rysunku 7) podczas gdy temperatura wtrysku wynosi maksymalne 300º C program zakwalifikował ją w zdecydowanej większości, jako „niską" i „średnią". Oznacza to, że nie można uznać jakości wypraski, jako wystarczającą, ponieważ temperatura na froncie przepływu tworzywa jest zbyt wysoka co może doprowadzić do defektów powierzchni i degradacji materiału.



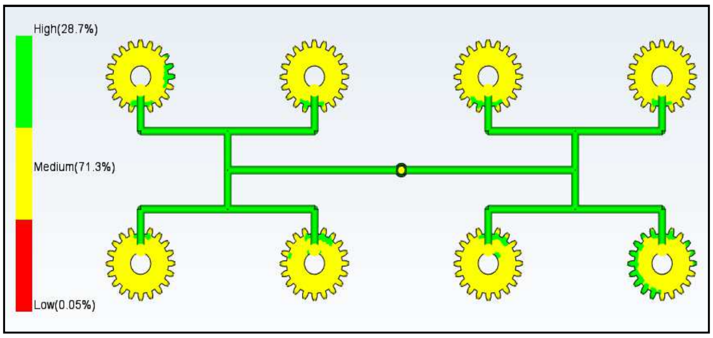
Rys. 7. Przewidywana jakość powierzchni wypraski – temperatura wtrysku 300º C

Wówczas rekomendowane jest zmniejszenie temperatury lub zwiększenie czasu wtrysku, aby spowolnić przepływ tworzywa, co spowoduje zmniejszenie naprężeń ścinających. Z ekonomicznego punktu widzenia bardziej sensownym rozwiązaniem jest obniżenie temperatury. Podczas zmniejszenia temperatury do 295º C przewidywana jakość w znacznym stopniu uległa poprawieniu (rysunek 8).

Po zmniejszeniu temperatury do 295º C przewidywana jakość wyprasek uległa poprawieniu. W tym wariancie około 22% powierzchni jest z jakością wysoką, około 45% ze średnią oraz 33% z niską. Nie występuje tutaj zjawisko dużych różnic jakości poszczególnych wyprasek. Program ponownie sygnalizuję, że temperatura na froncie przepływu może być zbyt wysoka, co może doprowadzić do produkcji wadliwych elementów. Jako działanie prewencyjne zalecane jest obniżenie temperatury wtrysku lub formy wtryskowej.



Rys. 8. Przewidywana jakość powierzchni wypraski – temperatura wtrysku 295º C



Rys. 9. Przewidywana jakość powierzchni wypraski – temperatura polimeru 290º C

Podczas analizy wariantu, gdy temperatura wtrysku wynosi 290ºC stwierdzono, że następuje nieznaczny wzrost jakości wysokiej (z 22,4% na 27,7%), natomiast zdecydowana poprawa jakości zakwalifikowanej jako średnia i brak występowania jakości niskiej. W tym przypadku czynnikiem zakłócającym pomyślny przebieg całego procesu może być zbyt długi czas potrzebny na chłodzenie wyprasek. Aby to zredukować należałoby ponownie zmniejszyć temperaturę wtrysku lub zmienić geometrię elementu - zaprojektować cieńsze przekroje.

PODSUMOWANIE

Użycie programu Autodesk Moldflow Adviser umożliwiło uzyskanie rezultatów dotyczących: długości czasu wtrysku, rozkładu temperatur, rozkładu ciśnień oraz przewidywanej jakości powierzchni produktu wtryskiwanego. Ponadto pozwoliło na optymalne określenie położenia miejsca wtrysku oraz poznanie rekomendowanych parametrów przetwórstwa. Rezultaty przeprowadzonych symulacji umożliwiają sformułowanie tezy, że miejsce punktu wtrysku na wyprasce w analizowanych przypadkach nie wpływa znacząco na czas wtrysku i jakość powierzchni. Widoczne różnice były minimalne, w małym stopniu wpływały na całość cyklu. Wybór miejsca wtrysku użytego w dalszej części badań był determinowany zmniejszeniem stopnia skomplikowania układu kanałów wlewowych oraz nie umieszczania go na pracującej części wtryskiwanego elementu. Stwierdzono, że najwyższa przyjęta temperatura stopu podczas wtrysku przyczynia się do przyspieszenia procesu wypełniania formy poprzez zmniejszenie lepkości polimeru. Jednocześnie jednak powoduje wydłużenie czasu potrzebnego na chłodzenie wypraski, co prowadzi do powstawania wyrobów o niedostatecznej jakości. Stosowanie temperatury najniższej z dostępnego zakresu doprowadza do wzrostu koniecznego ciśnienia, w związku z oporami związanymi z dużą lepkością tworzywa, lecz rekompensuje to poprzez zmniejszenie skurczu objętościowego i gwarantuje wyrób o zadowalającej jakości.

Uzyskane wyniki symulacji uwzględnione przy modelowaniu procesu formowania wtryskowego koła zębatego mogą być cenną wskazówką dla konstruktorów i technologów podczas projektowania procesu. Powinny także umożliwić dobranie optymalnych parametrów procesu, uzyskać wymaganą jakość detalu oraz pozwolić na zmniejszenie ilości wykonywanych prób testowych lub całkowite ich wyeliminowanie.

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Using 3D printing for getting composite prototypes

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ABSTRACT
The main types of prototyping are considered in this article, the advantages of using 3D printing are presented at the stage of technological preparation of production. The main modern materials which are used at 3D print are considered. The differences between ABS plastics, which are used for 3D printing and injection molding, are analyzed. Methods of obtaining prototypes of composite materials are described. The defects of 3D printing were found during prototype production.
Keywords: prototyping, 3D printing, properties, include milling

INTRODUCTION

Prototyping or developing samples of new products, is one of the five main stages of technological preparation for the production of plastic products. At this stage, the simplest system is created, a prototype of a technical device, mechanism or machine. Prototyping is used for ergonomic evaluation, visualization of appearance, product design, work checking, concept, functional assessment, namely: checking assembly, checking of individual functional parts, aerodynamic characteristics, etc. The advantages of prototyping include: reducing the time of technical preparation of production; reducing the cost of production, especially in small and single production; increasing the flexibility of production; use of computer technologies, integration of production with CAD systems [I].

METHODS

For making prototypes uses different methods, which include milling on CNC machines, molding on master-models, modelling, 3D printing. Recently, for prototyping plastic products gaining popularity of 3D printing. This promising method of prototyping makes it possible to quickly and cheaply make a sample of parts or machinery. Prototypes produced by 3D printing may have geometric forms of varying complexity and are limited only by the overall dimensions of the 3D printer's working field [II].

In spite of all of the advantages listed above, the prototype manufactured with 3D printing has many drawbacks. It should be noted that the 3D printing process does not always provide the parametric accuracy of the prototype, which transmits the identity of the geometric forms of the finished product, but does not transmit physical and chemical properties. Because of the difference in the chemical and physical properties of materials, in the process of manufacturing a prototype, the properties of the latter can differ radically [III].

Consider for example mechatronic plastic parts located in the car interior. The main materials used to fabricate them using injection molding technology are Acrylonitrile butadiene styrene (ABS), Polyethylene terephthalate (PET), Polyamide (PA) [IV]. At 3D print used mainly ABS, PET [5]. It should be noted that the mechanical properties of ABS used for injection molding and ABS for printing 3D differ, as shown in Table 1 [VI-VII].

Modern technology allows you to create prototypes of composite materials. At the moment, known printers that can print plastic is further reinforced with carbon fiber. Another interesting solution is the creation of materials simulating metal, stone or wooden surfaces. They represent a PLA plastic filament containing impurities, which gives the printed objects similar properties and structure.

The spectrum of known material delivery solutions through an extruder was analyzed, among which were: «Diamond Hotend» (Fig. 1) and «MH3000 R2» (Fig. 2). The first solution allows to melt several materials in the inner chamber, depending on the amount of material supplied, we can have a proportional amount of the fused substance at the outlet. The second solution allows you to print with successive engagement of several extruders, which are placed on the same level.

Table 1 - Technical characteristics of ABS plastic for injection molding and ABS for 3D printing.

Properties	ABS – 3D printing	ABS – injection molding
Bonding temperature, ℃	105	105
Bending strength, MPA	41	74
Boundary of tensile strength, MPA	22	46
Relative elongation, %	6	
Shrinkage when cooled, %	0,8	0,5-0,7
Density, g/cm³	1,05	1,06

The disadvantages of the first one is that for plastic melting, only one heater is used, and one nozzle that does not allow simultaneous printing of materials with different melting temperatures.

As a basis, we selected the multi-extruder technology, in which the remote location of several heating chambers is provided, the nozzles of which are on the same level [IV]. Each of the heating chambers is calibrated to melt its type of monofilament. Simultaneous use of materials with different properties makes it possible to print 3D objects that have characteristics of objects made of composite materials.

So, let's summarize that for the 3D print it is virtually impossible to obtain the repetition of the details, and accordingly, the accuracy, due to the influence of external factors on the printing process, such as ambient temperature, air flow and so on [VI].

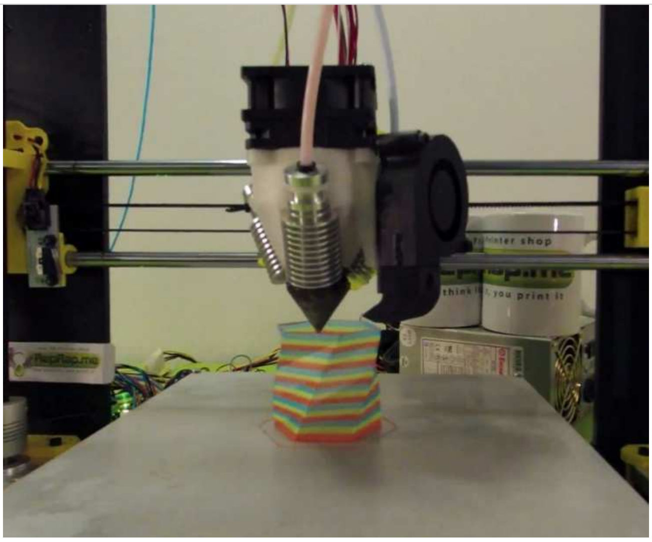

Fig. 1. Diamond Hotend technology.

It should be noted that because of the restrictions on the size of the 3d printer's working field, prototypes often are made of several parts, which are then glued together, while not only the strength of the prototype, but also the geometric shape deteriorates, since it is very difficult to precisely glue details of a complex form [VII].

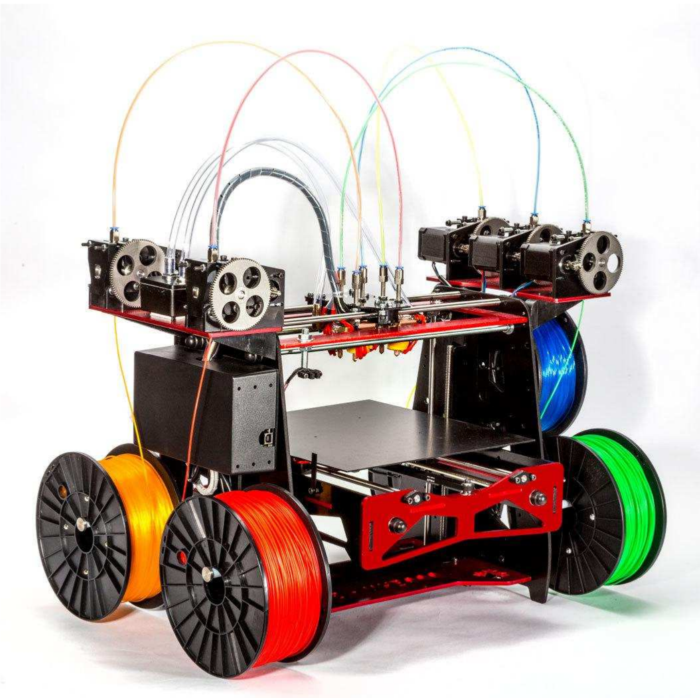

Fig. 2. Technology MH3000 R2

The prototype obtained from one part, using 3D printing, also differ in its properties from the final product and cannot be used to evaluate such parameters as: element illumination; sound quality when pushing the buttons, which depends on the interaction of the two materials among themselves; clamping of elements and other tests of quality control [VII].

Due to insufficient accuracy of 3D printing, a number of quality control tests cannot be conducted for the prototype to verify that the drawings or technical specifications are very relevant to the products used in automobiles, since they require high reliability. These tests may include individual controls, statistical sampling methods, and other methods suitable for the continuous production of a large number of final products. Prototypes are usually made with much tighter individual inspections and the assumption that some adjustment or recycling will be part of the manufacturing process. The parameter of roughness of the surface of the prototype does not always meet the requirements of the final product and the application of the coating in the form of paint or varnish does not always improve the surface condition [VI].

CONCLUSION

Engineers and prototype specialists are constantly striving to improve the technology of 3D printing, which will not yield to their qualitative characteristics with classical methods for obtaining details such as: injection molding, hot stamping, etc. In the future further research on this topic will consider the possibility of applying new methods 3D printing, which will allow to obtain prototypes with properties, which as closely as possible imitate the final product.

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Reduce vehicle weight by using composite components

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ABSTRACT
In this article we discuss the problems of the mass of cars. Analyzed the uses of plastic as substitute of metal components. The ways of facilitating plastic components by changing the methods of their production are considered. The advantages of innovative technologies in the production of new composite materials are illustrated. It is shown how the development of design affects the mass of components.
Keywords: vehicle, plastic, composite, reinforced plastic, foamed plastic, simulation-driven design

INTRODUCTION

The automotive industry has undergone major changes in recent years. First of all, it concerns electrified vehicles, which become viable and competitive. This is facilitated by more stringent emission standards, the cost of batteries, the development of infrastructure charging stations, restrictions on entry into settlements for cars with internal combustion engines and others. A significant obstacle to the propagation of electric vehicles is running stock which is 400-500 km in Tesla Model S, 300-400 in Chevrolet Bolt EV, but on average it does not exceed 200 km, which significantly limits the use of electric cars [I].

The distance that the car rides in is proportional to its mass, so you need to create lighter vehicles to increase your is running stock to achieve this, you need to reduce the weight of components, of which the car is composed. In an electric vehicle it is: power units, chassis, body, interior and other details, as well as durability, corrosion resistance, flexibility and high performance at low cost. In the early stages of automotive plastics were used as decorative elements, because they offered good mechanical properties in combination with a great look, however, their constant development has considerably increased the field of using, they are now present in virtually all nodes and aggregates. In one car, more than 10 plastic stamps can be used, among which the most common ones are polypropylene, polyurethane and polyvinyl chloride. t is estimated that the weight reduction of the car by 10% leads to a saving of 7% of energy consumption on its movement, so the use of light materials is a necessity in electric transport.

METHODS

Traditional approaches are used to reduce weight, while steel or aluminum parts are replaced by plastic, it's a bumper, body parts or interior. The freedom to create shapes offered by plastic parts is also key to their wider use, plastic allows you to combine several parts into one, saving the mass and cost, figure 1 [III].

Elements of the body parts of the car can use plastic materials to save mass, such material is polymer composites reinforced with carbon fiber, body panels of this material are lighter than 30% aluminum and 50% of steel counterparts, figure 2 [IV].

Elements which are made of composites are not only lighter than metal, but also show better results in crash tests, since the energy that destroys the panel is also wiped off on the layering of the composite fibers. It should be noted that developers claim to be able to create car body components. Similar technologies have been used in Formula 1 for many years, but the production of one component takes up to two months, which is not suitable for mass applications. To solve this problem a process (T-RTM Thermoplastic Resin Transfer Molding) was created, which allows to shorten the process to 5 minutes and carry out the operation in one step. The essence of technology lies in the establishment of a textile base in the form, where it is poured into a resin. According to this principle, a trunk lid for Porsche Carrera 4 [V] is manufactured.

The problem of facilitating plastic parts requires a revision of their production technology. Similar elements are modified by reinforcing fibers from glass, carbon, polyamide or organic, using selective amplification of high load zones or the entire component, which leads to a decrease in its mass with constant strength characteristics. In the production of such parts, reinforcing fibers are used as inserts for injection molding, figure 3 [VI].

Figure 1. Replacement of several metal parts by one plastic.

Figure 2. The car's wing which is made of polymeric composite (CFPP Carbon Fibre Polipropylene).

Figure 3. The parts are made using technology of injection molding with inserts of reinforcing fiber.

A promising way of facilitating the already existing plastic parts using plastic with pores, similar to porous chocolate. At the same time, pores can be formed by adding gas during the MuCell Molding process and by adding impurities to the molten plastic, which, in the process of its hardening, will form pores. Technology allows you to reduce the weight of parts by more than 20%, figure 4 [VI].

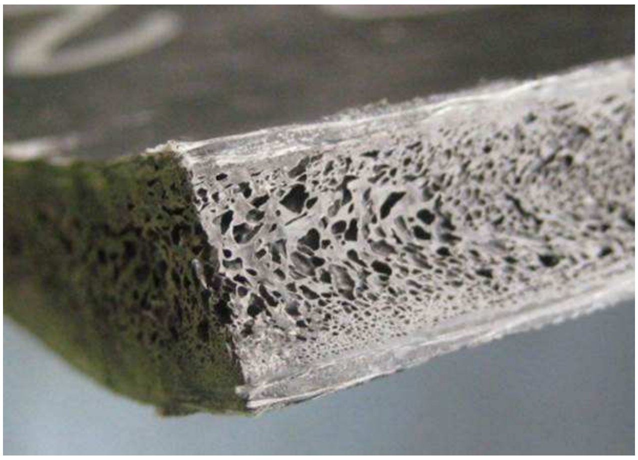
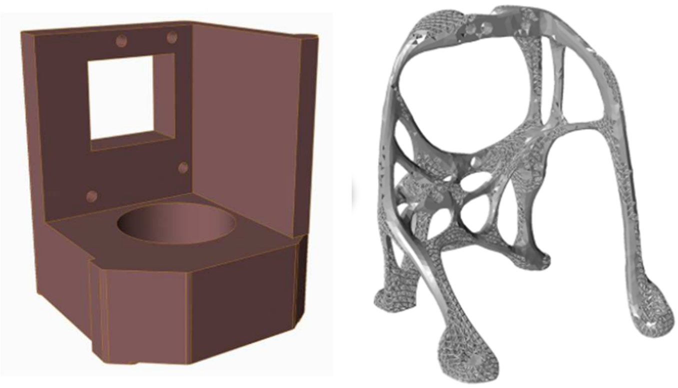


Figure 4. The detail is made using technology MuCell Molding.

The components manufactured in this way have high mechanical properties and a qualitative surface, which is achieved by the correct cooling of the mold. The size of the pore varies from 5 to 50 μm and reaches a density of 100 pores per cm^3. As gas, nitrogen or carbon dioxide is used, which is injected directly into a plastic melt. It should be noted that the cycle time of manufacturing such parts is reduced by 15-35% compared to the casting under pressure, and, due to lower tension in the material, the accuracy of the obtained sizes increases [VII]. Modern technologies allow to make wheel disks made of plastic, using injection molding technology, figure 5 [VIII].

The chemical giant BASF has developed a type of polyamide containing long glass fibers, with the resulting products 30% lighter than their metal counterparts [VIII]. Even more mass reduction can be achieved by making wheel discs made of carbon fiber. Reducing the mass of the wheels directly affects handling, acceleration and significantly increases the energy efficiency of the vehicle [IX]. Reducing the mass of plastic parts is possible even at the stage of their development by optimizing the geometric shape, which allows you to get maximum functionality with a minimum component mass. In order to implement this approach, it is necessary that the process of design and simulation of components be carried out as parallel as possible, and the CAD system helped the designer to use optimal solutions in terms of functionality and mass, figure 6 [X]. The elements shown in Figure 6 have the same functional, but the difference in mass is different in times.

Figure 5. Plastic wheel disks.



Before After

Figure 6. Effective component design.

Conclusion

There are many technologies that allow you to reduce the weight of a car by using plastic materials but introducing them into mass production requires significant investment and time. In spite of this, the future of automotive industry is precisely for the plastic components that replace the metal by themselves. Effective component development is a very innovative direction, which will not only reduce the weight of the component, but also accelerate its development. Getting the lighter body of electric vehicles, using new materials and approaches to their production and development, allows you to use a smaller amount of batteries, smaller brakes, a smaller engine, which leads to an additional reduction of mass, which will significantly increase the range.

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Membranes and membrane technologies used in environmental protection

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ABSTRACT

According to the World Health Organisation about 4,4 billion people do not have access to basic sanitation facilities. More than two billion people do not have access to safe drinking water [I]. The progressive pollution of waters and the environment motivate scientists and engineers to search the solutions, which are both economically and ecologically the best. They determine to promote improvement while supporting sustainable industrial development. Membrane processes are able to solve many environmental problems, including these related to nuclear technology. First of all, they are considered as potential methods useful for clean technologies that minimize the use of raw materials, rationalize energy consumption, and also reduce waste production. An example of such a process is membrane distillation (MD), which can be used for desalination of water or demineralised water production. MD is a process with much lower requirements for pre-treatment of feed water than other membrane techniques.

In this work presents the characteristics of membranes, membrane processes and the results of research on desalination of concentrated salt solutions of membrane distillation combined with crystallization. The process was carried out using capillary membranes made of polypropylene. Regardless of the type of the concentrated solution, the process obtained a salt concentrate and clean water. The results of the experiment confirmed that the supply temperature has a significant effect on the level of the permeate flux in the membrane distillation process. In addition, the study confirmed that as the concentration of salt in the feed water increased, the resulting permeate stream was reduced.

Keywords: clean technologies, membrane process, desalination

MEMBRANES – HISTORY, STRUCTURE AND MATERIAL

Two hundred seventy years have passed since the osmotic phenomenon was first observed by the French Cleric, A. Nollet in 1748. During the following century, osmosis was of especial interest to practitioners in the biological and medical sciences. Experimental work was conducted primarily with membranes of animal and plant origin. It was until 1867 that the first inorganic semi-permeable membrane was prepared by Traube. The nature of the phenomenon of osmosis has aroused interest among scientists. Currently, membrane techniques are increasingly replacing traditional methods for the separation of mixtures for example filtration, extraction. Membranes used in membrane techniques may be in liquid, solid or gaseous state. The variety of forms and methods of operation makes it difficult to give a strict definition of the membrane, however in 1984 on the initiative of the European Membrane Society, the term membrane was defined as the phase separating two other phases and acting as a passive barrier or active in the transport of matter between these phases.

Membranes can be made from organic or inorganic, synthetic or natural materials. These include: cellulose triacetate, polyamides, polysulphones, polyvinyl chloride, polyvinyl chloride, etc. The choice of material and the way the membrane is made depends on its intended use, as well as on the conditions in which the membrane is to operate (mainly pH, temperature, presence of some substances degrading the membrane surface, etc.). Each membrane is a kind of filter and as in normal filtration, where at least one of the components of the mixture being separated can pass through the membrane unhindered, while others are retained to a smaller or larger extent. However, differences with the traditional filter are based on the fact that membranes can separate compounds up to the molecular scope.The structure of the resulting membranes can be homogenous or porous. There is another division of the membranes due to the structure in the cross-section - they can be symmetrical or asymmetrical. The symmetrical diaphragms have the same pore size in the whole cross-section, therefore they can be entirely used for the separation of solutions. However, in the case of asymmetric membranes, the difference is on the decreasing pore diameter towards the thin, non-porous skin layer covering it. Separation then takes place from the epidermal side, the properties of which decide which components of the mixture will be separated by the membrane [II]. The separation process is carried out by means of membranes with their modules (supporting structure). This construction protects the membranes from mechanical damage, but also allows for a huge separation surface in a small volume.

CHARACTERISTICS OF MEMBRANE TECHNIQUES

Membrane processes are increasingly used in water treatment. Membrane installations can work independently or form part of multi-stage process systems. In addition to desalination, membrane techniques are also used in many industries. The most important membrane processes are summarized in Table 1, and the most important membrane processes are briefly described below.

Reverse osmosis (RO) - separation substances dissolved in low molecular weight water. The basis of this process is the phenomenon of osmosis consisting in the transport of solvent through the semi-permeable membrane layer (permeable to the solvent and impermeable to solutes). If the membrane separates solutions with different osmotic pressure, the osmotic flow of solvent into the solution with a higher concentration occurs until the pressure difference on both sides of the membrane is equal to the osmotic pressure (which is characteristic for a given solution). Increasing the internal pressure above the osmotic pressure will increase the chemical potential of the solvent in the solution and its flow in the opposite direction to the osmosis (i.e., the solvent will flow through the membrane from a more concentrated to dilute solution). This phenomenon is called reverse osmosis. For the reverse osmosis, the most commonly used membranes are aromatic polyamides and cellulose acetate. These membranes are capable of retaining solutes with a diameter of less than 10-10 m. Reverse osmosis is the basis of one of the desalination methods of seawater. It is also used for the purification and concentration of industrial wastewater, especially from the food, paper and galvanic industries. This method allows the recovery of water and valuable substances contained in wastewater.

Tab.1. The division of membrane techniques due to the type of driving force of the process.

Pressure difference	***Difference in concentrations (Active)***	***Temperature different***	***The difference on the potential electrical***
Reverse Osmosis RO	*Gas Permeation GS*	*Termo osmosis TRO*	*Electrodialysis ED*
Nanofiltration NF	*Dialysis D*	***Membrane distillation MD***	*Techniques using bi and tripolar membranes BPED*
Microfiltration MF			
Ulrafiltration UF			

Ultrafiltration (UF) - separation involves physical sieving and the efficiency of the process depends on the porosity of the membranes and the particle size of the solute. The method consists of particles with a diameter of 0.0001-0.02 micrometres or a molecular weight of 1000 to 100000. Polysulfone is one of the most suitable polymers used in the production of ultrafiltration membranes. The size and pore size distribution in the surface pore layer determine the selectivity of the mesh membranes. As in reverse osmosis, the ultrafiltration plant must contain elements that allow cleaning and washing of the membranes.

Currently, interest in electrodialysis is growing with a bipolar membrane. It is caused simplification of technological cycles, elimination waste and production of products high-quality. Electrodialysis (ED) the driving force in this process is the electric potential difference on both sides of the membrane, through which the ions are transported from the solution with a concentration lower to the solution with a higher concentration. The membranes used are made of cation exchange and anion exchange resins. Cation exchange membranes (negatively charged) allow the passage of cations, and anion exchange membranes (positively charged) allow anions to pass through. Such membranes can be obtained from the space of cross-linked polymers with incorporated ion-exchange groups capable of dissociation. Electrodialysis membranes are made of hydrophobic polymers such as: polyethylene, polystyrene, polysulphone, and commercial products have the shape of sheets. This technique can be classified as BAT (best available techniques) and currently current trends of innovation is located it is becoming more and more practical. Uses of bipolar membranes for manufg. ortho-phosphoric, salicylic, lactic and citric acids from their salts as well as for deacidification of tropical fruit juice, demineralization of milk, desalination of sea water, desulfurization of waste gases, separation of aminoacids and synthesis of alcoholates [VII, IX].

Membrane distillation (MD) is a separation process where a micro-porous hydrophobic membrane separates two aqueous solutions at different temperatures. The hydrophobicity of the membrane prevents mass transfer of the liquid, whereby a gas-liquid interface is created. The temperature gradient on the membrane results in a vapour pressure difference, whereby volatile components in the supply mix evaporate through the pores and diffusion and/or convection of the compartment with high vapour pressure, are transported to the compartment with low vapour pressure where they are condensated in the cold liquid/vapour phase. For supply solutions that only contain non-volatile substances, such as salts, water vapour will be transported through the membrane whereby demineralised water is obtained on the distillation-side and a further concentrated salt flow on the supply-side. Membrane distillation can be used for the production of distilled water and for concentrating aqueous solutions. The production of clean water from brackish water are the most common MD applications because non-volatile ionic particles are almost completely retained. The potential advantages of MD, in comparison with conventional separation processes, are found primarily in the lower working temperature and pressure, and thus the lower energy costs and less stringent mechanical properties.

In contrast to distillation and RO, supply solutions can be separated at a temperature well below the boiling point and under atmospheric pressure [III]. Typical supply temperatures around 30-60°C permit re-use of residual heat flows, and the use of alternative energy sources such as sun, wind and geothermics.In addition, in comparison with RO, MD is less susceptible to flux limitations caused by concentration polarisation, whereby a higher concentration of matter is obtained on the supply-side. Theoretically, MD offers 90-100% retention for non-volatile dissolved substances, whereby there is no limit on the supply concentration [IV].

THE MEMBRANE PROCESS DISTILLATION IN PRACTICE

In the presented work, tests of resistance to polymer degradation and wettability of PP membranes used to separate supersaturated NaCl solutions that would be used during desalination of water were carried out. During the process, a high flow temperature and one-stage MDC were used, which facilitates concentrating the solution [V-VI].

METHODS AND MATERIAL

The polypropylene capillary membranes Accurel PP S6 / 2 and Accurel PP V8 / 2 HF from the German company Membrana GmbH were used for testing. Diameter of the S6 / 2 membranes is dz = 2.6 / 1.8 mm, while the V8 / 2 HF membranes are respectively 8.6 / 5.5 mm. The pore sizes in both cases are similar and amount to about 0.2 microns. The diaphragms were mounted in immersion type own built modules (without external housing), which were mounted inside the flask (4 L) placed on the thermostat (feed temperature 313 K).

The MK1 module was made of four S6 / 2 membranes (length 0.2 m), while the MK2 module was one V8 / 2 HF membrane (length: 0.28 m). The distillate was pumped with a peristaltic pump inside the capillary membrane, and then returned to the distilled water tank cooled with tap water. The distillate cycle at the beginning of the test was filled with distilled water (4 L), then a certain amount of sodium chloride was added to the solution to achieve the supersaturation. The solution was intensely mixed (600 rpm).

To remove deposited NaCl crystals, the membranes were rinsed cyclically in distilled water. The research was conducted in the long-term, the installation worked continuously, which allowed to test the resistance of the membranes to wetting and the impact of cyclic crystallization of salts on the surface of membranes.

The distillate volume increase was measured once a day (after 24 hours of module operation). Electrical conductivity measurements were also made, a 6P Ultrameter multifunction meter (Myron L Company, USA) was used.

Photo 1. Testing installation for membrane distillation. 1. tank feed with immersed modules, 2. heating plate with mixing, 3. peristaltic pump, 4. distillate tank, 5. distillate tank with cooler. Own source.

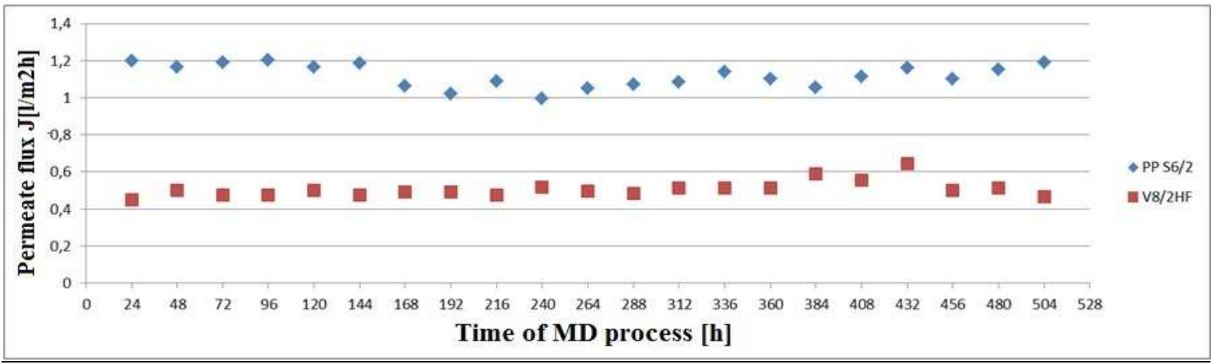

Fig.1 Changes in the permeate flux during module operation (TN = 33 ° C, 1g NaCl)

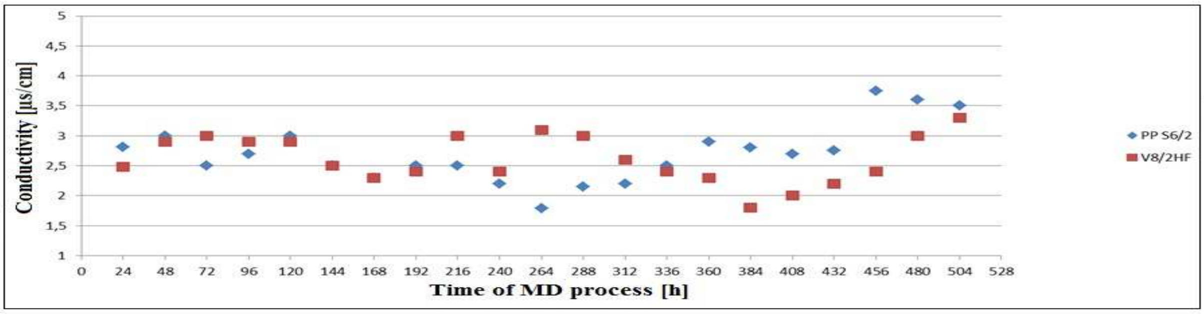

Fig.2 Changes in the conductivity of the proper distillate during module operation

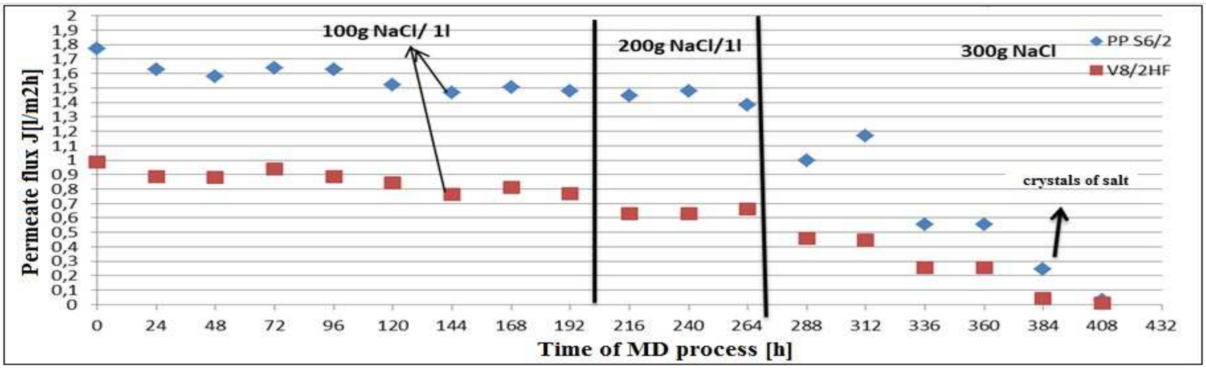

Fig.3 Changes in the permeate flux during module operation (TN=40°C, cN=100,200,300 gNaCl/L)

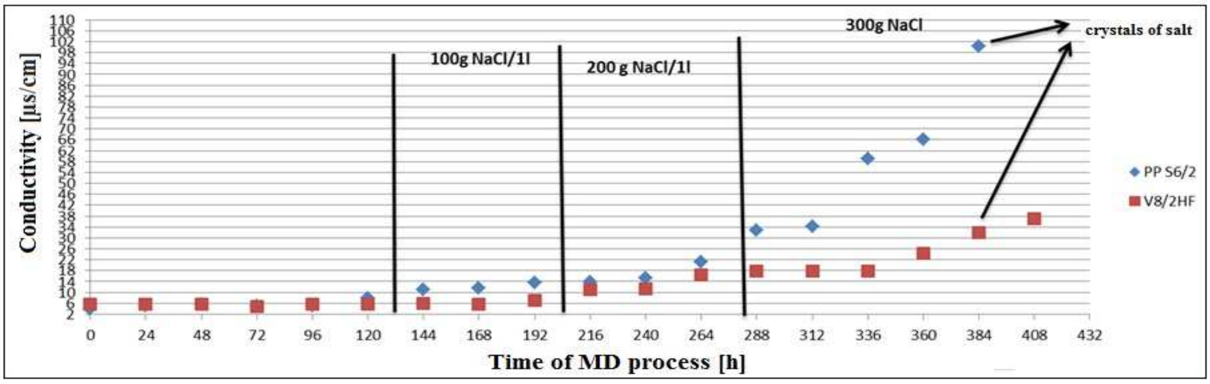

Fig.4 Changes in the conductivity of the proper distillate during module operation

RESULTS AND SUMMARY

The conducted research confirmed that the efficiency of the MD process depends on the temperature of the feed solution (feed), and on the concentration (fig.1). In the MD process, the water evaporated through gas-filled membrane pores, and the driving force was the difference in vapor pressure. Its value increased exponentially, which is why the feed temperature had a significant impact on the process is efficiency. The polypropylene membranes used showed good resistance to wetting (fig.2). The obtained results confirmed the usefulness of the MD process for concentration of non-crystallising salt solutions. However, studies have shown that in the case of salt crystallization on the surface of membranes, the resulting sediments accelerate the wetting of pores (fig.3,4). Increasing the membrane thickness allows for higher membrane durability, but for thicker membranes when concentrating solutions it is necessary to limit the scaling by using additional solutions to eliminate the supersaturation in the modules membrane [VIII]. However, further studies showed that at the moment of contact of the membranes with the crystallizing solution caused the membranes to wet and block their working surface, degrading the material.

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