The Turkish Journal of Occupational / Environmental Medicine and Safety

2017; Volume 2, Issue 1(3):73-79 Web: http://www.turjoem.com ISSN : 2149-471

SAFETY CALCULATION ACCORDING TO FLUID ANALYSIS IN PLASTIC-METAL PIPE CONNECTION PASSAGE USED IN WATER SUPPLY NETWORKS

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ABSTRACT

Introduction
The finite element method is often used to shape the design geometries of pipes and fittings. Analysis studies made with different types of fasteners have been investigated in the literature. It has been observed that the studies related to the pliable pipe connections commonly used in in-building installations are lacking. No study has been conducted on the flow analysis of the fasteners used in the transition from metal pipes to plastic pipes.

Material and methods
The 32 series set necklace provides fluid flow between the metal pipe and the plastic pipe. The assembly model has been designed using the Solid Works program. Surface stresses due to cavitations are calculated in the fluid analysis Flow Simulation module. These values were chosen as the pressure acting on the static analysis module.

Results
In the water network system, the transition from metal pipe to plastic pipe has been investigated. Internal pressure changes and cavitations were calculated. The effect of this fluid's pressure changes on the surfaces of the assembly design parts has been investigated.
Conclusions
Quantities and safety coefficients of plastic pipe, metal pipe, connecting bolt, rear cap and frontal mask were calculated. In the literature, the internal pressure changes which are not included in the static analysis are calculated by this study and the effect on the results is examined.

Key Words: Plastic - metal pipe connections, fluid analysis, safety coefficient.

INTRODUCTION

Plastic pipes are used in-building structures and used for irrigation of agricultural land. Plastic pipes can be connected to metal pipes with many fittings[1].According to different types of requirements, fittings like socket collar, elbow, tee and coupling can use. Plastic materials aren't used in installation lines because of the low safety factor and they cannot be withstand at high pressures. A scrap are included in the content of plastic pipe fittings produced in our country. With this junk contribution, human health is threatened also the strength properties are reduced. Although the weight of the socket collar made by our company is 40-80% lower than other manufacturers, the strength is higher because they use the original product [2].
During natural disasters such as earthquakes, floods are observed in agricultural and drinking water installations. Fatigue and cracks are observed in plastic pipe fittings due to temperature effect especially in cities with high temperatures. The high scrap mixture can cause cracks and water leaks in the plastic connections.
The fatigue is observed in materials with the effect of temperature and natural disasters such as earthquakes. The high safety factor of the fittings used in the installation reduces the fatigue effect. The safety factor of metal pipe fittings in city networks is at least 20 [3]. It is also claimed that the safety factor of Chinese imported products are lower.
The pressure resistances of the 63 series socket collar in different geometries with industrial design patent are examined [4]. A geometry with Moon-Star pattern has been developed. In this study water fluid analysis and pressure changes were not considered. While the 63 series socket collar is not used too much in the installation, the 32 series is the most consumed product. The safety factor of this material will be compared according to the iron fittings.
Safety and health in fittings is an important issue that needs to be investigated. Aluminum alloy fittings are desired to be improved because they are healthier and have higher corrosion resistance [5]. The effects of design parameters of aluminum fittings on maximum stress and safety factor were investigated [6]. An axis control tester has been developed to solve the problems that may occur due to axis eccentricity in pipe connections [7].Microstructure and hardness changes of cast iron fittings were investigated depending on the cooling rate [8].
Multipurpose experimental and pressure drop analysis in pipes and connections was investigated as a post graduate study with the aid of a designed test setup and flow analysis program [9].The pipe bending process of the elbow fitting was studied as a post graduate study by the LS-DYNA and finite elements method in the ANSYS program [10]. Pressure losses in commonly used plumbing components are theoretically and experimentally calculated [11]. Behavior under seismic influences of grounded pipes and is investigated [12].Behavior of pipes under different loads is investigated [13].
With this study, for the first time in the literature, the water flow analysis of 32 series socket collar, which is the most used product for plastic and metal fittings, will be done. Depending on this flow analysis, the dynamic and static pressures occurring in the connection passages will be observed. Water flow rate changes and the amount of turbulence will be examined.

MATERIALS METHOD

Installation Design:

The 32 series socket collar was made with the Solid Works program with reference to an improved industrial design. The measurements were made according to the 3/4 '' TS 11 standards most commonly used in building installations[4].The design has been improved that the M6 can be connected with two bolts.32 pipes are modeled from the inside and the outlet is assembled with 3/4" pipe with 4 mm wall thickness(Figure 1.).

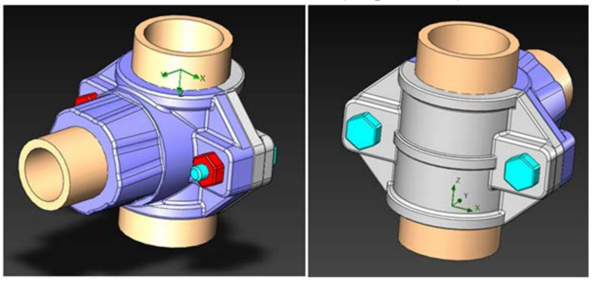

Figure 1. 32 - socket assembling design

Fluid Analysis

Plastic-to-metal pipe connection is transferred to Solid Works Flow Simulation module for fluid analysis. Considering the water system, 5 bar pressure and 30 L/ min flow rate were determined. The cavitations feature is activated. Figures 2 and 3 shows the analysis results and graphs.

Pressure Strength Analysis:

The results of fluid analysis have been examined. Pressure variation due to fluid velocity varies between 5 and 5.16 MPa in different regions. An increase in the amount of pressure is observed with respect to the fluid velocity and flow pattern. The static pressure calculation will be analyzed with these regional changes.
Different types of materials are used in the assembly model. In the analysis, iron pipe and bolts are selected from 1045 material, the socket necklace material is homopolymer, and plastic pipe material is PP. The mechanical properties of these materials are given in Table 1.

Table 1. Mechanical properties of assembling materials

Material Name	Density (kg/ m3)	Ultimate Strength (MPa)	Yield Strength (MPa)	Modulus of Elasticity (MPa)	Poisson's Ratio
1045	7850	625	530	205000	0,29
Homopolymer	933	39	33	1790	0,35
PP	908	32	30	153	0,33

RESULTS

Fluid analysis was done with Solid Works Flow Simulation. The flow rate varied from 0.5 to 4.7 m/s (Figure 2.a). Dynamic pressure variation up to 0.11 bar was observed (Figure 2.b). Turbulence width increased up to 2 mm (Figure 2.c).The pressure increase is shown in 3D (Figure 2.d).Pressure and flow rate map of the design geometry was created (Figure 3).The results of maximum stress and deformation in plastic fittings connected to fluid analysis are shown in Figure 4.The results of calculation of the safety factor, maximum stress and deformation amount of all assembling materials are given in table 2.

Table 2. Safety factors, maximum stress and deformation amounts of assembling parts

Material Name	Maximum Stress (MPa)	Maximum Deformation (mm)	Safety Factor
Top Cover	2,9	0,020	11,4
Back Cover	3,6	0,024	9,1
Bolt	18,6	0,019	15
Plastic Pipe	4,6	0,021	6,9
Nut	6,2	0,019	15
Metal Pipe	2,7	0,011	11,9

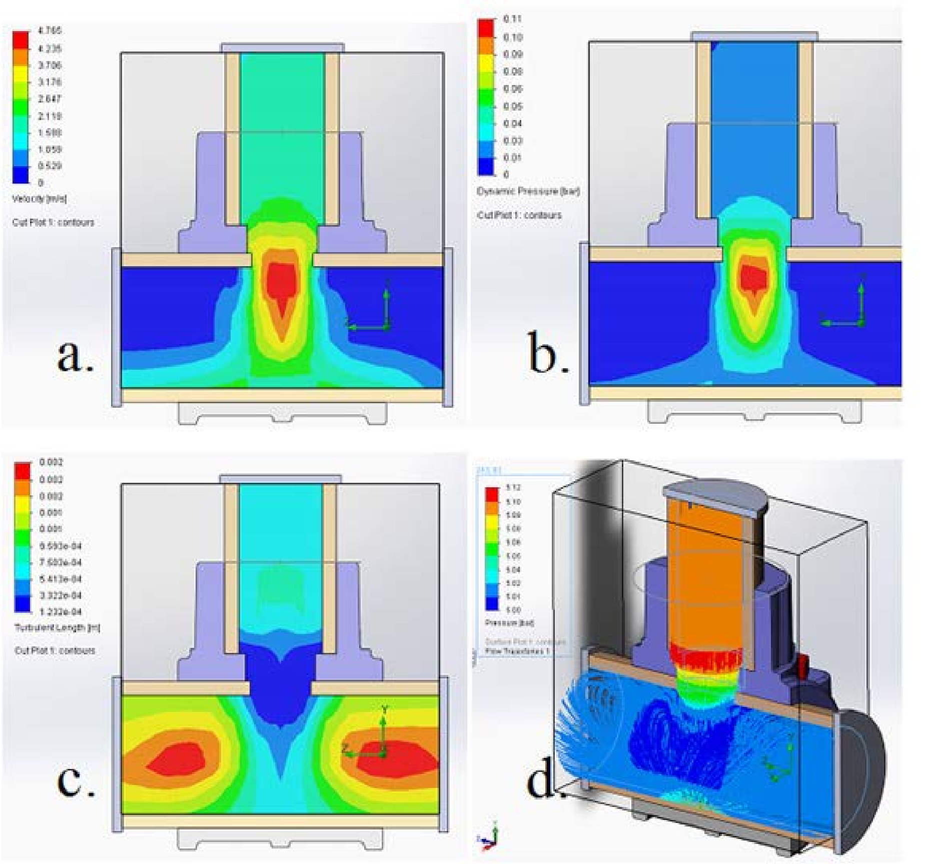

Figure 2. a) Flow rate, b) Dynamic pressure c) Turbulence length d) Pressure variation analysis results

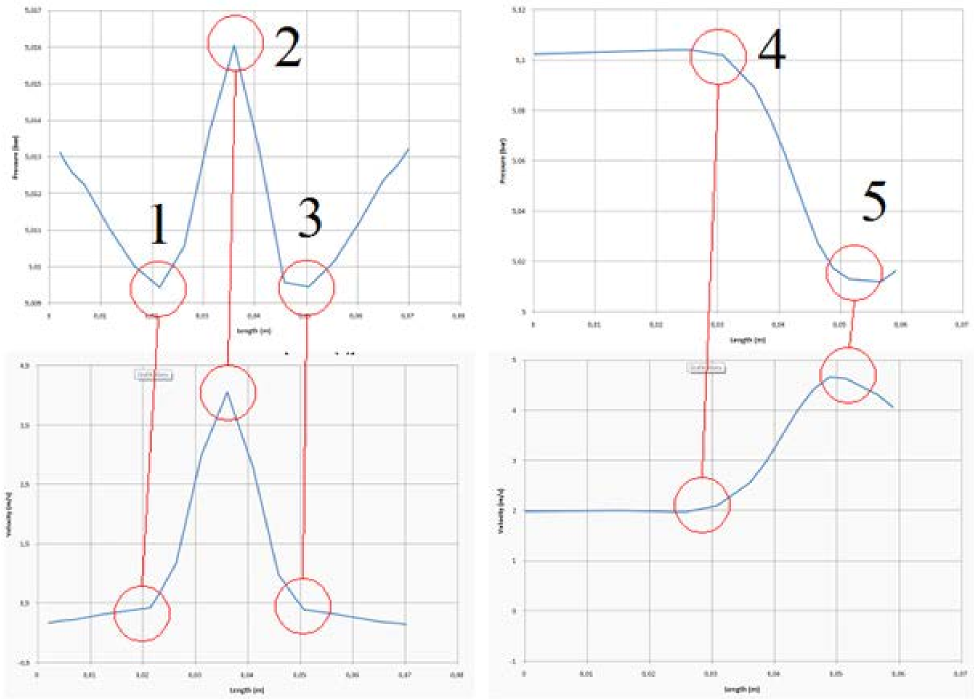

Figure 3. Horizontal axis (left) and vertical axis (right) graphs of the amount of pressure and flow rate

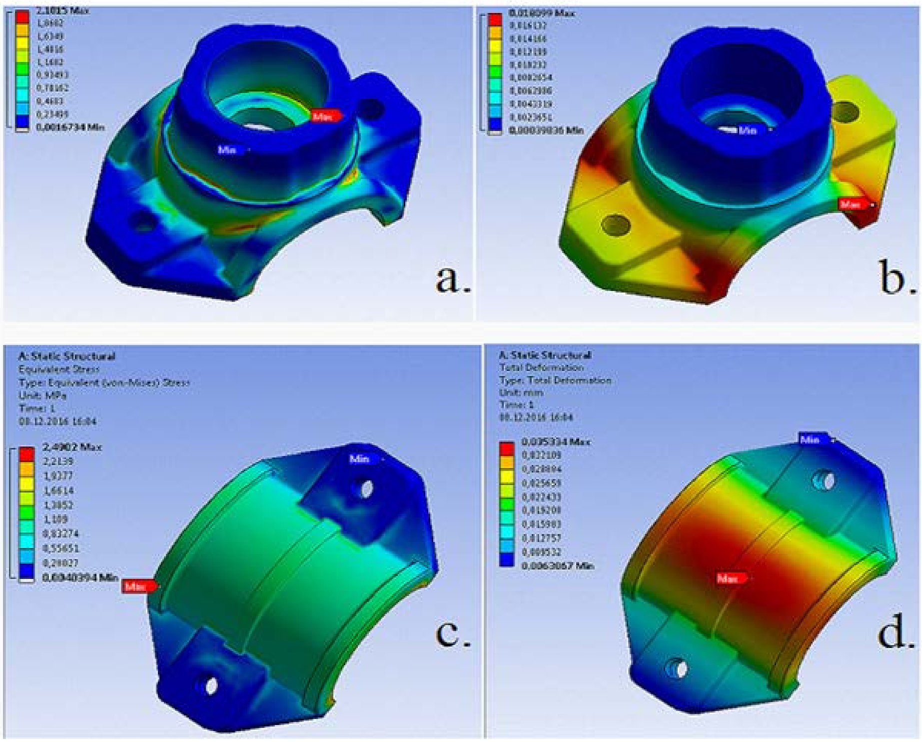

Figure 4. a) Maximum amount of stress of metal fitting b) amount of deformation c) amount of maximum stress of cover d) amount of deformation

CONCLUSION

In this study, maximum stress, deformation amount and safety factor of the assembly design of plastic - metal pipe fittings are determined. The highest amount of stress was measured in bolts with 18, 6 MPa. The safety factor of M6 bolts and nuts made of 1040 material is more than 15.The minimum amount of stress is 2.7 MPa in metal pipe. The plastic material with the lowest safety factor 6.9. The highest amount of deformation was observed 0.024 mm in the back cover. The metal pipe is the material exhibiting the least amount of deformation with 0, 11 mm (Table 2.).

When the results are examined, the safety factor of the plastic pipe and the back cover is lower than other materials. The belt design, which passes through the middle of the back cover, increases the safety factor (Figure 4.). It is thought that the safety factor of other designs without belt is higher. The maximum amount of stress increase in the front cover was observed at the bottom of the wick. The safety factor is increased with the model developed for the bite insert design.

When the fluid analysis was examined, an internal pressure difference of 5 to 5, 16 bar was observed. The flow rate increased from 2.1 m/s to 4.6 m/s when passing from plastic pipe to metal pipe. Dynamic pressure of 0.12-0.16 bar was observed in this area(Figure 2.).When Figure 3 is examined, the flow rate increases from 0,529 m / s in the first and third zones to 4.7 m/s in the second zone due to the effect of passing to the metal pipe. While the water in region 4 moves at a speed of 2 m/s after passing through the plastic pipe from the metal pipe, the exit from the metal pipe is provided at zone 5 at a speed of 4.6 m/s.

In this study, fluid analysis and compressive strength analysis were investigated to examine the safety of plastic-metal pipe connections. The fluid pressure change was added to the pressure analysis. This study investigated the effect of internal pressure differences on the safety of plumbing networks. Internal pressure changes are much more observed especially in pumps. This work was a prediction for the dynamic analysis of products with high internal pressure differences, such as pumps.

In this study, where safety in water networks is investigated, the safety factor of plastic pipe fittings is measured as at least 9.1. It has been determined that the safety factor of the elbow fittings used in the city networks was 20 as a result of the analyzes. It has been observed with this study that the safety factor of plastic fittings is less than that of metal fittings. With the addition of scrap material, this network security amount is expected to decrease even further. It is considered that the safety factor of plastic fittings that used in agricultural land, especially in natural disasters such as earthquakes and under high temperature effects, should be at least 8.It has been decided to investigate the maximum compressive strengths of plastic and metal fittings with the help of a high pressure oil pump.

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